SCAN TEAM REPORT
Scan 07-05

Best Practices In Bridge Management Decision-Making

Supported by the
National Cooperative Highway Research Program

The information contained in this report was prepared as part of NCHRP Project 20-68A U.S. Domestic Scan, National Cooperative Highway Research Program.

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The purpose of each scan and of Project 20-68A as a whole is to accelerate beneficial innovation by facilitating information sharing and technology exchange among the states and other transportation agencies and identifying actionable items of common interest. Experience has shown that personal contact with new ideas and their application is a particularly valuable means for such sharing and exchange. A scan entails peer-to-peer discussions between practitioners who have implemented new practices and others who are able to disseminate knowledge of these new practices and their possible benefits to a broad audience of other users. Each scan addresses a single technical topic selected by AASHTO and the NCHRP 20-68A Project Panel. Further information on the NCHRP 20-68A U.S. Domestic Scan program is available at

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This report was prepared by the scan team for Scan 07-05, *Best Practices in Bridge Management Decision-Making*, whose members are listed below. Scan planning and logistics are managed by Arora and Associates, P.C.; Harry Capers is the Principal Investigator. NCHRP Project 20-68A is guided by a technical project panel and managed by Andrew C. Lemer, Ph.D., NCHRP Senior Program Officer.

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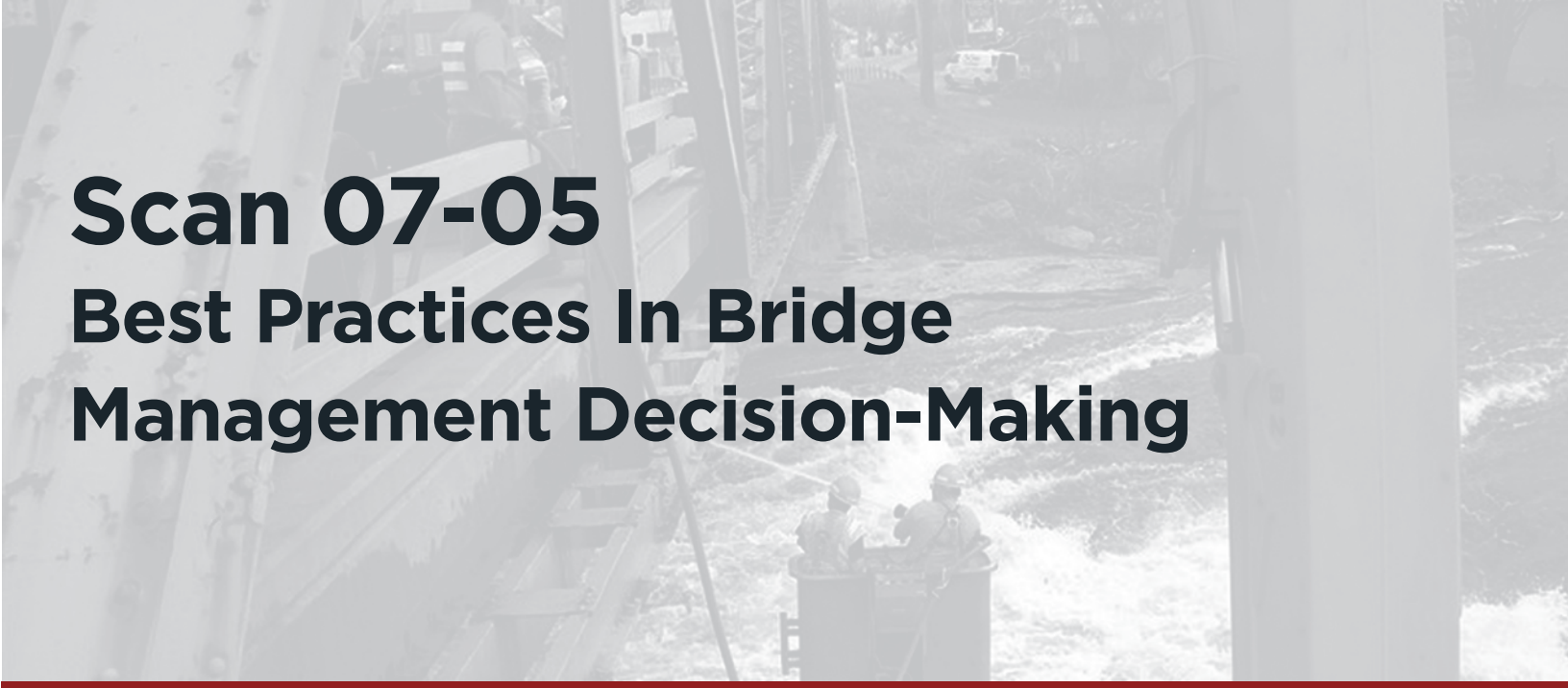
Disclaimer

The information in this document was taken directly from the submission of the authors. The opinions and conclusions expressed or implied are those of the scan team and are not necessarily those of the Transportation Research Board, the National Research Council, or the program sponsors. The document has not been edited by the Transportation Research Board.



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Best Practices In Bridge Management Decision-Making

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Abbreviations and Acronyms

ABME	Area Bridge Maintenance Engineer
AM	Asset Maintenance
BCFS	Bridge Condition Forecasting System
BDMS	Bridge Data Management System
BEIS	Bridge Engineering Information System
BIRIS	Bridge Inspection Reporting Information System
BNAM	Bridge Needs Assessment Model
BMPE	Bridge Maintenance Program Engineer
BMRI	Bridge Management Remote Inspection
BMS	Bridge Management System
BSA	Bridge Safety Assurance
BWOS	Bridge Work Order System
Caltrans	California Department of Transportation
CDL	Commercial Driver's License
CPM	Capital Preventive Maintenance
CSM	Capital Scheduled Maintenance
DelDOT	Delaware Department of Transportation
DOT	Department of Transportation
FARC	Feasible Action Review Committee
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
HBP	Highway Bridge Program
HMWM	High Molecular Weight Methacrylate
HT	Highway Technician
IMMS	Integrated Maintenance Management System

MAP	Maintenance Accountability Process
MAMIS	Maintenance Asset Management Information System
MBIS	Michigan Bridge Inspection System
MBM	Major Bridge Maintenance
MBRS	Michigan Bridge Reporting System
MDOT	Michigan Department of Transportation
MMS	Maintenance Management System
MPET	Maintenance Productivity Enhancement Tool
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NYSDOT	New York State Department of Transportation
ODOT	Ohio Department of Transportation, Oregon Department of Transportation
OPI	Organization Performance Indicator
QA	Quality Assurance
QC	Quality Control
RBM	Routine Bridge Maintenance
RBME	Regional Bridge Maintenance Engineer
SHOPP	State Highway Operations and Protection Program
SI	Structural Inspection
SMART	Structure Maintenance Automated Report Transmittal
SMI	Structures Maintenance and Investigations Group
STIP	State Transportation Improvement Program
TMS	Transportation Management System
TMW	Transportation Maintenance Workers
VDOT	Virginia Department of Transportation
WSDOT	Washington State Department of Transportation

Executive Summary

Introduction/Overview

Scan 07-05 is a domestic scan focusing on practices among U.S. transportation departments (DOT) for identification, prioritization, and execution of programs for management of highway bridges. The scan includes reviews of DOT manuals, guidelines, and policy statements; a collection of responses to amplifying questions from DOTs; and travel to seven sites for meetings with DOT staff. The most detailed information was collected from 13 DOTs that participated in meetings with the scan team. Document review includes input from 11 other DOTs. All sources are state or local government agencies of the United States (see Table 1.1).

Materials collected from participating agencies during the scan include PowerPoint presentations, maintenance manuals, technical memoranda, coding guides, policy memos, and spreadsheets used in prioritizing and executing bridge maintenance work.

This scan collected policies and procedures only. Visits to bridge sites or other field sites were not part of the scan.

Key Findings/Observations

The scan team observed that certain practices in current use in bridge maintenance are effective in improving overall bridge conditions. These key observations/findings are divided into three main categories: the bridge management process, preventive maintenance, and agency support. The first of these categories, the bridge management process, further touches upon four elements of an effective process: identification of maintenance needs, performance measures, prioritization, and verification. Each of these is further described below. Following, the scan's key recommendations are presented.

Bridge Management Process

Bridge management is a process that combines information on the needs of bridges, the significance of bridge conditions and risks, the appropriate remedies and actions, the available means of execution, and the efficient programming and coordination of maintenance work. Bridge management, as a process, responds to limitations in available resources and yields appropriate work programs for specified planning periods.

- Maintenance Needs

  The identification of maintenance needs at bridges is most effective when it is uniform, specific, and repeatable. Needs should be identified at the bridge element level. Needs must be stated as standard work actions so that procedures, expected costs, and requirements in permitting and scheduling are identified. To make the most effective use of work needs at bridges, needs must be stored in a corporate database accessible to program managers.

- Maintenance Performance Measures

  At DOTs where the use of performance measures were effective in documenting improvements to bridge conditions, performance measures were matched to objectives in bridge maintenance. Performance measures that are focused on deficient bridges deliver programs for deficiencies. Performance measures that are focused on PM needs deliver programs for preventive maintenance. Performance measures must both identify work that will achieve maintenance objectives provide simple indications of the status of bridge conditions.

  Performance measures are effective when upper management actively and consistently supports them and when they are used to monitor overall network conditions and progress in achieving network goals. Performance measures are less effective in selecting day-to-day work programs, which are best set by experienced, trained maintenance crew supervisors using easily available data and first-hand knowledge of bridges within their jurisdiction.

- Prioritization

  Prioritization of maintenance projects must integrate agency objectives for deficient bridges, for preventive maintenance of good bridges, for network performance, and for risk. The process for prioritization must recognize the effect that deferred maintenance will have on individual bridges and on the network of bridges.

  For automated evaluation of priorities, multi-object approaches are needed to combine the benefits of least cost, risk reduction, and preventive maintenance. Inputs to automated evaluations must include bridge conditions; bridge vulnerabilities; indicators for PM needs, such as paint health index; and attributes of bridge inventory.

  Procedures for prioritization must engage both central and regional DOT offices and must advance from network-level rankings of candidates to bridge-by-bridge selection of projects.

- Verification

  Bridge management processes that are reliable and useful in making decisions incorporate reports of completed maintenance work. Bridge management systems must also correlate the impact of the work on bridge condition measures through verification. Verification is needed to confirm that risk is reduced or that preventive maintenance needs are satisfied. Verification is most effective when it includes integration of DOT data systems so that bridge management applications can collect relevant information from crew- and contract-management applications.

Preventive Maintenance

A significant portion of bridge resources (i.e., funds and personnel) is being directed to preventive maintenance (PM) in some DOTs that have proactively sought to improve overall bridge condition measures. A strategy of emphasizing PM can succeed in improving or maintaining good bridge conditions.

To be effective, PM actions must be applied before bridge conditions become poor. DOTs must be able to recognize current needs for PM actions, anticipate near-term needs, and follow work-programming procedures that deliver PM actions promptly and at appropriate times. Successful programs target bridges that are in fair or good condition for PM actions.

To recognize and program preventive maintenance, DOTs must have trained staff, adequate funding, flexible allocation of funds, and clear plans of action for bridge components. These last two aspects, flexible allocation and clear plans, are key. Funding must be directed to preventive maintenance for bridges before bridges become deficient. DOT staff must recognize maintenance needs related to time in service, and not only to the defects.

Agency Support

The formal DOT organization must support the bridge management process at all levels. DOT bridge inspection teams, by training and experience, must be able to identify work needs and recommend actions. Bridge owners need to leverage their bridge site inspections for both the identification of needed work and the verification of completed work (from previous recommendations). Maintenance crews must take initiative in the execution of maintenance work and be guided, but not controlled, by lists of needs from bridge inspections. District maintenance engineers must collect information from inspectors and from crews, evaluate the continuing needs and trends in their bridges, and make appropriate applications to their central DOT office for funds and for projects. The central DOT office must operate with quantitative performance measures that are compatible with district operations and must recognize the first-hand knowledge that resides in DOT districts. DOT executives and government executives generally must accept that maintenance is not an episodic response to deficient bridges, but rather a continuing program of support for good bridges.

In its external aspects, agency-wide support for bridge management is seen in staff training, peer-exchange conferences, policies on preventive maintenance practices, Web-accessible guides and manuals and, in general, access of staff to technical knowledge and policy guidance for bridge maintenance.

Full explanations of these practices should be prepared and disseminated through documents, Web sites, webinars, presentations to AASHTO and TRB committees, and should be included as content in National Highway Institute courses for bridge maintenance and management. The effective practices are outlined below. An implementation plan begins on page 174. Information on practices at individual DOTs appears in the “Findings” sections in the body of this report.

Key Recommendations

The scan team’s key recommendations for bridge management decision-making are as follows:

- Adopt element-level bridge inspection programs and establish standard condition states, quantities, and recommended actions (i.e., maintenance, preservation, rehabilitation, and replacement) to match the operational characteristics of the agency maintenance and or

preservation program.

- Establish national performance measures for all highway bridges for comparisons among bridge owners.
- Use owner-specific performance measures to allocate funding levels for the full range of actions (i.e., maintenance, preservation, rehabilitation, and replacement) to optimize highway bridge conditions.
- Determine bridge needs and a proposed multiyear treatment program based on owner-specific objectives. Use the proposed program to develop a needs-based funding allocation, using all types of funding within the state's prerogative for each of the recommended action types (i.e., maintenance, preservation, rehabilitation, and replacement).
- Establish standards for preventive maintenance programs that are funded at levels set by analysis of performance measures. Programs must include the preservation needs of "cusp" bridges to keep them from becoming deficient bridges. In other words, do the right activity at the right time, keeping good bridges in good condition and moving away from the "worst first" approach. Experience in scan states has shown that preventive and minor maintenance must be a significant portion of bridge programs that optimize bridge conditions within limited budgets.
- Develop work programs for maintenance and preservation at the lowest level of management or supervision when supervisors with extensive field maintenance knowledge and experience staff those positions. Avoid blind use of work programs from bridge management systems (BMSs), and work programs dictated by goals to maximize performance measures (although both BMSs and performance measures do provide useful information to maintenance crews).

Scan Team Overall Recommendations

Based on the findings, the scan team also identified a larger set of overall recommendations in addition to the key recommendations. These overall recommendations, which are categorized into various bridge management areas, draw upon and expand the key recommendations to highlight effective bridge management practices that have broader program applicability. The overall recommendations are as follows:

Assessments: Element-Level Inventory and Inspection

- Identify work recommendations (set to match agency practices) and costs and store them in a database
- Continuously update accomplishments and unmet needs
- Create a feedback loop for validation to avoid re-reporting of resolved needs

Performance Measures

- Establish performance measures
- Include all bridges, in addition to those that are structurally deficient and functionally obsolete
- Ensure that the measures are suitable for establishing relative funding levels for crew or contract maintenance, capital program rehabilitation, and capital program replacement
- Ensure that the measures are suitable for national comparison

Funding/Resources

Develop for all highway bridges needs-based funding formulas that recognize the value of maintenance and repair at the appropriate time to improve bridge conditions and extend service life

Decision Tools

- Integrate project and network objectives, especially for program-level decision-making in asset management, to achieve single-asset optimization
- Use forecasting and modeling tools
- Use tools that are capable of evaluating maintenance scenarios that are consistent with agency maintenance practices

Programming

- Use priority indicators that integrate urgency, vulnerability, delays, cost, and other key factors
- Achieve the most effectiveness by coordinating work plans through local, district, and headquarter levels, incorporating local knowledge, and setting day-to-day work schedules at the lowest local level

Delivery Mechanisms

- Use a wide range of alternative design/contracting options for various types of maintenance and repairs, including state crews, contracted planned maintenance, on-call contracted as-needed repairs, and state specialty crews for specific repairs (e.g., spot painting, heat straightening, and corrosion mitigation)
- Continue efforts in performance-management type contracts
- Develop standardized item-based contracting for specific on-call projects

CHAPTER 1

Introduction

Background and Scope

Bridge maintenance engineers must employ a decision process to convert performance indicators into a prioritized listing of bridge maintenance and repair needs. Modern materials, equipment, innovations in methods, and new applications of familiar products can increase productivity, provide long-lasting repairs, and minimize traffic disruption. Maintenance forces using these enhancements are able to improve the service life of more bridges with the same or fewer resources.

The decision process, however, is critical, as bridge preservation requires timely intervention with effective treatments to address minor deficiencies before significant problems develop. In most states, the bridge maintenance engineer does the process manually with little or no formal guidelines. A decision support system to assist in determining the prioritized list of bridge needs using appropriate performance indicators would assist the engineer in the development of an effective work plan.

The scan team focused on identifying and visiting states that have developed an automated decision support system for bridge maintenance programming. The team sought to address how decisions are being made about routine maintenance and major rehabilitations and reconstructions to minimize traffic disruptions and control agency life-cycle costs. During the scan, the team interviewed bridge engineers responsible for developing the bridge maintenance program.

One of the scan's objectives was to identify effective decision support systems already in practice, list the benefits and costs of such systems, document the algorithm logic, and identify the performance indicators the systems used. A second objective of the scan was to provide a compendium of productivity-enhancing techniques, applications, and equipment for activities aimed at maintaining and preserving highway structures. Included in the review were practices and innovations that minimize disruptions to the mobility needs of highway users during the preservation/maintenance operation without compromising the quality of the activity.

State and local bridge maintenance engineers are the primary target audience of the scan's findings; however, structural engineers and asset managers will also be interested. Successful systems can serve as a model for a similar system that could be incorporated into state or national BMSs, which, in turn, would lead to a more robust bridge preservation program. The details on innovations and strategies that operations forces can employ to ensure that

high-quality results are achieved in the most productive manner will aid state and contractor preservation and maintenance crews, reduce the cost of the activity, and allow more work to be accomplished with the same limited preservation and maintenance resources.

A manual that provides information about successful programs would be valuable for bridge maintenance engineers, managers, technicians, and supervising foremen. Managers involved with specifications for bridge preservation and maintenance would also find such a manual helpful. The manual could be supplemental to the *AASHTO Maintenance Manual*.

Scan Overview

Scan 07-05 is a domestic scan focusing on practices among U.S. transportation departments for identifying, prioritizing, and executing highway bridge maintenance programs. The scan includes a review of DOT manuals, guidelines, and policy statements; a collection of DOT responses to amplifying questions; and the results of the scan team's visits to seven sites for meetings with DOT staff. The most detailed information was collected from the 13 DOTs that participated in meetings with the scan team; document review included input from 11 additional DOTs. All sources are state or local U.S. government agencies (see Table 1.1).

Agency	Office / Branch	Doc. Rev.	AQ[1]	Visit
Alabama DOT	—	Yes	—	—
Caltrans (California DOT)	Structures Maintenance and Investigations	Yes	—	Yes
Colorado DOT	—	Yes	—	
DelDOT (Delaware DOT)	Maintenance and Operations Division, Maintenance of Bridges and Roads	Yes	—	Yes
El Dorado County Public Works, California	County DOT	—	Yes	Yes[2]
Florida DOT	Office of Maintenance	Yes	Yes	Yes
Florida's Turnpike Enterprise	Turnpike Roadway Maintenance		Yes	Yes[3]
Idaho DOT	—	Yes	—	—
Illinois DOT	—	Yes	—	—
Louisiana DOT	Bridge Design[4]	Yes	—	—
Michigan DOT	Bridge Operations	Yes	Yes	Yes
Minnesota DOT	—	Yes	—	—
Montana DOT	—	Yes	—	—
New Mexico DOT	—	Yes	—	—
New York State DOT	Bridge Maintenance[4]	Yes	Yes	—
North Carolina DOT	—	Yes	—	—
Ohio DOT	Bridge Operations and Maintenance	Yes	Yes	Yes
Oregon DOT	Bridge Engineering[4]	Yes	Yes	—
Pennsylvania DOT	—	Yes	—	—

Agency	Office / Branch	Doc. Rev.	AQ[1]	Visit
Placer County Public Works, California	County Bridge Engineer	—	Yes	Yes[2]
Texas DOT	—	Yes	—	—
Virginia DOT	Structure and Bridge Division	Yes	—	Yes
Washington State DOT	Bridge Preservation	Yes	Yes	Yes
Wisconsin DOT	Bureau of Structures[4]	Yes	—	—

1 Responded to amplifying questions
2 Participated in meetings at the Caltrans offices in Sacramento
3 Participated by video link in meetings at FDOT offices in Tallahassee
4 Scan team member

Table 1.1 *Agencies in the scan*

Materials collected from participating agencies during the scan include PowerPoint presentations, maintenance manuals, technical memoranda, coding guides, policy memos, and spreadsheets used in prioritizing and executing bridge maintenance work.

This scan collected policies and procedures only. Visits to bridge sites or other field sites were not part of the scan.

The scan team consisted of six members from state agencies, one member from FHWA, and one member from academia, who also served as the report facilitator. The team members and their affiliations are listed below. The complete contact information and the biographical sketches for the scan team members are provided in Appendix A and Appendix B, respectively.

- Peter Weykamp, P.E., New York State DOT, AASHTO Co-Chair
- Tod Kimball, P.E., FHWA, FHWA Co-Chair
- George Hearn, P.E., DES, Subject Matter Expert
- Bruce V. Johnson, P.E., Oregon DOT
- Keith Ramsey, P.E., Texas DOT
- Arthur D'Andrea, P.E., Louisiana DOT
- Scot Becker, P.E., Wisconsin DOT

The specific findings from the scan team's visits to each of the following agencies are included in this report:

- California
- Eldorado County, California

- Placer County, California
- Delaware
- Florida
- Florida's Turnpike Enterprise
- Michigan
- New York State
- Ohio
- Oregon
- Virginia
- Washington

CHAPTER 2

California

In California, the scan team collected information from the Caltrans Structures Maintenance and Investigations (SMI) group. The California Department of Transportation (DOT) is known as Caltrans.

SMI is part of the Caltrans Division of Maintenance. SMI is responsible for bridge inspections, emergency response, load rating, and scour mitigation. SMI identifies work needs, sets priorities, and allocates work to DOT districts, to major maintenance contracts, to the Caltrans State Highway Operations and Protection Program (SHOPP), and to the capital program for rehabilitations and replacements. SMI also performs analysis for special loads on bridges.

SMI has offices in Sacramento, Oakland, and Los Angeles. The main office, in Sacramento, manages inspections for bridges in central and northern California. It operates the bridge management and data systems and manages statewide programs for scour mitigation, fracture critical bridges, and underwater inspections. The Oakland office deals mainly with toll bridges in the San Francisco Bay area. The Los Angeles office manages the statewide sign program and inspections for bridges in southern California.

SMI personnel inspect all state-owned and most locally owned bridges in California. SMI identifies needed repairs for state-owned bridges. For locally owned bridges, SMI makes recommendations for repairs and informs local governments.

DOT districts in California perform crew maintenance, roadway operations maintenance, project delivery, and environmental permitting. The DOT districts do not have design staff; instead, they engage SMI or consultants for engineering design as needed for maintenance projects. Caltrans has four special design units in bridge preservation that focus on joints, deck overlays, deck healers, and bridge-painting projects.

Maintenance Categories

Caltrans identifies four categories of maintenance:

- **Routine maintenance** is the repair of minor or major defects.
- **Preventive maintenance** includes crack sealing, deck sealing, deck overlay, joint projects, and bridge painting.
- **Rehabilitation** is the improvement of bridge elements to near-new condition.
- **Emergency maintenance** is immediate response to significant events or findings at bridges.

Expenditures for maintenance projects are $94 million per year. Current (2009) expenditures have experienced more than a tenfold increase since 2005 because many bridge projects have been redirected to the maintenance program from the rehabilitation program.

Maintenance Goals

Caltrans's goals in bridge maintenance are to preserve condition, improve safety, and maintain operation of all state-owned bridges. California identifies bridge management as the proper execution of all steps in maintenance from assessment through delivery. All steps, decisions, and data that are related to the care of bridges are components of the bridge management activity.

Bridge Maintenance Program

Inventory

There are 12,600 bridges in California (see Table 2.1). Of these, 10,500 are water crossings.

Category	Count
State-owned highway bridges > 20 feet	12,600
County- or locally owned highway bridges > 20 feet	12,500
State-owned highway bridges ≤ 20 feet	347
Pedestrian and railroad bridges	1,115
Overhead sign structures	24,000
Earth-retaining structures (i.e., retaining walls)	789
Tunnels	89

Table 2.1 *California structure inventory*

The inventory of state-owned bridges is 89% concrete, 7% steel, and 4% timber. State-owned bridges have an aggregate deck area of 233 million square feet and an asset value of $50 billion. The aggregate length of California's bridges is sufficient to extend from Oregon to Mexico. The inventory includes many large and/or complex bridges.

Local Agencies

California has 600 local agencies that have some maintenance responsibility for highway bridges. The role of Caltrans is to inspect fund projects for locally owned bridges. Caltrans has a division of local assistance to help local agencies develop bridge projects and qualify those projects for state or federal shares of funding. Some local agencies develop projects through metropolitan planning organizations or regional transportation planning authorities. Caltrans does not manage bridge inventories for local agencies; however, it does assist local agencies by providing information and collecting data required for federal reporting. Caltrans also does not track maintenance work for local agency bridges; however, its inspectors note completed repairs during safety inspections. When there are critical findings, Caltrans notifies the local owner, notifies FHWA, and follows up with the local owner until the finding is resolved.

Execution of Bridge Maintenance

Caltrans crews complete maintenance work through maintenance contracts, the capital program, and emergency contracts and perform minor repairs to decks, railings, and joints. Maintenance contracts provide deck treatments, overlays, and joint replacements.

Caltrans crews perform the lesser portion of bridge maintenance work because the volume of emerging needs for maintenance, as identified by bridge inspectors, is greater than the DOT crews can complete. Larger projects, such as bridge rehabilitation and replacement, are performed by contract under the Caltrans SHOPP program.

For some projects, Caltrans uses limited-bid projects in which a few select contractors are invited to submit bids that identify labor rates and material markups. Caltrans also uses force account contracts for some maintenance work.

Maintenance Staffing Levels, Training, and Longevity

Structure Maintenance and Investigations

SMI has a staff of 160 engineers and is part of the Caltrans Maintenance and Operations Division. SMI provides design work for most maintenance contracts. Caltrans Project Delivery, which is separate from Maintenance, performs bridge design and has a staff of 900 engineers. Of these, 325 are structural engineers.

Bridge Inspections and Inspectors

Bridge inspectors are part of the Caltrans bridge maintenance program, both organizationally and in the inspectors' role in identification of work needs at bridges. SMI has a group of area bridge maintenance engineers (ABMEs), each of which is assigned a regional group of bridges and is responsible for roughly the same total deck area. The ABMEs inspect bridges and direct teams to inspect bridges.

Bridge inspectors are professional engineers who are trained through rotating assignments to bridge design, bridge construction, and bridge inspection. Because of their training,

experience, and certification, inspectors' recommendations for bridge work are authoritative.

Maintenance Crews

Caltrans has 18 maintenance crews based in its 12 districts. The crews perform joint repairs and concrete repairs. Crew staff is seasonal, operating snow plows in winter and performing maintenance work in summer. Crew members hold general maintenance job titles and are general highway maintenance workers. California has bridge-painting crews, but does not have other dedicated bridge crews.

Paint Crews

Caltrans has 12 bridge-painting crews, six working statewide and six attached regionally to major bridges. The budget for bridge painting is $13 million annually. Caltrans has an inventory of 86 million square feet of painted steel on 846 bridges. Individual bridges that have a large painted area are shown in Table 2.2. DOT crews painted 900,000 square feet of steel in 2006–07. Production is declining, however, because of increasing requirements for containment of painting operations.

Bridge	Paint area (million ft^2)
Bay Bridge (Oakland)	9
Vincent-Thomas	1.6
Richmond – San Rafael	7.2
Carquinez Straits	2.4
Pit River Bridge	3

Table 2.2 *California large painted steel bridges*

All painting crew supervisors are certified by the National Association of Corrosion Engineers[1]. Crew supervisors perform daily quality control (QC) measures, and SMI staff from the Sacramento office conducts periodic quality assurance (QA) reviews.

Caltrans is losing painters to private firms. This is a particular problem in the San Francisco Bay area and in other large urban areas, where large painted steel bridges are located and living costs are high. An experienced DOT painter can join a private firm and earn a higher salary and work in more desirable conditions (i.e., indoors and not at a height).

Training for Maintenance Crews

Caltrans is developing a set of training modules for maintenance crews. The modules are Microsoft PowerPoint sessions and participant quizzes; some include hands-on demonstrations. DOT training will be supported by a written bridge repair guide. Training

[1] http://www.nace.org/

modules will be available on the Internet.

One training module addresses repairs to concrete bridge beams after high-load hits. The module presents three options for repair: concrete placed in forms, concrete applied pneumatically, and concrete placed by hand. The training module presents correct methods for preparation; details for formwork; repairs to reinforcing steel, including welded splices for bars; and placement and finishing of concrete.

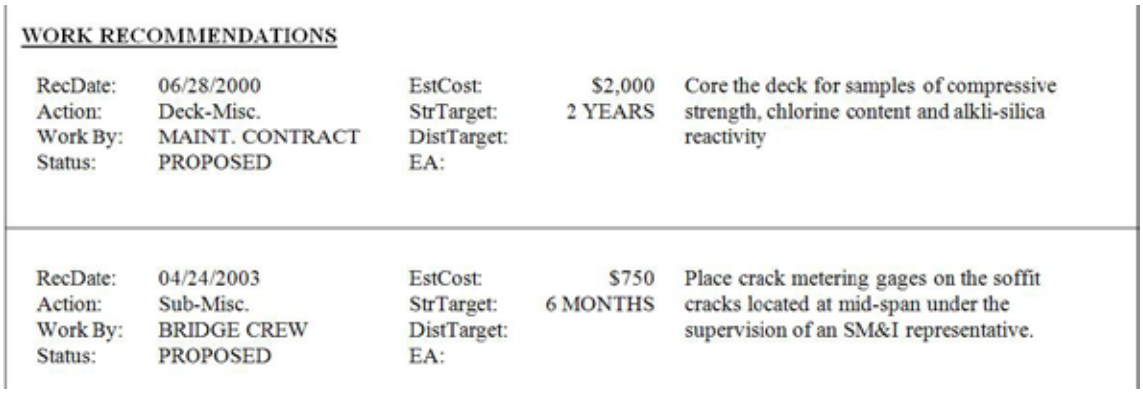
Maintenance Decisions

Identification of Maintenance Needs

SMI bridge inspectors identify maintenance and repair needs during safety inspections. The inspectors identify recommendations for work by standard action number and report costs and priorities for recommendations. They also recommend whether a Caltrans or contract crew should execute the work.

Work recommendations are identified as standard actions in dual numbering systems. One numbering system is used in the BMS and the other in the maintenance management system (MMS) (see Table 2.5 at the end of this section). The matrix of standard actions includes average costs, typical execution, and time to implement the action. Average costs for standard actions are updated annually from actual costs of crew work and contract bid items. Crew fieldwork accomplishments and costs are reported to California's Integrated Maintenance Management System (IMMS).

Inspectors prepare inspection reports using a software application that offers standard work recommendations and priorities from drop-down lists. Work recommendations by safety inspectors have six parts: date, work by, action, estimated costs, target date, and work description (see Figure 2.1). Priorities are shown as recommended time to completion. Times range from emergency to six months to 10 years. Inspectors' recommendations for bridge work can go forward to peer-review meetings for discussion of repair options.



WORK RECOMMENDATIONS

RecDate:	06/28/2000	EstCost:	$2,000	Core the deck for samples of compressive
Action:	Deck-Misc.	StrTarget:	2 YEARS	strength, chlorine content and alkli-silica
Work By:	MAINT. CONTRACT	DistTarget:		reactivity
Status:	PROPOSED	EA:		

RecDate:	04/24/2003	EstCost:	$750	Place crack metering gages on the soffit
Action:	Sub-Misc.	StrTarget:	6 MONTHS	cracks located at mid-span under the
Work By:	BRIDGE CREW	DistTarget:		supervision of an SM&I representative.
Status:	PROPOSED	EA:		

Figure 2.1 *California work recommendations*[2]

[2] Whitfield P, *Types of Bridge Maintenance Work*, 2009, PowerPoint

Maintenance crews make periodic walk-through inspections of bridges and can identify repair needs.

Programming

SMI prepares monthly summaries of work needed at bridges, and DOT districts use this information to develop detailed plans for maintenance work. Districts have access to these summaries and collect lists of work, which they enter into spreadsheets. Local agencies are sent copies of SMI inspectors' recommendations; however, the agencies do not have electronic access to the SMI database and cannot download bridge work lists.

Maintenance contract projects are selected based on SMI assessment of repair feasibility, effect on strength, time required, costs, traffic impacts, and aesthetics. For maintenance projects costing $4 million or more, or when an inspector wants input on recommendations for repairs, a peer-review meeting is held to get input from other inspectors, from designers, and, as needed, from engineers in bridge hydraulics, the geotechnical field, or other areas. Peer input becomes part of the bridge file.

For state-owned bridges, California considers the needs at bridges first, and later determines whether individual projects qualify for federal HBP funds. Local agencies preferentially undertake bridge projects that are eligible for federal funds.

Maintenance work exists in three tiers:

- Crew work (minor repairs)
- Major maintenance contracts (preservation)
- SHOPP contracts (rehabilitation and replacement)

Bridge contracts are either preservation projects or SHOPP projects. Preservation work includes deck treatments, deck repairs, joint repairs, and similar preventive maintenance work. Preservation projects are appropriate for bridges that are not in poor condition or are not structurally deficient or not functionally obsolete. California's SHOPP projects are applied to bridges that are in poor condition or are deficient or obsolete.

For all bridge projects, the SMI central office coordinates with DOT district offices to identify the bridges and projects to execute. SMI identifies the needs and priorities at bridges. The districts identify which projects are feasible and which may be encumbered by environmental or other constraints that will entail significant review and approval.

Improvements to roads and bridges are separate from maintenance and are outside of SMI's scope.

Performance Measures and Priority Indicators

Performance Measures

Caltrans tracks network-level performance measures that include the:

- Number of backlogged bridge projects
- Percentage of bridge element quantities in condition states 1 and 2 (good conditions)
- Number of bridges needing major maintenance projects
- Counts of structurally deficient and functionally obsolete bridges
- Network-average bridge health index
- Count of bridges having a health index below 80 (out of 100)
- Backlog of work directed to DOT maintenance crews
- Number of distressed bridges (A distressed bridge is one that should be rehabilitated or replaced, or that needs work to mitigate scour or seismic vulnerability.)

California's goals for performance measures are shown in Table 2.3.

Attribute	Measure	Goal
Bridge element condition	Network percentage of element quantity in condition states 1 and 2	≥ 85%
Need for major maintenance	Percentage of bridges in network	≤ 10%
Distressed bridges	Percentage of bridges in network	≤ 5%

Table 2.3 *California performance measures and goals*

Priority Indicators

California's priority indicators include bridge health index, vulnerability to scour or seismic hazards, and, for painted steel bridges, the paint health index. California's paint health index is similar to the bridge health index; it indicates the present value of a bridge's coating compared to the value of the coating in perfect condition. California initiates painting projects for bridges with a paint health index below 65 (out of 100).

Optimization of Maintenance Programs: Multi-Objective Priority Ranking

Caltrans applies methods developed in NCHRP 12-67, *Multiple-Objective Optimization for Bridge Management Systems*[3] in the prioritization of SHOPP project candidates. California uses utility functions to combine disparate inputs on bridge condition, vulnerability, and load rating. California finds that SHOPP priorities obtained from the automated process are similar to the ranking provided by SMI's normal process using peer review.

[3] http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=356

Outcomes of Maintenance

Maintenance Tracking

Maintenance crews in districts report completed work as each maintenance need is resolved. Completion of contract work, too, is noted in California's data systems for maintenance needs at bridges.

Reports from crews do not close records for maintenance needs. Instead, bridge inspectors from SMI verify work and report completion. California's data system keeps every work recommendation, along with its status, as completed, programmed, or outstanding. Once identified, work recommendations are tracked from inspection cycle to inspection cycle until they are resolved or rendered inactive (e.g., by bridge modification).

Effectiveness of Maintenance

California tracks the effectiveness of its bridge maintenance program in terms of the number of bridges that transition from the maintenance program to the SHOPP (rehabilitation and replacement) program. The goal is to reduce the annual count of bridges making this transition.

Several years ago, about 40 bridges were transitioning to SHOPP each year. After SMI forecast that an increase in maintenance funds would reduce this number, funds were re-allocated from SHOPP to maintenance and preservation projects. The focus on bridge preservation has been successful. Currently, about 20 bridges per year transition to SHOPP (Figure 2.2).

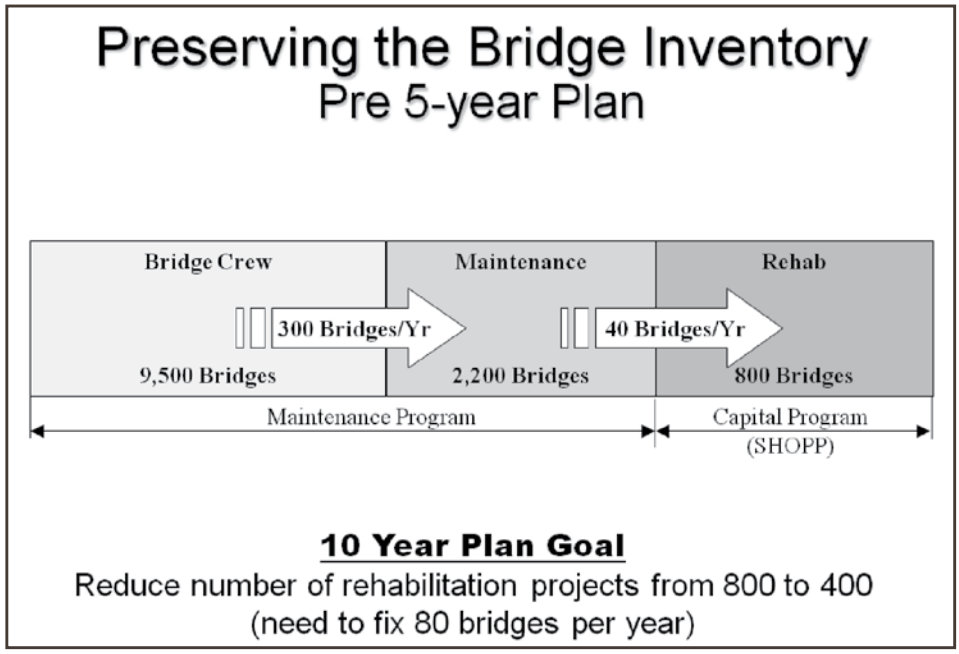


Figure 2.2 *California bridge programs*

Maintenance Budget

California's program for bridge preservation has annual expenditures of $94 million for projects such as joints, deck overlays, sealers, repairs, painting contracts, and emergency work. The SHOPP program is larger, about $300 million annually. The funds for bridge preservation and SHOPP are part of $1.6 billion that is available for maintenance of all transportation assets.

The California Transportation Commission determines the sharing of federal HBP funds between state and local governments. About 55% of federal HBP bridge funding is directed to local agencies. About 75% of federal funds for transportation improvements go to local agencies. Allocations to local agencies are based on roadway lane miles and bridge asset value, among other factors.

The Caltrans Finance Division makes four-year forecasts of funding availability and funding needs. California statute requires that the order of planned allocations be first to maintenance and operations, next to SHOPP, and then to projects for transportation improvements. In recent funding cycles, this process has yielded decreasing funds for improvements.

Data Systems

California uses a set of software applications for bridge inspections, bridge information retrieval, and bridge management. Caltrans districts employ spreadsheets for detailed planning and reporting of maintenance work.

California has a central Oracle database for bridge information that serves as a portal for the structures maintenance Web page, and the software applications Structure Maintenance Automated Report Transmittal (SMART), Bridge Inspection Reporting Information System (BIRIS), and Pontis BMS. California's bridge database is AASHTO BRIDGEWare Plus; that is, BRIDGEWare tables are used, together with additional tables that contain information specific to Caltrans applications.

Spreadsheets

California's central data systems for bridges, inspections, and work recommendations produce workbooks for use in execution of maintenance (see Table 2.4).

Spreadsheet	Content
owfile.xls	Outstanding work recommendations listing of bridges, actions, quantities, costs, and priorities
workrec.xls	Outstanding work recommendations within a specified time period
workdone.xls	Work completed within a specified time period
bridge_los.xls	Evaluation of bridge level of service based on health index and backlog of maintenance work

Table 2.4 *California bridge maintenance spreadsheets*

Structure Maintenance Automated Report Transmittal Application

California's SMART application provides data on bridge inspections, maintenance recommendations and history; channel profiles (for water crossings); utility encroachments; painted area quantities; joint locations, types, and lengths; and records of ultrasonic inspections (for bridges with pins). SMART provides a number of screens (dashboards) displaying sets of information useful to inspectors, bridge maintenance crews, and design engineers.

SMART helps track maintenance work. The progress of each maintenance need from recommendation to completion to verification is set using drop-down lists for work items.

Bridge Inspection Reporting Information System Application

California's BIRIS application is a portal to all design plans, as-built plans, and bridge photographs. BIRIS also reports information on maintenance work completed by DOT crews and by contractors.

Other Data Systems

Other California data systems that use or provide information on bridges and bridge maintenance include:

- **LP2000**: A system for retrieving data on local bridge inventories and conditions; used to support the local-government bridge program
- **IMMS:** The integrated maintenance management system used by DOT maintenance crews to report work production and costs
- **Transportation System Network (TSN)**: A traffic information system used by the bridge database to get roadway data

Materials and Methods

Caltrans presented its experience with deck treatments using high molecular weight methacrylate (HMWM) and deck overlays using polyester concrete.

High Molecular Weight Methacrylate Deck Treatment

Caltrans uses HMWM for deck treatment (see Figure 2.3), filling cracks and improving the freeze-thaw resistance of concrete decks. HMWM is applied to deck top surfaces using squeegees; then sand is broadcast on the HMWM gel as it cures. The finished surface has a skid resistance similar to that of the untreated deck.

Polyester Concrete Overlay Deck Treatment

California uses polyester concrete for deck overlays as thick as 6 inches (see Figure 2.4). Polyester provides an impervious overlay with good skid resistance and good wear resistance. California placed 1.9 million square feet of polyester concrete overlay in one year (2007–2008) and has placed 9.1 million square feet over the last 10 years. California began using polyester

concrete overlays in 1985.

Innovation

California identified three aspects of communication and use of information that help in its maintenance of bridges:

- The California State Bridge Maintenance Engineer receives a daily bulletin noting significant fires, stream flows, and other events that may affect transportation assets. The DOT can deploy staff in anticipation of the routes and regions that may need response.
- SMI meets with contractors for maintenance work to get their input on maintenance projects and methods.
- The Caltrans scour mitigation program makes real-time use of U.S. Geological Survey stream flow data and NEXRAD rainfall data to anticipate high flows in streams. Caltrans also correlates weather data with geographic locations of recent forest burn areas, increasing the estimates of stream and debris flows for these drainages[6].

Figure 2.3 *Deck treatment with HMWM*[4]

Figure 2.4 *Polyester overlay*[4]

Imms action code	Bms action code	Description	Typical esecution	Typical unit cost range	Units	Typ. struct. target
H30020	01	Deck-patch spalls	Bridge crew	$1,300–$2,600	Square feet	2 years
H30030	02	Deck-repair potholes	Bridge crew	$1,300–$2,600	Square feet	2 years
H30012	03	Deck-rehab	Contract	$20.90–$74.32	Square feet	4 years
H30013	04	Deck-resurface	Contract	$2.32–$16.16	Square feet	3 years
H30060	05	Deck-place overlay	Contract	$1.67–$15.51	Square feet	3 years
H30050	06	Deck-methacrylate	Contract	$1.30	Square feet	2 years
H30011	07	Deck-replace	Contract	$55.74–$92.90	Square feet	5 years

[4] Lee M, *Caltrans Guidelines for Treating Bridge Deck Cracks*, 2009, PowerPoint

[5] Lee M, *Caltrans Guidelines for Treating Bridge Deck Cracks*, 2009, PowerPoint

[6] Newton B, *Overview of Structures Maintenance and Investigations*, 2009, PowerPoint

Imms action code	Bms action code	Description	Typical esecution	Typical unit cost range	Units	Typ. struct. target
H30090	09	Deck-misc.	Bridge crew or contract	Varies	Square feet	3 years
H20010	10	Super-patch spalls	Bridge crew	$1,300–$2,600	Square feet	2 years
H20012	11	Super-rehab	Bridge crew or contract	Consult maint design	Square feet	4 years
H20011	12	Super-replace	Contract	$92.90–$167.22	Square feet	5 years
H20013	13	Super-epoxy inject	Contract	$152.40	Linear feet	3 years
NA	14	Super- strengthen	Contract	$900,000	Each	6 years
H20090	19	Super-misc.	Bridge crew or contract	Varies	Each item	4 years
H10010	20	Sub-patch spalls	Bridge crew	$1,300–$2,600	Square feet	2 years
H10013	21	Sub-epoxy inject	Contract	$76.20	Linear foot	3 years
H10012	23	Sub-rehab	Bridge crew or contract	Consult maint design	Each	5 years
H10011	24	Sub-replace	Contract	Varies	Linear foot6/ea	5 years
NA	25	Sub-scour mitigate	Bridge crew or contract	Consult hydraulics	Each	2 years
H10040	26	Sub-nav. Protect	Contract	Varies	Each location	3 years
H10090	29	Sub-misc.	Bridge crew or contract	Varies	Each item	4 years
H40010	30	Joint seals–repair/clean	Bridge crew	$47.55–$82.30	Feet	2 years
H40012	31	Joint seals–rehab	Contract	$473–$915	Feet	3 years
H40011	32	Joint seals–replace	Bridge crew or contract	$47.55–$82.30	Feet	3 years
		Joint–asphaltic plug	Contract	$260	Feet	
		Expansion dam	Contract	$153	Feet	
H41050	40	Bearings–clean	Bridge crew	$300	Each	2 years
H41013	41	Bearings–reset	Bridge crew or contract	$2,500–$5,000	Each	2 years
H41012	42	Bearings–rehab	Bridge crew or contract	Consult maint design	Each	2 years
H41011	43	Bearings–replace	Contract	Varies	Each	3 years
H31080	50	Appr. slab–mudjack	District	$360	Each slab/lane	2 years
NA	51	Appr. slab–repair	District	$840	Each slab/lane	2 years
H31060	52	Appr. slab–overlay	District	$1.67–$15.51	Square feet	3 years
H31011	53	Appr. slab–replace	District	$17,000	Each slab/lane	4 years
H50010	60	Railing–repair	Bridge crew	$1,300–$2,600	Feet	2 years
H50012	61	Railing–rehab	Contract	$46–$610	Feet	2 years
H50011	62	Railing–replace	Contract	$78–$101	Feet	5 years
NA	69	Railing–misc.	Bridge crew or contract	Varies	Each item	2 years

Imms action code	Bms action code	Description	Typical esecution	Typical unit cost range	Units	Typ. struct. target
H91040	70	Seismic–retrofit	Contract	Varies	Each site	4 years
H91010	71	Seismic–maintenance	Bridge crew or contract	$2,500–$5,000	Each location	2 years
NA	79	Seismic–misc. repair	Bridge crew	Varies	Each item	2 years
H90011	80	Bridge–replace	Contract	$177–$214	Square feet	7 years
NA	81	Bridge–rehab	Contract	$93	Square feet	5 years
NA	82	Bridge–collision damage	Bridge crew or contract	$15,000–$200,000	Each	1 year
NA	83	Bridge–paint ID	Bridge crew	$500	Each location	2 years
NA	84	Bridge–widen	Contract	$186	Square feet	5 years
NA	89	Bridge–misc.	Bridge crew or contract	Varies	Each item	2 years
H70060	90	Paint–rigging/contain	Paint crew	Varies	Each set-up	3 years
H70061	91	Paint–spot prep/spot paint	Paint crew	$5–$6	Square feet	3 years
H70062	92	Paint–spot prep/ full paint	Paint crew or contract	$7–$10	Square feet	4 years
H70063	93	Paint–full prep/full paint	Paint crew or contract	$31–$35	Square feet	5 years
H70069	99	Paint–misc activities	Paint crew	Varies	Each occurrence	2 years
NA	MA	Mech/elect–clean	M&E crews	Varies	Each location	
H80010	MB	Mech/elect–repair/adj.	M&E crews	Varies	Each set-up	
H80012	MC	Mech/elect–rehab/ upgrade	M&E crews	Varies	Each set-up	
H80011	MD	Mech/elect–replace	M&E crews	Varies	Each set-up	
NA	ME	Mech/elect–monitor/ test	M&E crews	Varies	Each set-up	
H80090	MZ	Mech/elect–misc.	M&E crews	Varies	Each item	

Table 2.5 *California maintenance actions*[7]

[7] *Bridge Action Matrix*, California Department of Transportation, 2009, Excel spreadsheet

California Department of Transportation *Structure Maintenance and Investigations*

California Bridge Action Summary *Sorted by No. of Recommendations*

Action	Number of Recommendations	Sum of Costs	Minimum Value	Maximum Value	Average Cost	Percent of All Work
06 - Deck-Methacrylate	3443	$88,052,295	$0	$1,499,700	$33,958	4.58
89 - Bridge-Misc	2667	$8,060,411	$0	$2,500,000	$6,591	0.42
32 - Joints-Replace	2133	$29,194,584	$0	$1,600,000	$16,292	1.52
60 - Railing-Repair	2044	$3,338,130	$0	$480,000	$2,853	0.17
83 - Bridge-Paint ID	1817	$1,163,545	$0	$250,000	$780	0.06
25 - Sub-Scour Mitigate	1676	$107,772,643	$0	$15,500,000	$152,869	5.60
87 - Bridge-Install Sign	1519	$885,700	$0	$125,000	$822	0.05
29 - Sub-Misc.	1448	$6,378,510	$0	$1,500,000	$9,694	0.33
62 - Railing-Upgrade	1168	$264,185,452	$0	$4,615,000	$239,733	13.74
01 - Deck-Patch spalls	1108	$3,735,520	$0	$565,000	$4,109	0.19
RV - Remove Vegetation	1108	$618,358	$0	$80,000	$1,347	0.03
10 - Super-Patch spalls	856	$2,014,790	$0	$156,000	$3,637	0.10
09 - Deck-Misc.	850	$10,325,971	$0	$2,811,000	$24,014	0.54
20 - Sub-Patch spalls	693	$3,024,910	$0	$800,000	$6,519	0.16

Table 2.6 *California bridge action summary* [8]

[8] *Bridge Action Summary,* California Department of Transportation, 2009, PDF file

CHAPTER 3

El Dorado County, California

The scan team met with Matthew Smeltzer, Deputy Director of the Design Division of the El Dorado County (California) DOT.

El Dorado County defines maintenance to include repair and rehabilitation of bridges and culverts. Maintenance is intended to preserve and extend the service life of assets. Preventive maintenance, in particular, includes work activities such as deck repair, deck resurfacing, lubrication and rust protection, bridge painting, and slope and soil stabilization.

Steel structures and timber structures receive cyclic maintenance actions, such as spot painting, lubricating, and bolt tightening. Concrete structures receive demand (i.e., defect-related) maintenance.

Bridge Maintenance Program

Inventory

El Dorado County has an inventory of about 300 bridges and culverts (see Table 3.1). The county has roads at elevations ranging from 1,100 to 6,000 feet above sea level. In addition to NBI-eligible spans, El Dorado County inspects and keeps basic inventory data on culverts with spans of less than 20 feet.

County or locally owned highway bridges > 20 feet	95
County or locally owned highway bridges ≤ 20 feet	~ 90
Pipes, smaller culverts ≤ 20 feet	~ 90
Pedestrian bridges	4
Earth-retaining structures (i.e., retaining walls)	20

Table 3.1 *El Dorado County structures inventory*

Maintenance Goals

El Dorado DOT completes repairs and preventive maintenance work within annual budget constraints. It also keeps a prioritized list of work needs, completing as much of this work as the budget allows.

Maintenance Execution

County crews perform minor maintenance activities. Projects that require more than a month of crew time and projects that are expensive are executed by contract.

Maintenance Staffing Levels, Training, and Longevity

El Dorado County DOT has four staff engineers with bridge design experience. This group is available for bridge projects, but is also responsible for other structural assets. The group's staff manages right-of-way and encroachment issues, environmental studies, and permits. For some projects, consultants are engaged to meet environmental review and compliance requirements. El Dorado County has standing task order agreements for consultant services.

El Dorado County DOT has one bridge maintenance crew. The supervisor has bridge construction experience and has been employed by the county for more than 20 years. The bridge crew has four members, who are trained in bridge inspection, hazardous chemical handling, and the use of climbing gear, among other topics.

Maintenance Decisions

Identification of Maintenance Needs

El Dorado County DOT collects inspection information with recommendations for work at bridges from both the state DOT and county DOT staff. County DOT bridge engineers review work recommendations, and county DOT engineers and field maintenance staff meet regularly to review work needs at bridges. The county DOT semiannually reviews needs in bridge preventive maintenance, rehabilitation, and replacement.

Programming Process

El Dorado County uses its bridge crew to perform maintenance projects that can be completed in fewer than 30 days at one site; larger projects are performed by contract. Preventive maintenance work, such as deck treatments and joint repairs, are applied to bridges in relatively good condition. Bridge rehabilitation projects are applied to structures with a sufficiency rating greater than 50. Bridge replacement projects are considered for bridges with a sufficiency rating less than 50.

Priority Indicators

El Dorado County DOT tracks NBI sufficiency ratings, bridge health indexes, and vulnerabilities to scour or seismic hazards to determine appropriate projects for bridges. The county uses a priority formula, implemented in a spreadsheet, to obtain combined scores of deck conditions, scour vulnerabilities, structural defects, potential extensions to service life, and critical flaws. These scores, together with the bridges' status as structurally deficient or functionally obsolete, determine the kinds and rankings of projects.

Outcomes of Maintenance

Maintenance Tracking

Maintenance crews for El Dorado County keep paper records of work needs and work completion. Work by county crews is not reported to Caltrans; instead, state DOT inspectors will observe completed work at the next inspection interval. Contract work that includes the use of state and/or federal funds is reported to Caltrans as work is completed.

Effectiveness of Maintenance

El Dorado County DOT's engineers and maintenance crews meet regularly to discuss maintenance methods and products, among other topics.

Maintenance Budget

The state or federal government provides most of the funding for the county's bridge projects. To access these funds, El Dorado County follows the procedures of the Caltrans Division of Local Assistance. County funds directed to bridge maintenance are about $200,000 per year.

CHAPTER 4

Placer County, California

Placer County is located in northeastern California and extends west to the suburbs of Sacramento and east to Lake Tahoe. County population is currently 333,000. Placer County has one of the highest rates of population growth in California.

Placer County's Department of Public Works is responsible for roads and bridges, among other county assets. For bridge maintenance, Placer County depends on Caltrans for technical expertise and on the federal government for funding. Together with Caltrans, Placer County Department of Public Works staff are engaged in all phases of bridge projects, including development, programming, environmental review, right-of-way, public input, design, and construction.

Maintenance Definitions

Placer County defines two categories of maintenance work. Type 1 maintenance, which is performed by Placer County maintenance crews, includes minor work at bridges, such as patching, signage, brush and debris removal, and emergency work. Type 2 maintenance, which is performed by contractors, includes bridge rehabilitation and replacement projects funded by the U.S. Federal Highway Bridge Program.

Type 1 and Type 2 maintenance differ in project scope and cost. Larger, more costly projects are Type 2, and smaller, less expensive projects are Type 1. While a deck replacement is more often a Type 2 project, it could be a Type 1 project on a small bridge.

Preventive maintenance includes deck crack repairs, deck treatments, bridge painting, bridge railing repairs, erosion control, and installation of scour countermeasures. These projects are funded through the Caltrans Division of Local Assistance and are applied to bridges in good condition with sufficiency ratings of 80 or higher.

Bridge preservation projects include deck treatments, deck replacements, and joint repairs and replacements.

Maintenance Manual

For bridge inspection, construction, and maintenance, Placer County uses manuals produced by FHWA and by Caltrans. Placer County follows the screening and ranking procedures for bridge projects published by the Caltrans Division of Local Assistance[9].

[9] http://www.dot.ca.gov/hq/LocalPrograms/lam/lapg.htm

Placer County is developing a bridge maintenance manual that will show typical bridge details and methods for bridge maintenance. County maintenance crews will use this manual for routine and minor maintenance projects. It will show commonly used repair methods and outline the requirements of Placer County's agreement with the California Fish and Game Department regarding water quality and periodic maintenance.

Bridge Maintenance Program

Bridge Inventory

Placer County's bridge inventory is shown in Table 4.1. Of the bridges, 40 are structurally deficient or functionally obsolete. The average age of bridges is 58 years, and the average daily traffic is 1,300 vehicles. Most county bridges are concrete, though Placer County has two significant steel bridges. One is a steel deck truss that crosses a 750-foot-deep valley; the other is a suspension bridge.

County-owned highway bridges > 20 feet	115
County-owned highway bridges ≤ 20 feet	40
Pipes, smaller culverts ≤ 20 feet	2,000
Pedestrian bridges	0
Railroad bridges	0
High mast lights	0
Overhead sign structures	0
Traffic lights	27
Earth-retaining structures (i.e., retaining walls)	0
Tunnels	1

Table 4.1 *Placer County structures inventory*

Placer County collects inventory and condition data for its short bridges. Over time, the county became the custodian of bridges that were built by the local water district or by Pacific Electric and Gas.

Engineering Design Review

Licensed professional engineers design and stamp structural repairs or other work that affects bridge safety features or bridge load capacity and will be performed by county work crews. All projects performed by contractors have stamped design documents.

Maintenance Goal

Placer County's maintenance goal is to preserve the integrity and safety of county-owned roads and bridges.

Maintenance Execution

County crews perform Type 1 maintenance, consisting of minor repairs and emergency work. Type 2 maintenance, consisting of bigger and more costly projects, is performed by

contract and most often involves the use of federal funds and the participation of the state DOT Division of Local Assistance. Type 1 maintenance is directed by a work order system within the county. Type 2 maintenance is a part of the county's overall bridge program and is coordinated with Caltrans.

Maintenance Staffing Levels, Training, and Longevity

Placer County Department of Public Works has a County Bridge Engineer who manages all bridge work and is supported by a staff that includes 13 engineers, a CADD technician, and the bridge project crew. The county bridge engineer is a registered professional engineer and an NBI-qualified bridge inspector. The county bridge engineer is engaged in bridge maintenance, bridge replacement, bridge rehabilitation, and projects for bridge seismic retrofit.

Generally, the engineering staff is engaged in projects for signals, signs, lights, sidewalks, and roads. The county bridge project crew has a crew superintendent and five or six road maintenance workers.

Maintenance Decisions

Identification of Maintenance Needs

Placer County relies on the bridge inspection reports provided by Caltrans to identify work at bridges. Some work is identified by road maintenance crews or by public input (i.e., complaints). The county bridge engineer and county road crews make periodic field reviews of bridges.

Communication of Needs

Placer County engineering staff reviews the work recommendations in the Caltrans bridge inspection reports. County engineers consider recommendations, examine budgets, and send work orders to the county maintenance crews, and the crew supervisors develop detailed work plans based on the work orders.

Programming Process

Placer County accesses federal funds for bridge preventive maintenance through the Caltrans Division of Local Assistance. Caltrans has a formal screening and prioritization process for bridge preventive maintenance projects.

Smaller, less costly projects are funded by Placer County at the discretion of the county road commissioner, who is the director of county public works. The commissioner works with the county's bridge engineer to identify bridge projects. County funds for bridge projects are a portion of the county's share of the state motor fuels tax.

Maintenance Programming Administration

Decisions on maintenance programming are made at the central office of the Placer County Department of Public Works. Each year, county engineers prepare a list of preventive

maintenance and general maintenance projects. Internally, the county bridge engineer prepares the project list and the director of public works approves it and then submits it to the county chief executive officer and the county board of supervisors for budget approval.

Permits - Environmental

Placer County maintains an agreement with the California Department of Fish and Game for in-stream work and has a countywide National Pollutant Discharge Elimination System permit for road maintenance work.

Priority Indicators

Priorities for maintenance projects depend on the work programming category (i.e., programmed through Caltrans or programmed as Placer County discretionary projects).

The Caltrans Division of Local Assistance screens and ranks projects funded through Caltrans. A spreadsheet method that combines NBI condition data, NBI appraisal data, element-level smart flags, and average daily traffic is used to rank projects funded directly by Placer County.

Outcomes of Maintenance

Maintenance Tracking

Placer County collects work recommendations from Caltrans inspection reports and enters them in a county spreadsheet, along with work completion, by crews or by contract. County engineers make field reviews of completed work. Twice a year the spreadsheets are updated and reviewed for new, completed, and outstanding work recommendations.

For most county-funded work, completion is not reported to Caltrans; state DOT inspectors make independent observations in the next inspection cycle. For major repairs and for all work entailing federal funds, the county makes formal reports of completion to Caltrans. These reports go to the DOT ABME and, for federal-share projects, to the DOT Division of Local Assistance.

Effectiveness of Maintenance

Placer County relies on information from the Caltrans ABME and the DOT Division of Local Assistance on the effectiveness of various maintenance methods.

QC and QA of maintenance work consist, at least, of field reviews by county engineering staff of completed work and of crew work in progress. For larger projects, typical construction procedures for prequalification, sampling, and evaluation of materials and methods are applied.

Maintenance Budget

Place County's annual budget for public works ranges between $80 million and $100 million. The annual budget for the bridge program ranges between $10 million and $17 million. Bridge maintenance is funded at about $1.2 million per year.

Placer County contributes 12.47% of total costs to projects that qualify for federal funds through the Caltrans Division of Local Assistance. Because of this leverage, the county favors federally eligible bridge projects, and a large portion of the county's bridge budget is derived from federal funds.

Data Systems

Placer County uses data from bridge inspections performed by Caltrans staff in a spreadsheet to list, schedule, and track maintenance needs at bridges. The country bridge engineer maintains the spreadsheet, which is used by county staff only.

CHAPTER 5

Delaware

The scan team met with Delaware DOT (DelDOT) staff that included the bridge maintenance engineer, bridge management engineer, bridge crew foremen, district maintenance supervisors, and district contract administrators. In addition, FHWA bridge engineers for Delaware and Maryland participated in the meeting in Delaware.

DelDOT is organized as a central office, four districts, and 16 inspection zones. Bridge inspections, recommendations for bridge work, and prioritization of bridge projects are all handled in the DOT central office.

DelDOT's central Division for Maintenance and Operations has a section for bridge management that keeps the bridge inventory database, performs bridge load ratings, processes overweight permits, operates the Pontis BMS, and determines priorities for bridge maintenance projects.

DelDOT's bridge design group manages projects for bridge rehabilitation and replacement, handling projects for bridge painting, scour remediation, and preventive maintenance. District contracts for maintenance provide repairs, treatments, component replacements, and painting. District crews perform minor repairs and replacement of pipe culverts (see Table 5.1).

Execution of work	Actions
Bridge design group (central)	Rehabilitations and replacements; projects having larger scope of work, maintenance of traffic, erosion control, right-of-way, or public involvement
Bridge management group (central)	Painting, scour remediation, pile jacket projects; recommendations for replacements
District structures maintenance contracts	Concrete repair, painting structural steel, joint replacement, bearing replacement, bridge deck overlay, pile rehabilitation, and scour repairs
District crews	Preventive maintenance and minor repairs, scour repairs, and pipe culvert replacements

Table 5.1 *Delaware bridge work categories* [10]

Preventive maintenance activities include washing, lubrication, deck treatments, deck overlays, joint repairs and replacements, steel painting, bearing repairs and replacements, and retrofits for seismic and scour vulnerabilities.

[10] Finney D and Weber C, *Domestic Scan Tour – Best Practices in Bridge Management Decision Making*, Delaware Department of Transportation, 2009, PowerPoint

Bridge Maintenance Program

Inventory

DelDOT has an inventory of about 1522 bridges and culverts (see Table 5.2); of these, 825 structures are NBI-length. Delaware inspects all structures with at least 5-foot span and 20-square-foot hydraulic opening. For structures shorter than 20-foot span, Delaware uses inspection intervals longer than 24 months. There are 686 bridges (all span lengths) and 836 culverts (all span lengths). A bit more than 50% of the state-owned bridge population is steel.

State-owned highway bridges > 20 feet	825
State-owned highway bridges ≤ 20 feet	697

Table 5.2 *Delaware National Bridge Inspection Standards bridges*

Few bridges in Delaware are locally owned. One toll authority owns 20, municipalities own seven, and the Delaware Department of Natural Resources (i.e., parks) owns some.

Maintenance Execution

Crew Work

DOT districts assign maintenance work to their crews on a case-by-case basis, consistent with crew capability and availability.

Contract Maintenance

DelDOT keeps open-ended contracts for maintenance activities. Contracts have schedules of standard items for bridge maintenance work. Contracts have a fixed three-year duration and a fixed maximum cost, but no specified quantities for items at the time of award. Each year, DelDOT identifies the items and quantities committed to each contract.

Maintenance Staffing Levels, Training, and Longevity

The central office for bridge management at DelDOT has a staff of 11 people. The staff comprises a bridge maintenance engineer, a bridge management engineer, three two-person inspection teams, an inspection supervisor, a structural engineer who performs bridge load ratings, and an assistant to the structural engineer. The central office operates the BMS and prepares programs for bridge maintenance work.

Maintenance Crews

Each DOT district has a six-person bridge crew that works on structures generally, and is responsible for maintenance of building facilities and highway bridges. The job title for crew members is physical plant maintenance technician. All of these technicians are equipment operators; those who have skills in mechanical maintenance, plumbing, or welding receive wages at one pay grade higher than that of a general physical plant maintenance technician.

DOT crews perform minor repairs to bridges and sign structures, do painting and graffiti

removal, replace culverts, and perform maintenance for movable bridges.

Contract Managers

Each DOT district has two or three staff members to manage bridge contracts. Managers are engineers or inspection personnel and usually have duties in addition to contract management. Design documents are developed in the DOT central office. Maintenance contracts managed in districts provide for repairs to drains and guardrails, patching of concrete surfaces, and microsurfacing for decks.

Maintenance Decisions

Inspections

DelDOT's central office manages bridge inspections; The DOT performs 650 bridge inspections per year. Consultants perform the 50 to 100 bridge inspections that have significant demands in access or traffic control. Consultants also perform all inspections for electrical and mechanical equipment for movable bridges.

Identification of Needs

Needs for maintenance work are derived from bridge inspection reports. Work intended for DOT crews is identified as one among nine standard maintenance actions listed in Maximo, Delaware's MMS (see Table 5.3). Other maintenance needs are determined from condition ratings and the inspection report narratives.

■ Removal of vegetation and debris when affecting the bridge
■ Repair of erosion and placement of erosion control measures when the bridge is affected (Condition State 2 or worse) (Element #364)
■ Repair of deck, slab, and approach slab spalls (Condition State 2 and top surfaces only)
■ Repair of asphaltic concrete (AC) overlay (Condition State 2 only) (Element #11) or repair of hot mix (any condition state) over culvert, slab under fill, filled arch or approach slab, or hot mix wedge placement to account for settlement at the ends of bridges
■ Cleaning out of scuppers and/or drains
■ Cleaning/clearing of weep holes in prestressed (PS) concrete box beams
■ Cleaning/flushing of bearings/bearing seat (use when debris may cause deterioration of bearing or bearing seat)
■ Application of protective coating – deck (when element #358 is Condition State 2 or worse), parapets, sidewalk, or approach slab (used to seal minor cracks; specify coating material to be used)
■ Sealing of joints in concrete slope paving and/or between the slope paving and the abutment or wing wall

Table 5.3 *Delaware Maximo maintenance actions*

Delaware's central office compiles the list of needed maintenance work and sends suitable work items to districts. That is, the central office examines work needs in the context of the work capabilities in each district. Districts begin with this list and develop detailed work plans for crews and for contract maintenance.

Communication

Delaware is a small state with a small bridge inventory, which makes central management of inspection and maintenance possible. Delaware's bridge inspection program manager, bridge maintenance engineer, and bridge management engineer are all located in a single building, making it easy for them to meet and discuss bridge items needing attention.

Maintenance Priorities

Recommendations by bridge inspectors for maintenance work become work orders for DOT crews. The orders are stored in the Maximo MMS. Work orders have associated priorities (see Table 5.4), and districts generally complete work orders with the highest priority first.

Maximo priority	Actions
3	Removal of vegetation and debris Repair of erosion and placement of erosion control measures
2	Repair of deck, slab, and approach slab spalls Repair of AC overlay or repair of or hot mix over culvert, slab under fill, filled arch or approach slab, repair of hot mix wedge placement to account for settlement at the ends of bridges Cleaning out of scuppers and/or drains
1	Cleaning/clearing of weep holes in PS concrete box beams Cleaning/flushing of bearings/bearing seat Application of protective coating to deck, parapets, sidewalk, or approach slab Sealing of joints in concrete slope paving and/or between the slope paving and the abutment or wing wall

Table 5.4 *Delaware Maximo action priorities*

Maintenance Programming

DelDOT's central maintenance and operations office develops bridge projects and checks with DOT programmers to determine whether funds are available.

Bridges are identified and ranked for major projects based on a system of deficiency points (see Figure 5.1). Once each year, DOT maintenance and design staff meets to compute and review

deficiency points. Bridges that need major work are identified, and each bridge is designated as either a maintenance project or a design project. Delaware's design division handles bridge rehabilitations and replacements. The state's maintenance and operation division handles bridge preventive maintenance, painting, and scour remediation projects.

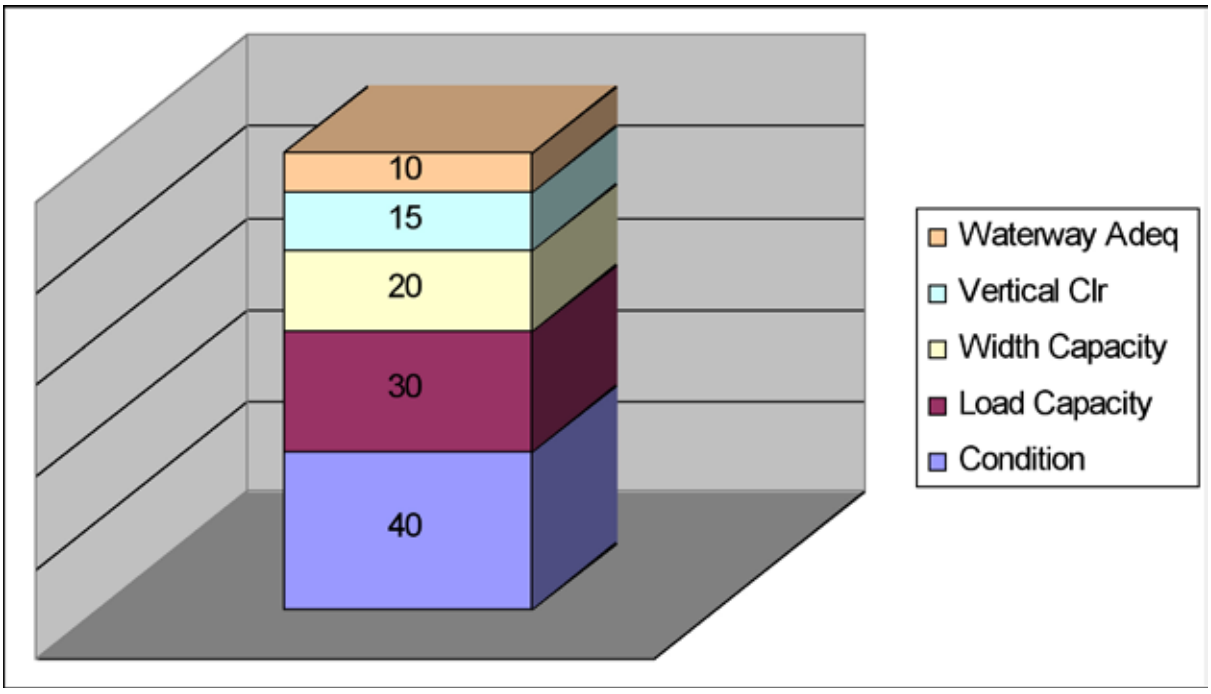


Figure 5.1 *Delaware deficiency weights*[11]

Delaware prioritizes bridges, not work activities. Once a bridge is selected for programming, all necessary repairs at the bridge are scoped and executed.

DOT districts perform maintenance projects using crews or contracts, as appropriate. Delaware's central DOT office assigns maintenance projects to districts, which execute these projects in the general ranking of deficiency points. The number of projects completed is limited by available crews and funding.

Maintenance Programming Administration

Performance Measure

Delaware tracks the network percentage of structurally deficient bridges as a performance measure.

[11] *DelDOT Bridge Management System*, Delaware Department of Transportation, 2009, PowerPoint

Priority Indicator: Deficiency Formula

Delaware uses a formula for deficiency points to establish work priorities among bridges. This deficiency formula combines a health index, structural condition rating, structural deficiency, benefit/cost ratio, load capacity, width capacity, vertical clearances, waterway adequacy, functional class, detour length, average daily traffic (ADT), historic significance, and vulnerabilities (e.g., scour and fracture of critical members). Deficiency is reported on a 0 to 100 scale, much like the NBI sufficiency rating (see Figure 5.1).

Outcomes of Maintenance

Work completed by DelDOT crews is tracked in Maximo, an MMS. Bridge inspectors make work recommendations as standard actions in Maximo. Work orders, created in response to recommendations, are stored in Maximo and executed by DOT crews, which report work completion to Maximo.

Maintenance Budget

Delaware's budget for structures maintenance includes $1.5 million per year for contract maintenance, $1 million per year for scour remediation, and $1 million per year for bridge painting.

Allocations to DOT districts are general maintenance funds. Districts decide how to apply funds for bridges and other assets.

Bridge Preservation

DelDOT's formula for deficiency points is the basis for identification of candidates for preventive maintenance projects. Delaware has an agreement with the FHWA for the use of HBP funds for preventive maintenance. Eligible work items are listed in Table 5.5.

■ Concrete spall repair
■ Painting of steel
■ Deck overlay w/concrete
■ Deck overlay w/epoxy
■ Replace AC overlay and add waterproofing
■ Joint replacement/repair
■ Repair/replace joint trough and piping
■ Concrete crack sealing
■ Pile jackets (nonstrengthening)
■ Re-point masonry
■ Clean and restore paint/coating (cables)

Table 5.5 *Delaware preventive maintenance actions*

■ Clean, paint, and grease bearings
■ Replace bearings
■ Waterproofing membrane (concrete and timber decks/slabs)
■ Concrete sealing
■ Power wash – steel
■ Power wash – concrete decks
■ Power wash – bearing and bearing seats
■ Lubricate bearings
■ Drill weep holes in PS box beams/slabs
■ Scour countermeasures
■ Seismic retrofit
■ Safety enhancements

Table 5.5 *Delaware preventive maintenance actions (continued)*

Data Systems

Until recently, Delaware used Pontis, its BMS, only to store element-level inspection data. Delaware now has developed its preservation model sufficiently that model outputs are similar to the recommendations that DOT engineers would make. In this development, Delaware modified some bridge elements, making condition state language match available work activities. DelDOT has performed element-level inspections of its bridges since 1994. Delaware has also developed an in-house *Element Data Collection Manual*[12].

[12] *Element Data Collection Manual*, Delaware Department of Transportation, 2008, 66 pp

CHAPTER 6

Florida

The scan team met with the Florida DOT (FDOT) Division of Maintenance and its group for bridge operations (see Figure 6.1). FDOT has eight districts: seven are geographic, and the eighth is Florida's Turnpike Enterprise (see page 54). The DOT central office provides planning and administration and develops policy. FDOT districts perform the operations (i.e., the selection and execution of maintenance work for bridges). FDOT districts are autonomous and operate within policies set by the DOT central office.

Figure 6.1 *Florida Department of Transportation* [13]

Maintenance Catagories

FDOT defines maintenance as the preservation of a structure, including all its appurtenances, in original condition or as subsequently improved. Maintenance includes any activity intended to sustain an existing condition or to prevent deterioration. Examples include cleaning, lubricating, painting, and application of protective systems.

[13] Paredes MA, *Florida's Approach to Bridge Preservation for New Structures*, Florida Department of Transportation, Corrosion Research Lab, 2009, PowerPoint

Florida identifies categories (see Table 6.1) of preventive maintenance, routine maintenance (see Table 6.2), and periodic maintenance. Preventive maintenance activities include deck cleaning, operation of cathodic protection systems, and general upkeep of systems for movable bridges. Routine maintenance includes most minor repairs. Periodic maintenance activities are major repairs, joint replacements (see Figure 6.2), deck treatments, and deck overlays.

Category	Note
Preventive Maintenance	Cleaning, cathodic protection systems, and systems for movable bridges
Routine Maintenance	Performing prescheduled maintenance and repair activities for deck joints, decks, railings, superstructures, channels, electrical systems, mechanical systems, and movable structures
Periodic Maintenance	Restoring bridge to original condition via movable systems rebuild, deck major repair, superstructure or substructure major repair, paint system replacement, deck joint replacement, deck/slab overlay, scour countermeasure application, or fender repair replacement

Table 6.1 *Florida maintenance categories*

Action ID	Action title and unit
805	Bridge Joint Repair (LF)
806	Bridge Deck Maintenance and Repair (LF)
810	Bridge Handrail Maintenance and Repair (LF)
825	Superstructure Maintenance and Repair (MH)
845	Substructure Maintenance and Repair
859	Channel Maintenance (MH)
861	Routine Bridge Electrical Maintenance (MH)
865	Routine Bridge Mechanical Maintenance (MH)
869	Movable Structure Maintenance (MH)

Table 6.2 *Florida maintenance actions*[14]

Figure 6.2 *Florida joint replacement*[15]

[14] *FDOT Bridge Work Orders,* Florida Department of Transportation, 2009, PowerPoint

[15] Campbell KB, *Bridge Repair and Rehabilitation Program,* Florida Department of Transportation, 2009, PowerPoint

Rehabilitations are performed to bring bridges up to current standards and use state and federal funds. Bridge repair and rehabilitation projects are reactive and based on information from bridge inspection reports. Repairs are assigned by district bridge maintenance offices and paid for only with state funds. Repairs often include activities such as pile jacketing and the addition of corrosion control systems.

Maintenance Goals

FDOT's goals for maintenance are expressed in its network-level performance measures. Its goals include prompt completion of maintenance work orders, preservation of bridges in good condition, and timely improvements to structurally deficient and weight-restricted bridges.

Documents

FDOT publishes maintenance work methods in its *Bridge Maintenance and Repair Handbook*[16].

Bridge Maintenance Program

FDOT has an inventory of about 5,600 NBI-length bridges and culverts. Local agencies and toll authorities own about 6,000 other bridges. In addition to highway bridges, FDOT inspects traffic signal mast arms, high mast lights, and overhead sign structures (see Table 6.3).

State-owned highway bridges > 20 feet	5,462
Toll-authority-owned highway bridges > 20 feet	1,087
County- or locally owned highway bridges > 20 feet	4,953
Other highway bridges > 20 feet	148
County- or locally owned highway bridges ≤ 20 feet	27
Pipes, smaller culverts ≤ 20 feet	138
Pedestrian bridges	94
Railroad bridges	37
High mast lights	2,816
Overhead sign structures	5,531
Earth-retaining structures (i.e., retaining walls)	1
Tunnels	1

Table 6.3 *Florida structures inventory*

[16] *Bridge Maintenance and Repair Handbook,* Florida Department of Transportation, no date, 202 pp

Maintenance Execution

Florida uses DOT crews, site contracts, and asset maintenance (AM) contracts to execute maintenance work for bridges. Florida allocates work roughly as 20% to DOT crews, 40% to site contracts, and 40% to AM contracts.

Asset Maintenance Contracts

AM contracts are performance-based and provide for open-ended execution of standard maintenance work activities. Contractors are paid monthly based on the quantity of work items completed. DOT districts perform QA reviews on AM contractor work. The Southwest District executes all of its maintenance work orders using an AM contractor.

Maintenance Staffing Levels, Training, and Longevity

Staff in Florida's maintenance program includes bridge inspectors, inspection supervisors, load raters, project managers, structure maintenance engineers, repair managers, field coordinators, crew supervisors, crew members, CADD technicians, and document specialists. Job titles, certifications, and staff numbers in FDOT's maintenance program are shown in Table 6.6 at the end of this section.

Maintenance Crews

Seven DOT districts have maintenance yards and maintenance crews. Florida's Turnpike Enterprise has no maintenance crews. One district has a special bridge crew, and three districts have heavy bridge crews that are able to perform major repairs. Other districts have maintenance crews that do bridge work, but are not specialized to bridges. Each district's maintenance engineer is the overall supervisor of the district's crews. For Florida's Turnpike Enterprise, the maintenance engineer is a coordinator of contract maintenance activities.

DOT bridge crews typically include a supervisor, a welder, an equipment operator, and two laborers. Staff with additional skills, such as carpentry or concrete finishing, and additional staff for traffic control are deployed with crews as needed.

Maintenance Decisions

Identification of Maintenance Needs

Bridge inspectors recommend maintenance work as part of routine safety inspections. Feasible Action Review Committees (FARCs) review inspectors' recommendations in DOT districts. FARC members include district structural engineers, project managers, bridge inspectors, and representatives of maintenance crews, maintenance yards, and AM contractors. FARCs meet once or twice each week.

Programming

FARCs decide which work recommendations to execute and assign priorities to recommendations (see Table 6.4). Selected work recommendations are entered into Florida's Bridge Work Order Library. In turn, work orders are assigned and completed. Each district's

FARC handles recommendations from 10 to 20 bridge inspections per week. Work orders are issued within 30 days of completion of bridge inspections and can have a required time for completion from 60 days to no fixed deadline. Work orders are tracked by Florida's MMS.

Priority	Completion time
1 Emergency	Completed within 60 days of issue
2 Urgent	Completed within 180 days of issue
3 Routine	Completed within 365 days of issue
4 Informational	None

Table 6.4 *Florida priorities for maintenance needs*

Needs for emergency maintenance work do not go to FARCs for review. When a need for emergency maintenance work is discovered or has been caused by an extreme event, the bridge maintenance office is notified immediately and action is taken to stabilize the bridge. Florida uses fast-response contracts, limited to $120,000, for emergency response. Fast-response contracts are awarded after obtaining quick cost quotes from a few qualified contractors. If the needed repairs cost more than $120,000, larger awards can be made after a declaration of emergency. The DOT's central maintenance director, the DOT general counsel's office, and the secretary of the DOT must approve a declaration of emergency.

Bridge Work Plan

In addition to its maintenance work order system, FDOT develops bridge work plans annually for larger projects. DOT districts, and specifically district structures maintenance engineers, make programming decisions for major repairs, rehabilitations, and replacements of bridges. FDOT's central office reviews districts' decisions for projects in the work plan.

Florida's planning horizon is five years. Annual planning efforts add projects at the planning horizon and review the status of projects already in the plan. Work on project scoping and development begins at a two-year horizon.

Permits

DOT districts have environmental staff that handles permitting issues for bridge maintenance work.

Priority Indicators

Bridge condition ratings and bridges' status as structurally deficient or functionally obsolete guide the selection of projects for rehabilitation or replacement. These measures are used to identify, but not to rank, bridge projects.

Performance Measures

Florida tracks performance measures for the bridge network that include timely completion

of work orders, bridge conditions, and programming for bridges needing improvement or replacement (see Table 6.5).

Measure	Completion time
Timely completion of work orders	100% of all priority 1 and 2 work orders and 95% of all bridge work orders must be completed on time
Bridge condition ratings	90% of all state bridges must be at good or better condition
Structurally deficient or weight-restricted bridges	100% programmed for repair or replacement within six years of being identified
Economy replacements	100% programmed for replacement within nine years of being identified

Table 6.5 *Florida performance measures*

In 2008, FDOT districts completed 7,476 of 7,492 (99%) work orders on time and completed all priority 1 and priority 2 work orders on time.

Programming Scope

Projects are scoped at the bridge level. When a bridge is programmed for a larger project (i.e., larger than the activities in Florida's work order system), the scope includes all work necessary to extend the life of the bridge, consistent with its anticipated year of replacement, if any.

Optimization of Maintenance Programs

Florida's selection of maintenance and repair methods is based on engineering judgment, with the goal to extend bridge service life.

Outcomes of Maintenance

Maintenance Tracking

Florida's MMS supports tracking of maintenance work orders from their assignment to their completion. Information on work orders is available on FDOT's intranet. AM contracts entail work reporting and verification of work by DOT engineers as part of their measurement and compensation provisions. Larger contracts, such as contracts for projects in Florida's bridge work plan, are tracked by FDOT's Financial Management Section.

Bridge conditions, and conditions that improve as a result of maintenance, are usually evaluated in the next regular inspection cycle. For major repairs, special inspections may be made and the condition data updated. If repairs affect (i.e., improve) bridge capacity, new load rating computations are made when the repairs are complete.

District bridge maintenance staff has monthly production meetings to review progress in work orders, AM contracts, and site contracts. Any backlogs in work order or contract maintenance are examined.

Effectiveness of Maintenance

FDOT determines the effectiveness of bridge maintenance through district QC reviews of all

priority 1 and 2 repairs; continuing contacts and teleconferences between the DOT central office and the DOT districts to exchange data and experience; and specific examinations of recurring problems that may be associated with a component, material, or repair method. In addition, FDOT's central office makes annual QA reviews of DOT districts. These reviews include a review of 10 to 15 bridge work orders to determine that correct priorities were assigned and appropriate actions were taken.

Maintenance Accomplishments

Accomplishments of Florida's bridge maintenance program are indicated by network average condition ratings. These ratings are reported to the Florida Transportation Commission.

Documents Related to Programming

Procedures for use of Florida's bridge work order system (BWOS) are published in the *Bridge Work Order Handbook*[17] .

Maintenance Budget

Florida's budgets for bridge maintenance are allocated to two program areas:

- Routine maintenance
- Periodic and rehabilitation maintenance

Routine maintenance uses state funds only. DOT districts make annual requests to the DOT central office for funds for routine maintenance. The DOT Executive Management Committee approves requests. Allocations are intended for all routine maintenance needs in districts. Districts decide how to allocate funds to various work needs.

Funds for periodic and rehabilitation maintenance are based on bridge inspection and inventory data (see Figure 6.3). Districts are allocated funds based on the combination of the following:

- Inventory of bridges with a structural condition rating of less than 6 (Inventory is measured as the sum bridge deck area. These bridges are said to be noncompliant.)
- Tons of painted structural steel
- Number of bridges with fender systems
- Number of movable bridges

A fifth component, called the district discretionary fund, is available for unexpected needs.

[17] *Bridge Work Order Handbook,* Florida Department of Transportation, State Maintenance Office, Tallahassee, 2001, 84 pp

District BRRP Funding = Statewide BRRP District % Noncompliant Bridges
+ District Fixed Cost Inflation Multiplier
+ District Discretionary Fund Allocation
Statewide BRRP = Total Program Funds – Fixed Cost – Discretionary Fund
District Fixed Cost = Painted Steel (tons) Average Annual Painting Cost
+ Number of Fender Systems Average Annual Repair Cost
+ Number of Movable Bridges Average Annual Repair Cost
Discretionary Fund = $5 million statewide

Figure 6.6 *Florida maintenance staffing* [18]

For fiscal year 2010, Florida's budget for routine maintenance is $9.8 million and for bridge repair is $72.7 million. An FDOT budget plan is available at http://www.dot.state.fl.us/financialplanning/.

Florida allows DOT districts to bank funds. Districts can accumulate funds over several years to meet the costs of very large projects without loss of funds. Statewide, all funds are spent or committed in every fiscal year. The banking system allows an accountable redistribution of funds among districts.

Federal HBP Funds for Preventive Maintenance

Federal funds support FDOT's bridge inspections and bridge replacements; these funds are not used for preventive maintenance.

Data Systems

FDOT uses an MMS, a financial management system, and the Pontis BMS. Execution and reporting of bridge work orders are handled in the MMS. Monitoring and reporting for projects in the bridge work plan are handled in the financial management system. The BMS stores bridge inspection data and provides input to bridge work plans. Data from the BMS are imported to both the MMS and financial management system.

FDOT has developed a Project Level Analysis Tool to provide scoping of projects and forecasts of projects within a 10-year planning period[19].

Materials and Methods

Carbon Fiber Reinforced Plastic Repairs

FDOT has used carbon fiber reinforced plastic (CFRP) repairs since the 1990s. The earliest repairs were installed more than 15 years ago and serve today without problem. CFRP repairs

[18] *Bridge Maintenance and Repair Program,* Florida Department of Transportation, 2009, PowerPoint

[19] Hubbard B, *Project Level Analysis Tool,* Florida Department of Transportation, 2009, PowerPoint

are used to remedy high-load hits and corrosion and construction defects and to increase strength in beams. CFRP repairs are a general method to respond to a loss of cover for reinforcing steel. FDOT's use of CRFP is guided by documents from the American Concrete Institute[20] and the National Cooperative Highway Research Program[21].

Bridge Load Testing

FDOT's materials laboratory performs diagnostic load tests and proof load tests on bridges. The lab owns two loading trucks and an array of sensors and data collection equipment, including strain gauges, laser deflectometers, displacement gauges, and tilt meters. The testing program allows Florida to evaluate bridges that lack design plans and assess the load ratings of bridges that may have greater strength than rating calculations indicate. In some cases, load testing and load (re)rating of bridges can have significant effects on freight mobility. For one bridge without design plans, Florida employed a three-dimensional scanner to obtain point clouds to define surface geometry (see Figure 6.4).

Costs for bridge tests are about $10,000 for analytical work and two to three days of fieldwork involving all eight personnel from the DOT's materials lab.

Figure 6.4 *Florida bridge and surface scan*[22]

Corrosion-Resistant Design for New Bridges

FDOT's design life for bridges is 75 years. To achieve this, Florida considers the exposure environments for bridges and identifies suitable concrete cover requirements, reinforcement protection, and reinforcement materials. While Florida rarely has snow or freezing temperatures and highway bridges have no exposure to deicing salt, bridges along the Atlantic and Gulf coastlines are exposed to sea salt. Of Florida's state-owned bridges, two-thirds touch salt water.

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[20] *Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures,* ACI Committee 440, technical committee document 440.2R-08, 2008, 76 pp

[21] Mirmiran A, Shahawy M, Nanni A, and Karbhari V, *Bonded Repair and Retrofit of Concrete Structures Using FRP Composites*, NCHRP Report 514, 2004, 102 pp

[21] *Bridge Testing in Florida*, Florida Department of Transportation Structures Research Center, 2009, PowerPoint

Corrosion Control for Existing Bridges

Among Florida's older (existing) bridges, damage to substructures is a common problem. Repair projects usually include three tasks: rehabilitation of reinforcing steel, installation of corrosion control systems as new concrete is placed, and monitoring of the control systems during routine inspections. Contract maintenance personnel install corrosion control systems, which are always part of repairs to concrete members in salt water.

Titanium mesh is Florida's most commonly used anode for impressed current systems for corrosion control. The system entails placing the mesh below (i.e., inside the cage of) reinforcing steel, installing a rectifier at the site, and monitoring the system's performance.

Arc-sprayed zinc is applied directly to the concrete surface for sacrificial corrosion control systems. Steel studs are driven into concrete, and then zinc is applied, making contact with the steel studs and, through them, with internal reinforcing steel. Arc-sprayed zinc is used in rehabilitation of structural steel beams, too, usually as a shop process. Steel beams are removed, zinc is applied, and then the beams are reinstalled. Florida expects 40-year service for this type of sacrificial control of corrosion.

Zinc mesh is placed in pile jackets for sacrificial control systems (see Figure 6.5). Sacrificial systems are also made with submerged bulk zinc or aluminum anodes with electrical connections to reinforcing steel.

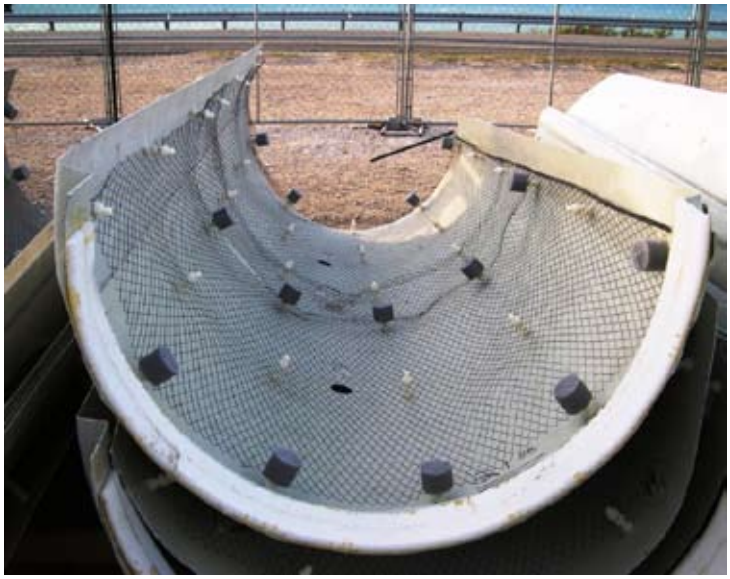

Figure 6.5 *Florida mesh in pile jacket form*[23]

[23] Lasa IR, *Florida's Approach To Bridge Preservation, Corrosion Control For Older Bridges,* Florida Department of Transportation, Corrosion Research Lab, 2009, PowerPoint

Job title	Training and other requirements	Staffing							
		DOT District							DOT Central Office
		1 & 7	2	3	4	5	6	Tpke	
Bridge inspectors	Bridge inspection class for divers commercial dive training, NHI bridge training	2	11	9	8	4	4		
Load rating engineer	Registered professional engineer	2			1	1	3		1
Project managers	Engineaering degree	4		2	1	2	5		
Assistant structures maintenance engineer	Registered professional engineer	2	1	1	1	1	1		
Structures maintenance engineer	Registered professional engineer	1	1	1	1	1	1	1	1
Bridge management inspection engineer	–								1
Bridge repair engineer	–				3				1
Structures repair manager	Professional engineer or ability to obtain							1	
Structures field coordinator	State certified bridge inspector							1	
Structures systems manager	Familiarity with software							1	
Heavy bridge crew technician	NHI bridge training, hand tool operation training, CPR and first aid, defensive driving, CDL, safety training				3	4			
Heavy equipment operator	NHI bridge training, hand tool operation training, CPR and first aid, defensive driving, CDL, safety training				1	1			
Heavy bridge crew supervisor	Supervisory training, safety training, hand tool operation training, CDL, defensive driving, on-the-job training		2			1			
CADD technician	Trained in CADD					1			
Document specialist	On-the-job training					1			
Bridge inspection supervisor	NHI bridge training		1			1			

Table 6.6 *Florida maintenance staffing*

Job title	Training and other requirements	Staffing							
		DOT District							DOT Central Office
		1 & 7	2	3	4	5	6	Tpke	
Engineering, all other level 3	All bridge personnel – prevention of blood-borne pathogens, loss prevention procedures, defensive driver, safety, fire prevention, HAZMAT first responder all crew personnel – MOT, boating safety, confined space, fall protection, towing safety, inspection – NHI bridge training, CPR, first aid		13						
Engineering, all other level 1			1						
Engineering techs, all other level 2			4						
Highway maintenance workers level 3			9						
Highway maintenance workers level 2			3						
Highway maintenance workers level 1			11						
Maint and repair workers, general level 2			4						
Electrical and elect. Repairs level 2			3						
Truck drivers, hwy and trac trailer level 2			1						
Clerical and admin		1	6					1	

Table 6.6 *Florida maintenance staffing (continued)*

CHAPTER 7

Florida's Turnpike Enterprise

The scan team met with Aran Lessard, the Structures Maintenance engineer for Florida's Turnpike Enterprise, by video link from Tallahassee. Aran Lessard is employed by a consultant to FDOT.

Florida's Turnpike Enterprise is an administrative district (District 8) of the state DOT. The turnpike, created in 1953, traverses 16 counties and five of the seven other DOT districts. The turnpike identifies 11 bridge work areas, as shown in Table 7.1.

Work	Note
Bridge joint repair	Reconstruction of joint headers, restoration of joint seals, repair of mechanical joint systems
Bridge deck maintenance and repair	Repair of concrete spalls, repair of concrete cracking (e.g., epoxy injection, surface treatment, and restore reinforcing)
Bridge handrail maintenance and repair	Repairs to concrete elements (e.g., patch concrete spalls, repair cracks, and restore reinforcing), repairs to steel elements (e.g., tighten/replace fasteners, and replace damaged elements)
Bridge superstructure maintenance and repair	Repairs to concrete beams/slabs (e.g., patch concrete spalls, repair cracks, restore reinforcing), repairs to steel beams/connectors (e.g., tighten/replace loose hardware, replace damaged steel elements, and clean and apply anticorrosion paint), maintenance painting of structural steel application of Class V coating to concrete surfaces
Bridge bearing maintenance and repair	Repairs to beam bearings (e.g., clean corrosion and paint and replace bearing pad)
Bridge substructure maintenance and repair	Repairs to concrete elements (e.g., patch concrete spalls, repair cracks, and restore reinforcing), repairs to slope protection (e.g., repair cracks in slope protection panels, restore seals, and restore lost fill), repairs to MSE wall systems (e.g., restore damaged panels, restore fill retaining devices – screens and fabrics, clean drains, and restore joint seals)
Channel maintenance	Restoration of eroded areas (e.g., install fill or rip rap), clear vegetation, reshape channel, remove sediment buildup
General maintenance	Needs that are nonstructural in nature and not related to safety , clean dirt and debris (e.g., from joints, on top of caps, along bottom flanges, and around bearings), graffiti removal, clean-out of drainage systems, deck sweeping, restoration of roadway line striping, electrical maintenance

Table 7.1 *Florida's Turnpike Enterprise maintenance work areas* [24]

[24] Lessard A, *Amplifying Questions*, Florida Department of Transportation Turnpike Enterprise, 2009

Work	Note
Routine maintenance, minor repair	Work to restore structural element to original condition, spall repairs, minor joint repair, bolt tightening and the like
Periodic maintenance, major repair	Larger projects that restore deteriorated components to safe and serviceable condition
Major bridge rehabilitation, replacement and construction	Larger projects developed and managed by the Turnpike Capital and Construction Program

Table 7.1 *Florida's Turnpike Enterprise maintenance work areas (continued)*

Preventive maintenance actions used by Florida's Turnpike Enterprise are listed in Table 7.2.

■ Maintenance painting of structural steel (typically every 15 to 18 years)
■ Coating of steel elements with anticorrosion spray (if concrete cover cannot be properly restored)
■ Timely repair of concrete cover for prestressing steel in beams
■ Timely repair of deteriorating joint seals
■ Restoration of seals around earth-retaining / slope protection systems
■ Cleaning of drainage systems

Table 7.2 *Florida's Turnpike Enterprise preventive maintenance*[25]

Maintenance Categories

Florida's Turnpike Enterprise identifies bridge work categories that include general maintenance, routine maintenance (minor repairs), periodic maintenance (major repairs), and bridge rehabilitation and replacement. General maintenance is for nonstructural defects. Minor repairs include spall patching, minor repairs to joints, and bolt tightening. Major repairs are channel modifications, wing wall replacements, beam replacements, and other larger works, usually handled by site contracts. Rehabilitation and replacement are not maintenance, but these projects are identified through the determination that maintenance remedies are not sufficient.

Documents

Turnpike maintenance activities conform to FDOT requirements and employ its documents, including those listed in Table 7.3.

[25] Lessard A, *Amplifying Questions*, Florida Department of Transportation Turnpike Enterprise, 2009

■ FDOT Procedure 850-010-030-g, *Bridge and Other Structures Inspection and Reporting*
■ FDOT Procedure 850-010-035-b, *Bridge Load Rating, Permitting and Posting*
■ FDOT Procedure 850-010-031-a, *Bridge Operations and Maintenance Manual*
■ *FDOT Bridge Maintenance & Repair Handbook*
■ FDOT Procedure 850-010-011-d, *Bridge Underwater Operations*
■ *FDOT Bridge Management System Coding Guide*

Table 7.3 *Florida's Turnpike Enterprise documents fort maintenance*[26]

Bridge Maintenance Program

For Florida's Turnpike Enterprise, maintenance of bridges is part of roadway maintenance. Structures maintenance includes bridges, sign structures, high mast lights, and large culverts.

Inventory

The turnpike has 701 bridges, most of which are low-level crossings with four spans or fewer, and are 300 feet long or less (see Table 7.4). The longest individual spans are between 250 and 280 feet. Multibeam bridges make up approximately 80% of the turnpike bridge inventory. Concrete bridges, either reinforced or prestressed, comprise 85% of the bridge inventory. Most crossings are freshwater crossings, and the turnpike has no bridges in extremely aggressive environments for corrosion. The turnpike has approximately 40 large bridges (see Table 7.5). The turnpike owns no cable-stayed bridges, no trusses, no segmental box bridges, and no movable spans.

State-owned, highway bridges > 20 feet	699
Pipes, smaller culverts ≤ 20 feet	206
Pedestrian bridges	2
High mast lights	496
Overhead sign structures	713

Table 7.4 *Florida's Turnpike Enterprise structures inventory*[27]

Count	Description	Bridge length
1	SR419 over Lake Jessup	~7,900 ft.
1	Thomas B. Manual Bridge	~3,000 ft
5	Ramp and Mainline Bridges	1,500–2,000 ft.
10	Ramp and Mainline Bridges	1,000–1,500 ft.
22	Ramp and Mainline Bridges	500–1000 ft.

Table 7.5 *Florida's Turnpike Enterprise large bridges*

[26] Lessard A, *Amplifying Questions*, Florida Department of Transportation Turnpike Enterprise, 2009
[27] Lessard A, *Amplifying Questions*, Florida Department of Transportation Turnpike Enterprise, 2009

Maintenance Execution

Maintenance Contracts

Contract forces execute all maintenance of turnpike bridges. Contract maintenance provides for concrete repairs, drainage cleaning and repair, graffiti removal, asphalt maintenance, guardrail maintenance, sign structure maintenance, and lighting maintenance. Of the four geographic zones of the turnpike, two have work-order-based, regional repair contracts and two have AM contracts.

General maintenance and routine repair work is accomplished with both AM and work-order contracts. The turnpike contract manager initiates each authorization for structural repair work in response to work requests generated by the structures inspection program. Professional engineers are engaged at two points: they sign inspection reports and prepare and seal design work, if needed for repairs. AM and work-order contracts handle all minor repairs. Contracts are geographic, so contractors deal with a stable inventory of structures and a stable level of work.

Work-order-based, regional repair contracts are loaded with work items and funds for work items. These contracts are usually one year in duration; AM contracts, however, have a seven-year duration. Turnpike staff performs a QA review of all work provided by contractors.

Larger repair projects and projects for bridge rehabilitation are performed under site contracts, which are developed and funded either through the Turnpike Work Program Office or the Turnpike Roadway Maintenance Office, depending on the scope of work required.

Bridge Inspection Contracts

Turnpike bridge inspections are executed through two regional contracts, one for the northern portion of the turnpike and one for the southern portion.

Maintenance Staffing Levels, Training, and Longevity

Florida's Turnpike Enterprise has a staff of five that is involved in bridge maintenance work. These personnel coordinate with managers for contract inspections and contract maintenance work. Staff titles are shown in Table 7.6. The current structures maintenance engineer has been in that position for four years.

Work	Note
Structures maintenance engineer	Professional engineering registration Applicable work experience (i.e., structures inspection and repair)
Structures repair manager	Professional engineering registration or ability to obtain (i.e., EI certification) Applicable work experience (i.e., structures inspection and repair)
Structures field coordinator	State certified bridge inspection certificate Applicable work experience (i.e., structures inspection and repair)
Structures systems manager	Familiarity with required software (e.g., PONTIS, BWOS, or DOTNET) Applicable work experience (i.e., structures inspection and repair)
Structures staff assistant	General understanding of structures maintenance procedures

Table 7.6 *Florida's Turnpike enterprise structures maintenance staff* [28]

Turnpike staff work collaboratively and come to know the responsibilities and procedures of the various staff positions. This kind of cross-training is part of turnpike staff development.

Maintenance Decisions

Identification of Maintenance Needs

Bridge maintenance needs are identified in structure inspections. Inspection consultants provide recommendations for structural work. A FARC comprising inspection personnel, turnpike structures maintenance personnel, and repair contract managers reviews the work recommendations. The FARC determines what actions to take and what priorities to assign. Any qualified staff, such as turnpike maintenance personnel, can recommend work at bridges. Work recommendations are submitted to the structures maintenance engineer and to the FARC for disposition.

The FARC issues work orders to the Florida BWOS for assignment. Work orders go on to turnpike regional managers for execution through the regional maintenance contracts.

The four-level maintenance priorities are the same as the FDOT priority system for work orders.

Maintenance Programming Process

Programming procedures for maintenance vary with magnitude of work (see Table 7.7). General maintenance (e.g., lane striping or replacing sign light bulbs) is noted during bridge inspections, and memos on needs are sent to contract zone managers. Routine maintenance and minor repairs are executed through the FDOT BWOS once work orders are reviewed and issued by the turnpike's FARC. Major repairs are executed with site contracts that include design plans and specifications. The turnpike maintenance group or turnpike construction group manages site contracts, depending on the magnitude of the project.

Work category	Programming process
General maintenance	Memo sent to zone contract manager for execution by regional contract
Routine maintenance, minor repairs	Executed by work order added to the routine maintenance contract
Periodic maintenance, major repairs	Site contract with specific scope after approval of turnpike maintenance engineer
Major bridge rehabilitation, replacement and construction	Site contract developed through the Turnpike Work Program Office and managed by the Turnpike Construction Department

Table 7.7 *Florida's Turnpike Enterprise maintenance programming*

The FARC review process allows inspection personnel, repair contract personnel, and structure management personnel the opportunity to participate in programming decisions.

[28] Lessard A, *Amplifying Questions*, Florida Department of Transportation Turnpike Enterprise, 2009

Maintenance Programming Administration

Organizationally, the Turnpike Structures Maintenance Department is part of the larger Turnpike Roadway Maintenance Department, which is responsible for maintaining all aspects of the turnpike system, including roadway structures.

The turnpike has a group of environmental professionals that can assist in maintenance projects.

Priority Indicators

The turnpike relies on inspection reports and on element-level conditions to determine what repairs must be made. Priority indicators are not used.

Programming Scope

Decisions in maintenance and repair depend, in part, on the expected remaining service life of each bridge. Repair options for each bridge are considered separately.

Optimization of Maintenance Programs

Optimization of turnpike maintenance is prompt attention to minor repairs to avoid larger and more expensive repairs later.

Outcomes of Maintenance

Maintenance Tracking

Florida's Turnpike Enterprise uses the same procedures for maintenance tracking as those used by other FDOT districts. Turnpike staff updates the Florida BWOS with information provided by contractors when work orders are completed. Completed work is verified in the next safety inspection; turnpike contract management staff also verifies work as part of close-out documentation for contracts. In addition, Turnpike Structures Maintenance staff performs quality reviews of a percentage of previously completed repairs on structures.

FDOT's work order system tracks maintenance needs selected by the FARC. Needs not selected by FARC may be tracked in informational databases and may be programmed when resources become available. The backlog of turnpike maintenance needs is typically between $500,000 and $1 million in estimated project costs.

Bridge inspectors have access to the FDOT BWOS and get reports of completed work. Part of a safety inspection is the verification of completed work. For large repairs, inspections to verify work are scheduled separately and in advance of the cycle for routine safety inspections.

Design Changes to Bridges

For bridge rehabilitations, replacements, or other projects that may change a bridge's design, Turnpike Structures Maintenance staff monitors the project development and reviews design documents at 60%, 90%, and 100% completion. Maintenance staff can provide input on which design details work well in service and on anticipated maintenance costs.

Effectiveness of Maintenance

Turnpike maintenance staff participates in routine, periodic meetings among personnel in FDOT districts. Maintenance staff participation in design review is beneficial.

Accomplishments in Network

There are no network-level performance measures for turnpike structures. Instead, detailed information from inspection reports and the level of work needs that are identified through the inspection program indicate the maintenance program's accomplishments. One essential accomplishment is the provision of service along the turnpike without disruption.

Quality Control and Quality Assurance

The Florida Turnpike Enterprise *Procedure and Quality Control Plan for Structures Maintenance* document guides structure inspections, maintenance and repair, inventory management, and other tasks. The document outlines the process for allocation of resources and the timeliness of inspection and maintenance of structures for Florida's Turnpike Enterprise.

The turnpike program for structures maintenance is reviewed annually in a QA review. The program's quality is measured by correct identification and timely completion of work. FDOT central office staff performs the QA review. Evaluations include:

- Repair work properly completed and documented
- Bridge rehabilitation projects properly programmed
- Bridge inspections properly performed and documented
- District QC reviews performed and documented
- District bridge load ratings properly reported

Documents Related to Programming

The turnpike produces an annual *Tourbook* that contains formal requests from FDOT Structures Maintenance, requests from other turnpike entities, and requests for large projects. Projects in the *Tourbook* proceed as funding is available and as DOT executive management approves. Once funded, projects are identified in the *FDOT Bridge Work Plan*.

Maintenance Budget

Budgets fund turnpike zone contracts for maintenance. Estimates of workloads and associated costs are generated as part of contract development. The turnpike's inventory of bridges and needs for maintenance are stable. The resulting workloads and contract costs are predicable. In addition, long-range estimates of costs for large projects and periodic maintenance are prepared. The Turnpike Work Program Finance controls a fund for emergency repair work. Bridge inspection costs are estimated, too, from known and stable workloads.

Approximate annual budget amounts for inspection, maintenance, repair, and management of turnpike structures, including bridges, overhead signs, culverts, and high mast light towers, are shown in Table 7.8.

Structures inspection work	$1.7 million
Structures maintenance and minor repair	$0.8 million
Structures rehabilitation and major repair	$1.0 million
Structures emergency (contingency)	$1.0 million
Structures program oversight	$0.5 million

Table 7.8 *Florida's Turnpike Enterprise maintenance budget amounts*

Bridge Preservation

The turnpike has a single program, structures maintenance, that provides for both bridge maintenance and bridge preservation. Bridge-painting projects make up much of the bridge preservation program. The turnpike has a goal of repainting at 15-year intervals, but finds that painting at longer intervals (e.g., 18 years) can be adequate for many bridges. Bridge preservation projects include those listed in Table 7.9.

■ Steel bridge painting
■ Concrete deck replacement and/or sealing
■ Channel restoration
■ Concrete culvert rehabilitation
■ Beam bearing rehabilitation
■ Bridge vertical clearance upgrade
■ Bridge joint rehabilitation

Table 7.9 *Florida's Turnpike Enterprise bridge preservation*

Preservation projects consume between 5% and 10% of overall funds for structures rehabilitation, repair, and maintenance.

Federal HBP Funds for Preventive Maintenance

Florida's Turnpike Enterprise does not use, or request, federal HBP funds for preventive maintenance.

Balancing Preservation and Improvement (Capital) Projects

Turnpike maintenance staff is involved in review of bridge replacement and improvement projects. Because it is informed on large projects, maintenance staff is able to prioritize other bridge repair and preservation work. Where it is efficient, some preservation work is included in the scope of improvement projects. For example, when a steel bridge is widened, it may be efficient to repaint the existing beams in the same project.

The turnpike has growing demands for traffic capacity. Bridges are replaced more often to increase traffic capacity and less often for reasons of age or deterioration. Bridge replacements are part of larger corridor improvement projects.

Data Systems

The data systems used by Florida's Turnpike Enterprise include the Florida Maintenance Management System, the Bridge Work Order System, and the Pontis Bridge Management System (see Table 7.10).

Data system	Note
Maintenance Management System	Contract repair costs
Bridge Work Order System	Assignment and completion of work orders for structure repair work
Pontis Bridge Management System	Structure inventory and inspection data

Table 7.10 *Florida's Turnpike Enterprise data systems*

The data systems are engaged sequentially, and all three are used in identifying, assigning, and tracking of bridge maintenance work. Inspection reports and inspectors' recommendations for maintenance work are stored in Pontis BMS. FARC reviews recommendations for work, which can advance as work orders to the BWOS. The work order indicates the work, its scope, and its priority. Work orders are forwarded to the appropriate contract manager. When work is completed, the costs are recorded in the state's maintenance management system. The work is verified in the following inspection cycle.

The Pontis data system and the BWOS are both accessible to staff in Turnpike Structures Maintenance and to turnpike inspection consultants. Staff in Turnpike Roadway Maintenance operates the state's MMS.

Materials and Methods

Turnpike Structures Maintenance relies on its FARC to consider repair needs and options for actions. The FARC considers both immediate needs at bridges and longer term plans for bridges. That is, if a bridge may be replaced soon as part of a corridor improvement, then repairs are made consistent with that expectation.

Structures maintenance staff are included in the review of turnpike improvement projects. In the Turnpike's plans review process, maintenance staff become aware of plans for individual bridges and can contribute to design selections, especially as these may affect future maintenance needs; also, improvement projects can be expanded to include preservation work at some bridges.

The extensive use of contracts, both for repair work and for inspections, engages many professionals in all areas of road and bridge maintenance work. Newer methods, newer materials, and newer technologies are quickly introduced to turnpike work through this

extensive contact with professionals.

Many portions of the turnpike compete with other, non-toll routes. The turnpike strives to provide efficient and effective transportation service to its users. One specific mobility issue is related to oversize, tandem-trailer trucks. The turnpike accommodates these vehicles along some corridors and provides staging areas so that tandem rigs can be assembled and broken down as they access and later leave high-mobility corridors along the turnpike.

CHAPTER 8

Michigan

The scan team met with engineers at Michigan DOT's (MDOT's) central office for bridge operations. MDOT has responsibilities for all state-owned transportation assets, including airports, ferries, railroads, mass transit, and highways. MDOT is responsible for 80% of state-owned assets.

MDOT has a decentralized organization. The DOT central office provides policies and program guidance. Michigan DOT has seven regions, which perform bridge inspections, develop bridge projects, deploy bridge maintenance crews, and develop plans for preventive maintenance and bridge rehabilitation and replacement. Michigan has 26 transportation service centers around the state that serve both DOT regions and Michigan counties.

The Michigan State Transportation Commission sets high-level policies for MDOT. The commission is established in Michigan's state constitution and provides a public forum for development of transportation policy. The governor appoints the commissioners.

MDOT coordinates bridge work with 1,800 local governments and planning authorities, including 83 county road commissions and 533 municipal agencies. MDOT has jurisdiction of 8% of the approximately 120,000 route miles in Michigan.

Maintenance Categories

Michigan's bridge work categories include routine maintenance, capital scheduled maintenance (CSM), capital preventive maintenance (CPM), bridge rehabilitation, and bridge replacement. CSM includes minor repairs, spot painting, concrete sealing, bridge washing, and drain clearing; CSM keeps bridges in good condition.

CPM restores elements that are damaged and keeps bridges and elements from becoming deficient; CPM includes bridge painting, joint replacements, and epoxy overlays.

Bridge rehabilitation includes extensive repairs, such as rigid overlays for decks. Replacement projects include deck, superstructure, and bridge replacements.

Documents

MDOT's documents related to bridge maintenance include the *Capital Scheduled Maintenance Manual*[29] , *Pontis Bridge Inspection Manual*[30] , and the *Bridge Deck Preservation Matrix*[31].

[29] *Capital Scheduled Maintenance*, Michigan Department of Transportation, 2008, 56 pp
[30] *Pontis Bridge Inspection Manual*, Michigan Department of Transportation, 2007, 96 pp
[31] *Bridge Deck Preservation Matrix,* Michigan Department of Transportation, 2008, 2 pp

Bridge Maintenance Program

Inventory

MDOT owns 4,465 NBI-length bridges: 1,000 that have a span of between 10 and 20 feet, 173 pedestrian bridges, and 128 railroad bridges (see Table 8.1). One MDOT region, metropolitan Detroit, has 40% of the state's bridge inventory.

State-owned highway bridges > 20 feet	4,465
County or locally owned highway bridges > 20 feet	6,445
State-owned highway bridges ≤ 20 feet	1,061
County- or locally owned highway bridges ≤ 20 feet	76
Pedestrian bridges	173
Railroad bridges	128

Table 8.1 *Michigan bridges inventory*

Local agencies own 6,500 NBI-length bridges, 76 short-span bridges that are known to MDOT (there may be more short-span bridges not reported by local agencies), 61 pedestrian bridges, and 253 railroad bridges.

Maintenance Actions

Michigan's maintenance actions for bridge decks include crack sealing, healer-sealers, patching, overlays, retrofit with membranes and asphalt wearing courses, asphalt caps, and deck joint replacements (see Figure 8.1). Michigan's matrix for deck actions relates deck conditions to available repair methods and lists the expected service lives of repairs.

Deck condition state				Repair options	Potential result to deck BSIR		Next anticipated evaluation
Top surface		Bottom surface					
BSIR #58a	Deficiencies %[a]	BSIR #58b	Deficiencies %b		Top surface BSIR #58a	Bottom surface BSIR #58b	
≥ 5	N/A	N/A	N/A	Hold[c] Seal cracks/healer sealer[d]	No change	No change	1–8 years
	≤ 5%	> 5	≤ 2%	Epoxy overlay	8, 9	No change	10–15 years
	≤ 10%	≥ 4	≤ 25%	Deck patch[e]	Up by 1 pt	No change	3–10 years

Figure 8.1 *Michigan bridge deck action matrix*

Deck condition state				Repair options	Potential result to deck BSIR		Next anticipated evaluation
Top surface		Bottom surface					
BSIR #58a	Deficiencies %[a]	BSIR #58b	Deficiencies %b		Top surface BSIR #58a	Bottom surface BSIR #58b	
4 or 5	10%–25%	5 or 6	≤ 10%	Deep concrete overlay[h]	8, 9	No change	25–30 years
		4	10%–25%	Shallow concrete overlay[h,i]	8, 9	No change	10–15 years
				HMA overlay with waterproofing membrane[f,h,i]	8, 9	No change	8–10 years
		2 or 3	> 25%	HMA cap[g,h,i]	8, 9	No change	2–4 years
< 3	> 25%	> 5	< 2%	Deep concrete overlay[h]	8, 9	No change	20–25 years
		4 or 5	2%–25%	Shallow concrete overlay[h,j]	8, 9	No change	10 years
				HMA overlay with waterproofing membrane[f,h,i]	8, 9	No change	5–7 years
		2 or 3	> 25%	HMA cap[g,h,ic]	8, 9	No change	1–3 years
				Replace deck	9	9	40+ years

[a] Percent of deck surface area that is spalled, delaminated, or patched with temporary patch material.

[b] Percent of deck underside area that is spalled, delaminated, or map cracked.

[c] The "Hold" option implies that there is ongoing maintenance of filling potholes with cold patch and scaling of incipient spalls.

[d] Seal cracks when cracks are easily visible and minimal map cracking. Apply healer sealer when crack density is too great to seal individually by hand. Sustains the current condition longer.

[e] Crack sealing can also be used to seal the perimeter of deck patches.

[f] Hot mix asphalt overlay with waterproofing membrane; deck patching required prior to placement of waterproofing membrane.

[g] Hot mix asphalt cap without waterproofing membrane for ride quality improvement. Deck should be scheduled for replacement in the 5-year plan.

[h] If bridge crosses over traveled lanes and the deck contains slag aggregate, do deck replacement.

[i] When deck bottom surface is rated poor (or worse) and may have loose or delaminated concrete over traveled lanes, an in-depth inspection should be scheduled. Any loose or delaminated concrete should be scaled off and false decking should be placed over traveled lanes where there is potential for additional concrete to become loose.

Figure 8.1 *Michigan bridge deck action matrix (continued)*

Actions in CSM include bridge washing, spot painting, vegetation control, joint repairs, and installation of relief joints in approach pavements (see Table 8.2). Actions in CPM include scour protection, bridge painting, pin/hanger replacements, and joint replacements.

Projects for bridge rehabilitation and bridge replacement are executed where bridge conditions, vulnerabilities, or deficiencies require.

Category	Code	Work type
Bridge capital scheduled maintenance	460	Superstructure wash
(Category code 44)	461	Vegetation control
	462	Drain system clean/repair

Table 8.2 *Michigan work types and codes*[32]

Category	Code	Work type
	463	Paint – spot
	464	Joint repair
	465	Concrete sealing
	466	Crack sealing
	467	Minor concrete patching
	468	Approach pavement relief joints
	469	Slope paving repair
	476	Miscellaneous bridge CSM
Bridge capital preventive maintenance (Category code 43)	418	Overlay – epoxy
	419	Deck patching
	420	Scour protection
	421	Miscellaneous bridge CPM
	422	Paint – complete
	423	Pin and hanger replacement
	430	Joint replacement
	431	Substructure patching (NBI item #60 ≥ 5)
	432	HMA cap (no membrane)
	433	Paint – zone
	434	HMA overlay (w/ waterproofing membrane)
Bridge rehabilitation (Category code 13)	115	Superstructure repair
	116	Substructure repair (NBI item #60 ≤ 4)
	117	Substructure replacement
	135	Widen – maintain same # lanes
	139	Miscellaneous rehab
	417	Overlay – shallow
	424	Overlay – deep
Bridge replacement (Category code 22)	130	Deck replacement
	137	Superstructure replacement
	221	Bridge replacement
	234	Miscellaneous replace
	452	Culvert replacement
Bridge miscellaneous (Category code 45)	470	Miscellaneous bridge
	471	New technologies
	472	Bridge inspection
	473	Studies/scoping
	474	Bridge removal

Table 8.2 *Michigan work types and codes*[32] *(continued)*

Category	Code	Work type
	475	Special needs
	477	Railroad oversight
	478	Relocation of railroad facilities
Bridge improvement (Category code 23)	230	Widen, add lanes
	231	Widen, replace deck, add lanes
	232	Widen, replace superstructure, add lanes
	233	Replace bridge, add lanes

Table 8.2 *Michigan work types and codes*[32] *(continued)*

Maintenance Goals

Over the past 10 years, MDOT developed and implemented a strategic plan for maintenance of trunkline bridges. The goals were to achieve and maintain good or fair conditions (i.e., an NBI rating of 5 or higher) at 95% of bridges on interstate roads and 85% of other bridges. Michigan executed its plan by addressing all bridges with critical needs and applying preventive maintenance at other bridges to preserve existing conditions.

Michigan at first planned to allocate 30% of its funding to preventive maintenance, 25% to bridge rehabilitations, and 45% to bridge replacements; however, it was difficult to deliver the number of preservation projects furnished with a 30% share of funding. The allocation for bridge preservation was adjusted first to 20% of funding and later to 22% of funding.

Today, plan goals are met in some MDOT regions. Statewide, interstate routes have 88% of bridges in good or fair condition and 89% of other bridges in good or fair condition.

Maintenance Execution

Michigan performs maintenance with DOT crews and performs contract maintenance in two categories: CSM and CPM.

Crew Maintenance

MDOT crews perform minor repairs and some preventive maintenance following work recommendations from bridge inspection reports. Crews have access to inspectors' work recommendations through the Michigan Bridge Inspection System (MBIS). Crews are sometimes aided in their work with small contracts (i.e., under $25,000) that provide specific tasks, such as saw-cutting for pavement relief joints or surface preparation for painting.

CSM and CPM Contracts

[32] Gill A, *Bridge Program*, Michigan Department of Transportation, presentation to the scan team, 2009, PowerPoint

CSM and CPM contracts are site contracts that are developed and awarded in a routine process of scoping, engineering, and competitive bidding. CSM and CPM contracts furnish the maintenance activities listed in Table 8.3.

Bridge ID	Insp. freq. (months)	Next inspection	Inspection required	Bridge description
B03-50013	24	3/6/2010	Steel beam end	M-53 NB / MIDDLE BR CLINTON RIVER
S01-63022	6	12/3/2008	Beam end inspection and substructure sounding	I-96 / KENT LAKE RD
S06-63043	15	9/26/2008	PCI beam end	CROOKS RD / M-59
S01-63102	24	8/14/2009	Deck bottom sounding (slag bridge)	US-24 NB TO 696 EB / M-10 EB

Table 8.3 *Michigan Metro region in-depth inspections – sample list*

Statewide Support

MDOT has crews based in the central office that provide services and personnel to the MDOT regions. The central office provides ReachAll equipment and operators, certified welders with a mobile steel shop housed in a semi-trailer, and an overhead sign and fabrication shop. Central office crews make monthly visits to movable bridges for trial openings and lubrication, as required.

Contract Versus Crew Maintenance

CSM and CPM programs have averaged about 256 projects per year over the last three years. Maintenance by MDOT crews has touched more than 500 bridges per year.

Maintenance Staffing Levels, Training, and Longevity

Apart from the MDOT central crews, maintenance staff is based in DOT regions. Regional staff includes bridge inspectors, regional bridge engineers, maintenance supervisors, maintenance leadworkers, and transportation maintenance workers (TMWs).

Michigan bridge inspectors are TMWs. Regional bridge engineers are professional engineers and are NBI-qualified inspection team leaders. Regional bridge engineers perform QC reviews of bridge inspection reports.

Every MDOT region has some personnel dedicated to bridge maintenance. Typically, more people are assigned to maintenance crews in summer than in winter. In winter, TMWs are deployed to road operations maintenance.

Regional bridge maintenance crews often include equipment operators and certified welders. Through experience, crew members become familiar with most aspects of bridge maintenance and repair work. MDOT provides training for equipment operators and continuing training and certification for operators of aerial lifts for personnel.

Regional Notes on Maintenance Program

University Region Maintenance Program

MDOT's University region has an inventory of 1,000 structures. Preventive maintenance activities include deck patching, joint replacements, and steel painting. Bridge maintenance tasks are often coordinated along a corridor. Movable bridges are washed twice annually. The region has two special crews for bridge work, such as application of healer-sealers, joint repairs, deck flood coats, thin epoxy overlays, and emergency repairs.

The University region staff includes a delivery group and a development group. The delivery group has bridge inspectors and bridge maintenance crews. Work recommendations from bridge inspections are added weekly to a regional spreadsheet. Bridge crews view this spreadsheet through a regional data server. As crews complete work, the date of completion is added to the spreadsheet. The region engineer selects bridges for maintenance work, and all work needs are executed for the bridges selected. The average service period in the University region is seven years between projects at the same bridge.

The University region uses contractors for larger projects, for projects needing similar work performed at many bridges, and for bridge sites that require greater effort in traffic control and diversion.

Detroit Metropolitan Region Maintenance Program

MDOT's Metro region has 1,497 bridges. Of these, 13% are in poor condition. The Metro region has a number of bridge decks made with concrete having slag aggregates, an option available to contractors from 1960 to 1985. As a result, some deck soffits have loose concrete. Replacement is the only remedy for these decks.

The Metro region handles high traffic volumes. Bridge projects are organized along corridors to take advantage of shared detour routes.

The Metro region tracks its bridge deterioration rate in terms Figure 8.2). The Metro region's bridge program has greatly reduced the bridge deterioration rate.

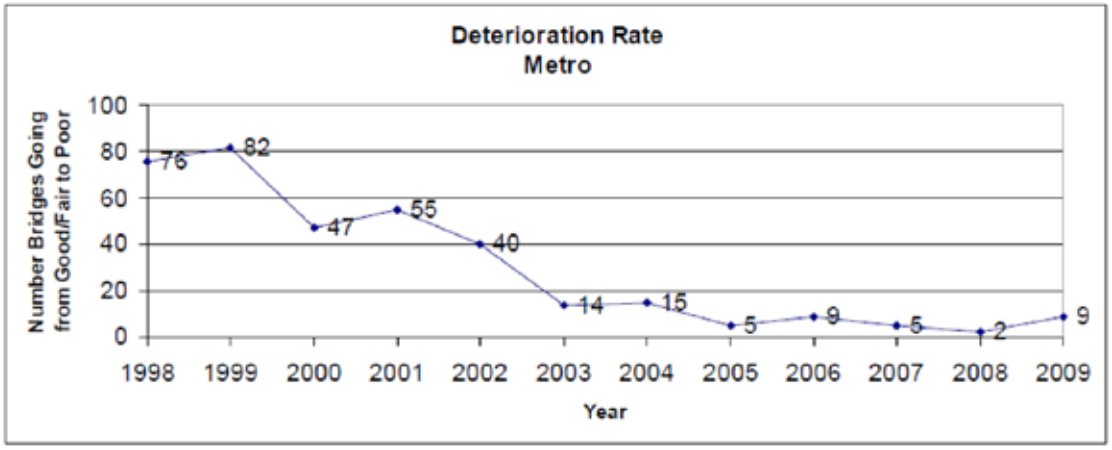

Figure 8.2 *Michigan Metro region deterioration data*[33]

The Metro region anticipates maintenance needs based on ongoing experience with its bridges. The Metro region plans in-depth inspections of selected components to prepare for repair work (see Table 8.3).

Southwest Region Maintenance Program

MDOT's Southwest region is responsible for nine counties and 495 bridges. There are three Transportation Service Centers in the Southwest region. This region's annual budget for the bridge crew is $1.4 million. In 2008, the crew placed 190 cubic yards of deck repair materials, 3,376 square feet of epoxy flood coating, 1,978 linear feet of joint sealing, 1,768 linear feet of joint replacement, and cleared overhead (soffit) spalls at 348 travel lanes below bridges.

Michigan's Southwest region has nine full-time personnel on maintenance crews and 12 to 14 additional personnel during the summer months. Job titles include maintenance supervisor (TMS-11), transportation maintenance leadworker (TMW-9), and transportation maintenance worker (TMW-8).

The Southwest region's bridge crew has its own portable mixer for quick-setting concrete materials. The crew has converted a roofing elevator into a floating conveyor for rip rap (see Figure 8.3).

Figure 8.3 *Michigan Southwest region's floating conveyor for rip rap*[34]

[33] *Current State of Metro Region Bridge Network*, Michigan Department of Transportation, 2009, 23 pp

[34] Roberts K, *Southwest Region Specialty Crews*, Michigan Department of Transportation, presentation to scan team, 2009, PowerPoint

Maintenance Decisions

MDOT's decision process for bridge work begins with information from bridge inspection reports. It examines the impacts of bridge conditions on mobility and selects the bridge projects to develop. The DOT districts make specific proposals for bridges and projects. MDOT's central office examines the effect on network average conditions of various mixes of maintenance, rehabilitation, and replacement projects.

Identification of Maintenance Needs

Bridge inspectors identify repair needs. Regional bridge managers review the recommendations, identify top priorities, and develop work schedules for crews. These schedules are reviewed at monthly meetings of regional bridge managers, project programmers, and staff at MDOT transportation service centers. MDOT holds annual meetings of maintenance personnel from the central office and regions to review work plans for the coming construction season.

During bridge inspections, work recommendations are identified in two modes. Inspectors can select standard actions from drop-down lists in Michigan's inspection reporting system. Inspectors select standard repairs, provide estimates of quantities, and identify repairs as candidates for crew or for contract maintenance. Comment boxes allow the inspectors to make additional recommendations or make cut-and-paste additions. Inspectors can quickly reaffirm recommendations from previous inspections.

MDOT regional staff can view inspectors' recommendations using Michigan's Web-based inspection reporting system

Maintenance Priority

Recommendations for nonemergency maintenance are assigned a high, medium, or low priority. Recommendations for emergency maintenance are assigned one of three priorities on a separate scale:

- Priority 1 work must be completed immediately.
- Priority 2 work must be completed within 6 months.
- Priority 3 work can be completed as part of the routine maintenance program.

Any recommendation for emergency work may require input from bridge design engineers.

Programming Process

The DOT central bridge operations office and bridge staff in the DOT regions jointly select projects for contract maintenance, preventive actions, rehabilitation, and replacement. Regional offices and the DOT central office both identify bridge projects. Each year, the central office issues a call for projects, and regions respond with specific candidates and scopes, together with justifications for these projects. Regions are expected to program all bridges that have a structural condition rating of 4 or lower; they will also program most bridges with a

structural condition rating of 5. Central and regional staff jointly review bridge candidates. The review yields agreed sets of projects.

Decisions in Michigan's bridge program fit within the MDOT strategic plan and the state's long-range plan. Michigan's strategic plan is focused on meeting condition-based performance goals for bridges. Its long-range plan addresses all MDOT-controlled assets.

In the past 10 years, MDOT has made substantial progress improving its critical and deficient bridges. Functional obsolescence, by itself, was not addressed. Now, with improved network conditions, there is greater interest in modernizing the MDOT network and reducing the number of functionally obsolete bridges.

Scoping for Bridge Projects

Regions perform project scoping, often using DOT crews. Fieldwork for scoping includes in-depth inspection of structural components, preparation of damage maps for decks, and collection of thickness measurements for beam parts and beam ends. When consultants perform the scoping, the contract value is often about $10,000. DOT regions prepare scoping reports that present two or three repair options and make recommendations among these options. Cost estimates for proposed work are prepared using standard spreadsheets with average bid item costs maintained by Michigan's central bridge operations office. Information from scoping reports is input to ProjectWise[35].

Five-Year Plans

Bridge projects are programmed in five-year plans that are updated annually. Bridge replacement projects enter the plan at a five-year horizon. Bridge rehabilitation projects enter at a three-year horizon. Project scoping is usually done at a two- or three-year horizon.

Big Bridge Program

MDOT has a dedicated program and budget for maintenance of big bridges (see Figure 8.4)[36]. Michigan's big bridges include 30 signature bridges, 14 large decks (> 100,000 ft2), 5 unique bridges (segmental box, tied arch, or cable-stayed), and 12 movable bridges, including a double-deck movable bridge that has been converted from rail use to snowmobile use. The big bridge program is managed by the MDOT central bridge operations office. The annual budget for big bridge maintenance is currently $16 million.

[35] A data-sharing sharing environment for engineering projects offered by Bentley Systems; see http://www.bentley.com/en-US/Products/projectwise+project+team+collaboration/

[36] US 41, Portage Lake, Michigan

Figure 8.4 *The Houghton-Hancock Bridge, part of Michigan's Big Bridge Program*[37]

Performance Measures and Priority Indicators

MDOT uses NBI condition ratings both to track average network performance of bridges and to determine the category of bridge work needed at each structure (see Table 8.4). Michigan tracks the numbers and percentages of bridges in good, fair and poor condition. Good bridges have NBI ratings of 7 or higher for deck, superstructure, and substructure. Fair bridges have NBI ratings of at least 5. Poor bridges have at least one NBI rating of 4 or below.

Replacement	NBI 4 or lower
Rehabilitation	NBI 4 or 5
Preventive maintenance	NBI 5 or higher

Table 8.4 *Michigan programming and NBI condition ratings*

MDOT's goals are to keep 95% of bridges on freeways and 85% of other state-owned bridges in good or fair condition. Michigan uses the NBI-based performance measures to assign funds to bridge work areas (preventive versus rehabilitation versus replacement) and to determine the overall success of the bridge maintenance program.

MDOT has modified the condition state language for some Pontis elements to provide more specific indications of work needs[38].

Optimization of Maintenance Programs

Michigan uses spreadsheet-based procedures to forecast network conditions that may result

[37] Reed L, *MDOT Bridge Scoping*, Michigan Department of Transportation, presentation to the scan team, 2009, PowerPoint

[38] *Pontis Bridge Inspection Manual*, Michigan Department of Transportation, 2007, 96 pp

from various maintenance strategies. The spreadsheet is called the Bridge Condition Forecast System (BCFS). The inputs to BCFS are an annual budget and estimated costs for bridge replacement, bridge rehabilitation, and bridge preventive maintenance. Costs are expressed as unit cost per bridge deck area.

BCFS contains Markov-chain deterioration models for NBI condition ratings. Of the two chains, one is for untreated, continuing deterioration and the other is for the outcomes of projects to improve bridge conditions (see Figure 8.5 on page 76). BCFS provides a network-level analysis. An output of BCFS is a measure of future network performance.

Outcomes of Maintenance

Maintenance Tracking

MDOT regions use spreadsheets to schedule crew work and to report the completion of work at bridges. Periodically, lists of completed work are moved to a bridge repair history list that is part of Michigan's Bridge Reporting System. Once entered into regions' spreadsheets, work needs remain there until they are resolved; unmet needs remain visible for scheduling.

Inspection Quality

Michigan conducts QC reviews of 10% of all state bridge inspection reports. All bridge owners and each DOT region undergo QA review by the DOT central office at 10-year intervals. In the QA process, the central DOT office makes file (office) and field reviews and provides advice to bridge owners on improvements to inspection programs.

Capital Preventive Maintenance (CPM)				**CPM Effectiveness 3 years**					
Percent Pavement Condition Worked On (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
					0.5	0.5			
CPM Moved to (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
					0.25	0.5	0.25		
Rehabilitation									
Percent Pavement Condition Worked On (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
0	0	0	0.17	0.33	0.32	0.18			
Rehab Moved to (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
					0.3	0.55	0.15		
Replacement (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
0.9					0.1				

Figure 8.5 *Michigan bridge condition forecasting system – improvement probabilities*

Replace Moved to Replacement (NBI condition rating)									
0	1	2	3	4	5	6	7	8	9
								0.5	0.5

Figure 8.5 *Michigan bridge condition forecasting system – improvement probabilities (continued)*

Effectiveness of Maintenance

MDOT holds annual bridge maintenance conferences attended by region crews, bridge inspectors, bridge engineers, county personnel, and material and equipment suppliers. The conference lasts for one and a half days and is attended by nearly 200 people.

MDOT central office maintenance personnel work daily with different regional crews and offer advice from their statewide experiences.

MDOT's statewide bridge committee meets monthly to discuss bridge needs.

Maintenance Budget

Michigan's annual budget for bridge operations is $185 million:

- $163 million is distributed to DOT regions for replacements, rehabilitations, and preventive maintenance.
- $16 million is allocated to the Big Bridge Program.
- $3 million is allocated to special needs, such as emergency maintenance.
- $3 million is allocated to Michigan's emerging technology program for trial applications of new materials and methods.

U.S. federal HBP funds make up $110 million of Michigan's bridge operations budget. Other federal programs, such as interstate maintenance, surface transportation, and national highway system funds, are also used to fund bridge preservation projects.

Funds are distributed to regions based on their proportion of statewide inventory in each work category. For each region, the inventory of bridges in each work category (i.e., prevention, rehabilitation, and replacement) is computed. The work categories have significantly different costs. The average cost of a bridge preventive maintenance project is $450,000. The average cost of bridge replacement is $2.2 million. In 2009, Michigan will execute 118 preventive maintenance projects, 87 rehabilitation projects, and 51 replacement projects.

Federal HBP Funds for Preventive Maintenance

Michigan applies some federal HBP funds to preventive maintenance projects. (FHWA approval came in 2002.) Michigan's systematic process employs several data systems: the BCFS; the Michigan Bridge Reporting System; Pontis; and Possible Projects, an automated

scoping tool. Michigan's program for preventive maintenance has reduced the rate of deterioration for trunkline bridges. In 1999, 200 bridges transitioned to poor condition. In 2008, only 50 bridges transitioned to poor condition[39].

Data Systems

MDOT has a central Oracle database for information about its highway network. The database supports six management systems for six distinct asset classes. All assets are located using a linear referencing system. The database has a transportation management system (TMS) shell that delivers access to a variety of user portals, each of which supports a specific use and provides a specific level of access to data. The TMS also serves the FHWA edit/update program for annual NBI reporting.

Bridge Condition Forecasting System

MDOT's BCFS uses Markov-chain deterioration models for NBI condition ratings. Markov transition probabilities are updated each year with NBI ratings from MDOT's inspections. BCFS is a tool to study the effects of a mix of maintenance projects and the resulting future conditions of the network. The mix and the number of maintenance projects are determined by funding. BCFS is also used to forecast the outcomes resulting from input levels of funding.

Michigan Bridge Inspection System

Inspectors use the MBIS to complete bridge safety inspection reports. Owners access MBIS to identify the types of inspection needed (e.g., routine, fracture-critical, or underwater) and to assign inspectors. MBIS is accessible over the Internet and is available 24 hours a day. Inspectors also use MBIS to update their credentials annually, to get assignments to inspections, to retrieve previous inspection reports in preparation for the next cycle, and to input their reports for completed inspections.

MBIS has multiple levels of data security. Each bridge owner sees only his or her own bridges. Inspectors can modify only the inspections assigned to them. Access overall is limited to persons having a legitimate need for the system.

Most data entries are from drop-down lists, reducing stray or miscoded entries and typographic errors. Even the inspectors' names are provided on drop-down lists, since the population of qualified inspections is an established list in any one year.

MBIS also allows input of action plans, such as scour action plans. Bridge plans and photographs are not currently linked to MBIS records.

Michigan Bridge Reporting System

The Michigan Bridge Reporting System (MBRS) helps in the formation of five-year plans and in the regions' response to the DOT central office's call for projects. The MBRS lists critical

[39] Gill A, *Bridge Program*, Michigan Department of Transportation, presentation to the scan team, 2009, PowerPoint

structures, structurally deficient bridges, bridges that are eligible for federal bridge funds, and other information.

MBRS provides Web-based access for secure viewing and collection of data from Michigan's TMS database. The data are available to bridge owners, local agencies, and their consultants; MDOT establishes appropriate account and login privileges for each party. MBRS lists programmed work together with the scope and costs of projects.

Possible Projects

MDOT has recently developed an application for automated project scoping based on condition ratings and inspectors' work recommendations. Possible Projects is a spreadsheet that assembles projects for bridges, estimates project costs, and forecasts network performance measures for input levels of funding.

Possible Projects analyzes entire projects at individual bridges. This is distinct from the Pontis BMS approach for network-wide work on similar elements. A sample of Possible Projects output is shown in Table 8.5.

		Condition					
Structure number	**Facility**	**Deck**	**Super**	**Sub**	**Surface**	**Paint**	**Possible projects – work description**
1783	I-96 BL (GRAND RIV)	6	6	6	7		Joint repair (insp. rec.) + repair reinf. concrete railing (insp. rec.) + submerged pile cap/footing repair + submerged pile repair
1785	I-96 EB	5	7	7	7	N	Pier wall repair
1786	I-96 WB	5	7	6	7	N	Pier wall repair
1787	CLINTONIA RD	6	6	6	8	6	Pier wall repair
1788	JONES RD	6	6	6	6		Repair reinf. concrete railing + pier wall repair
1791	M-100	3	5	4	5	N	Replace deck (cs5) + pier wall repair
1793	I-96 EB	6	6	6	6		Joint repair (insp. rec.) + repair reinf. concrete railing + pier wall repair
1794	I-96 WB	6	6	6	6		Joint repair (insp. rec.) + repair reinf. concrete railing + pier wall repair
1795	US-127	4	4	5	7	N	Repair reinf. concrete railing + repair unpainted steel stringers + full paint unpainted steel stringers + pier wall repair

Table 8.5 *Michigan's possible projects*

Pontis BMS

MDOT has been using Pontis BMS and performing element-level bridge inspections since 1995. Michigan has 350,000 element-level inspection records for the state-owned bridges. Local agencies have 36,000 element-level inspection records for 2,000 structures.

Michigan finds that smart flags are important to the effective use of agency rules in the Pontis preservation model. (Flags indicate specific work needs at elements.) An example of Michigan's use of smart flags in agency rules is shown in Table 8.6.

Priority	Criteria	Action				
		State 1	State 2	State 3	State 4	State 5
1	Bottom surface smart flag > 50% State 5	Do nothing	Do nothing	Replace deck	Replace deck	Replace deck
2	Deck spall >30% State 2 or worse	Do nothing	Element repair (patch deck)	Overlay deck	Replace deck	Replace deck
3	Deck bottom surface > 50% State 4 or worse	Do nothing	Overlay deck	Overlay deck	Deep overlay	Replace deck
4	Deck spall > 15% State 2 or worse	Do nothing	Element repair (patch deck)	Overlay deck	Shallow overlay	Replace deck
5	Deck cracking > 50% State 3 or worse	Do nothing	Overlay deck	Overlay deck	Shallow overlay	Replace deck
6	Deck bottom surface > 50% State 2 or worse	Do nothing	Overlay deck	Overlay deck	Shallow overlay	Deep overlay
7	Deck cracking > 50% State 2 or worse	Do nothing	Overlay deck	Overlay deck	Shallow overlay	Shallow overlay

Table 8.6 *Michigan agency rules for bare concrete deck* [40]

Michigan is currently comparing outputs from the Pontis preservation model with Michigan's ongoing process for selecting and programming bridge projects. Michigan seeks a set of agency rules that yields Pontis outputs that most nearly match Michigan's existing selection process. At present, Pontis outputs for bridge projects are similar to Michigan's decisions for about one third of its projects. For other projects, Pontis outputs can indicate either lesser or greater scope than Michigan engineers would select.

Deterioration models in Pontis require large amounts of data to populate all transition probabilities for all elements in all environments. Michigan has a large set of element-level inspection data, but still does not have sufficient data to populate all transition probabilities.

[40] Kelley R, *Michigan Pontis Update*, Michigan Department of Transportation, presentation to scan team, 2009, PowerPoint

Maintenance Management System

Bridge crews use an MMS that tracks costs and production in broad work categories. The MMS does not record the specific repairs and repair products applied to individual bridges.

Maintenance Activity Reporting System – Southwest Region

Michigan's Southwest region uses its Maintenance Activity Reporting System to plan, schedule, track, and report maintenance costs and accomplishments.

Materials and Methods

Innovation in Crew Maintenance Methods – Southwest Region

MDOT's southwest region has specialty maintenance crews that are staffed by 20 TMWs in the summer and eight TMWs in the winter. The specialty crews repair spalled areas on bridges along the region's main corridors on a two-year cycle.

The region has its own mobile concrete mixing truck, improvises other equipment for channel work, and has adapted a power washer from converted mudjacking equipment. The members of the specialty crews have all completed the NBI bridge inspection course.

The specialty crews coordinate with the MDOT central construction testing lab for trials of new products and materials, which can include materials not yet on Michigan's qualified products list. In these trials, Michigan's construction testing lab gets crew input for product evaluation.

Work at bridges is coordinated where possible. Joint repairs are done together with deck patching operations. Types of joint repair are matched to deck conditions. For example, joint repairs for decks in poor condition and likely to become candidates for rehabilitation or replacement can be placement of a hot rubber seal to stop leaks.

The specialty crews spend 90% of their time on work recommendations from bridge inspection reports.

Deck Treatments

Michigan DOT uses healer-sealers with a broadcast layer of sand aggregate for traction. The healer-sealer hardens more quickly than thin epoxy overlay, and it penetrates. Products used by Michigan include Unitex[41] and Polycarb[42]. Thin epoxy overlays are used in a two-layer system with a chipped flint rock aggregate for skid resistance.

Joint Seals

MDOT has a procedure for splicing joint glands to make repairs without full replacement of the glands. The adhesive for a gland splice is Flexi-Tech (Thortex[43]), an adhesive used by the military to repair bullet holes in tires. Flexi-Tech is a two-part rubber compound that mixes and handles like two-part epoxies. Set times are about 5 minutes. Flexi-Tech is available in different rubber flexibilities. (Refer to the Shore[44] Durometer, a hardness measure for polymer materials.)

Crack Sealing

MDOT seals cracks in concrete decks both with broadcast healer-sealers and by chasing cracks with epoxy. The choice of method depends on the prevalence and spacing of cracks. Cracks close together are repaired with broadcast applications. Cracks farther than 2 feet apart are chased[45].

[41] http://www.unitex-chemicals.com/Products/default.aspxwerPoint
[42] http://www.poly-carb.com/
[43] http://www.thortex.com/products.html
[44] http://www.matweb.com/reference/shore-hardness.aspx
[45] Johnson T, University Region, Michigan DOT, presentation to the scan team, 2009, PowerPoint

CHAPTER 9

New York State

The scan team collected information on New York State DOT's (NYSDOT's) bridge maintenance program from Peter Weykamp, the New York Bridge Program Maintenance Engineer and co-chair of this scan project.

In New York, all minor repairs, cyclical maintenance, and demand work (i.e., unscheduled work) are considered bridge maintenance. Activities as substantial as partial deck overlays are considered bridge maintenance (see Table 9.1).

Category	Note
Cyclical maintenance	Activities to be done on a cycle (e.g., washing bridges, lubricating bearings, and sealing concrete surfaces)
Minor repairs	Activities that restore bridge elements to the original condition or repair impending safety issues (e.g., spall repair, minor joint repair, and bolt tightening)
Corrective maintenance, major repairs	Repairs that are larger in scope and require substantial effort to restore deteriorated components (e.g., cap beam/pier column repair, wing wall replacement, structural concrete repairs, and steel beam repairs)
Major bridge rehabilitation, replacement and construction	Work that requires initiation of a complete design review process

Table 9.1 *New York maintenance categories*

Preventive maintenance in New York includes maintenance painting of structural steel, repair/replacement of expansion joints, brush-hogging of slopes, maintenance of scour protection systems, washing of bridges, cleaning of drainage systems, and sealing of concrete surfaces.

Documents

Three documents guide bridge maintenance practice in New York State.

- *Fundamentals of Bridge Maintenance and Inspection*[46] reviews common types of bridge distress and practical methods for maintenance and repair. *Fundamentals* includes cyclic preventive maintenance actions with suggested intervals for their use. It also presents element-specific methods for preventive maintenance. All work is intended to extend the service life of bridges.

[46] *Fundamentals of Bridge Maintenance and Inspection,* New York State Department of Transportation, Operations, Office of Transportation Maintenance, 2008, 74 pp

- *Maintenance and Operations First Guidance*[47] is DOT-wide guidance issued for all asset classes. Maintenance focuses on a practice of providing maintenance first and avoiding larger repairs later. With Maintenance, NYSDOT makes a conscious decision to approach infrastructure management by keeping good infrastructure in good condition. Maintenance includes specific guidance on maintenance activities to perform, as well as suggested cycles.
- *Deck Evaluation Manual*[48] is a basic, single reference for bridge maintenance engineers. It presents methods for evaluation of decks, procedures for collection and interpretation of data, and criteria for selection of maintenance methods. *Deck* presents treatments, the correlation of deck treatment with deck age, and cost-effective strategies for deck preservation.

An additional manual, called the *Bridge Preservation Manual*, is in preparation by NYSDOT. *Bridge* is geared to regional bridge engineers. Preservation topics are collected as modules, of which two are complete: "Use of Sacrificial Anodes" and "Steel Bearing Replacement Using Elastomeric Bearings." Two more modules will be complete by the end of summer 2009: "Steel Repair Procedure Guidelines" and "Thin Polymer Overlays."

Bridge Maintenance Program

Inventory

The bridge inventory in New York includes more than 7,600 state-owned highway bridges, 8,200 state-owned culverts, and 8,500 highway bridges maintained by local governments (see Table 9.2).

State-owned highway bridges > 20 feet	7,643
Other highway bridges > 20 feet	206
State-owned highway bridges ≤ 20 feet (large culverts)	8,200
High mast lights	500
Overhead sign structures	5,198

Table 9.2 *New York structures inventory*

Maintenance Execution

Bridge maintenance in New York is accomplished by state crews and by contract. The workforce for state crews numbers about 550 people. NYSDOT has special crews and special job titles for bridge maintenance crews. Maintenance contracts can be site contracts or job-order contracts.

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[47] *Maintenance and Operations First Guidance*, New York State Department of Transportation, Operating Division, 2004, 28 pp

[48] *Bridge Deck Evaluation Manual,* New York State Department of Transportation, Structures Design and Construction Division, 1992, 88 pp

Crews

DOT maintenance crews are engaged in snow removal operations during winter months and are available for bridge work at other times. The budget for snow removal provides crew members' salaries. Funding directed to crew maintenance furnishes materials, equipment, and specialized services needed to support fieldwork.

A professional engineering review of maintenance plans is needed for some repairs, such as structural lifting, repairs to steel girders, and repairs in response to critical findings.

Contracts

New York uses job order contracts to complete maintenance work that is considered too extensive, difficult, or time-consuming for DOT crews. This type of contract is awarded with defined work items, but without specified quantities. Regional bridge maintenance engineers (RBMEs) use these contracts when needed. Job order contracts often provide in-kind replacements of bridge components.

Permits

Each DOT region is staffed with two environmental professionals, one for construction projects and one for maintenance work. Staff in the Office of Environment in the NYSDOT central office supports these personnel.

Maintenance Goals

NYSDOT's mission is to maintain and preserve the transportation infrastructure in a safe and efficient manner. New York has explicit goals for work effort directed to maintenance and goals for network-wide reductions of defects. Bridge maintenance goals are:

- Direct 25% of hours of state forces to preventive maintenance activities
- Reduce the number of deficient bridge joints by 20% each year.
- Reduce the number of deficient substructures by 20% each year

Additional maintenance goals in NYSDOT are listed in the commissioner's capital plan :

- Give priority to more highly utilized assets, particularly those in the interstate and national highway system
- Perform appropriate preventive and corrective maintenance activities as detailed in the department's Maintenance and Operations Plan
- Give priority to the rehabilitation or replacement of bridges with seriously deteriorated critical elements (condition rating less than 3)

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[49] *Glynn AC, Multimodal Transportation Program Submission: 2009–2014.* New York State Department of Transportation, 2008, 55 pp

- Give priority to maintaining bridges on interstate routes in good condition (average condition rating greater than 4.5) and bridges on national highway system routes in at least fair condition (average condition rating greater than 4)
- Reduce load restrictions on bridges on interstate and other national highway system routes
- Give priority to maintaining large culverts in at least fair condition (structural and obstruction ratings 4 or better)

Maintenance Strategies

NYSDOT has three overlapping strategies that guide maintenance work programs. At least 25% of maintenance effort is directed to bridges in good condition. Joint condition is tracked, and bad joints are repaired promptly to avoid future damage to other components. A vertical-down strategy repairs bridges with good decks and superstructures, but poorer substructures[50].

Maintenance Staffing Levels, Training, and Longevity

NYSDOT's job titles and personnel numbers for bridge maintenance are listed in Table 9.3.

State forces bridge maintenance (full time):	Count		State forces field crews (seasonal):	Count
Bridge maintenance program engineer	1		Bridge repair supervisor 2	41
Assistant bridge maintenance program engineer	2		Bridge repair supervisor 1	82
Regional bridge maintenance engineer	11		Bridge repair mechanic	164
Assistant regional bridge maintenance engineer	18		Bridge repair assistant	230

Table 9.3 *New York maintenance staffing*[51]

NYSDOT's requirements in training and certification vary with job title and level of responsibility (see Table 9.4). NYSDOT recently created a skills training program that delivers instruction in many common repair activities. DOT bridge crew supervisors developed the program.

[50] *Maintenance and Operations First Guidance,* New York State Department of Transportation, Operating Division, 2004, 28 pp

[51] Weykamp P, *Draft Response to Amplifying Questions,* New York State Department of Transportation, 2009

Bridge maintenance program engineer and regional bridge maintenance engineer
Professional engineering registration
Applicable work experience (i.e., structures inspection and repair)
Assistant bridge maintenance program engineer and assistant regional bridge maintenance engineer
Applicable work experience (i.e., structures inspection and repair)
Professional engineering registration, if available
Field crew supervisors
Competitive exam
Applicable work experience (bridge repair)
Field crews
Applicable work experience (bridge repair)
Welders
NYSDOT welder certification

Table 9.4 *New York maintenance staff qualifications*[52]

Among current staff, NYSDOT's maintenance program engineer has been in the position for 12 years. The RBMEs have been in their positions for five years on average.

Maintenance Decisions

NYSDOT's bridge maintenance program engineer (BMPE) in the central DOT Office of Operations establishes program direction, initiatives, and innovations. The BPME works with Region Bridge Maintenance Engineers (RBMEs) in each of these areas. NYSDOT's engineers use information from the Bridge Data Management System (BDMS) to evaluate bridge work histories, performance of new product applications, and outcomes of research efforts. The BPME, the RBMEs, and other bridge managers in NYSDOT and in other agencies share information about their bridge maintenance methods and products. The BPME is the primary liaison for NYSDOT to the community of practitioners for bridge maintenance.

Identification of Maintenance Needs

DOT regions develop lists of maintenance needs and plans for maintenance work. The RBMEs and their assistants use inspection reports, bridge field reviews, bridge work histories, and input from bridge repair specialists 2 (field supervisors of bridge crews) to identify the bridges and maintenance actions to add to work plans. Bridge inspection reports provide much of the

[52] Weykamp P, *Draft Response to Amplifying Questions,* New York State Department of Transportation, 2009

input to decisions on bridge maintenance. The RBMEs and their assistants review condition ratings and inspectors' comments and relate these to regions' local knowledge of bridge history to develop maintenance programs. The general process is shown in Figure 9.1.

Intervals for cyclic maintenance are set by Maintenance and Operations First guidelines[54]. The regional structures engineers program bridge-painting projects based on condition ratings for paint.

Communication among the parallel activities for crew work, contract work, cyclic work, and painting work is achieved in New York's regional structural management teams.

NYSDOT's bridge inspectors do not make recommendations for maintenance work. Inspectors assign flags for conditions that must be addressed by bridge maintenance and provide reports for DOT maintenance staff to review and make separate determinations for bridge maintenance work. NYSDOT makes element-level inspections. Regional inspection programs are directed by RBMEs.

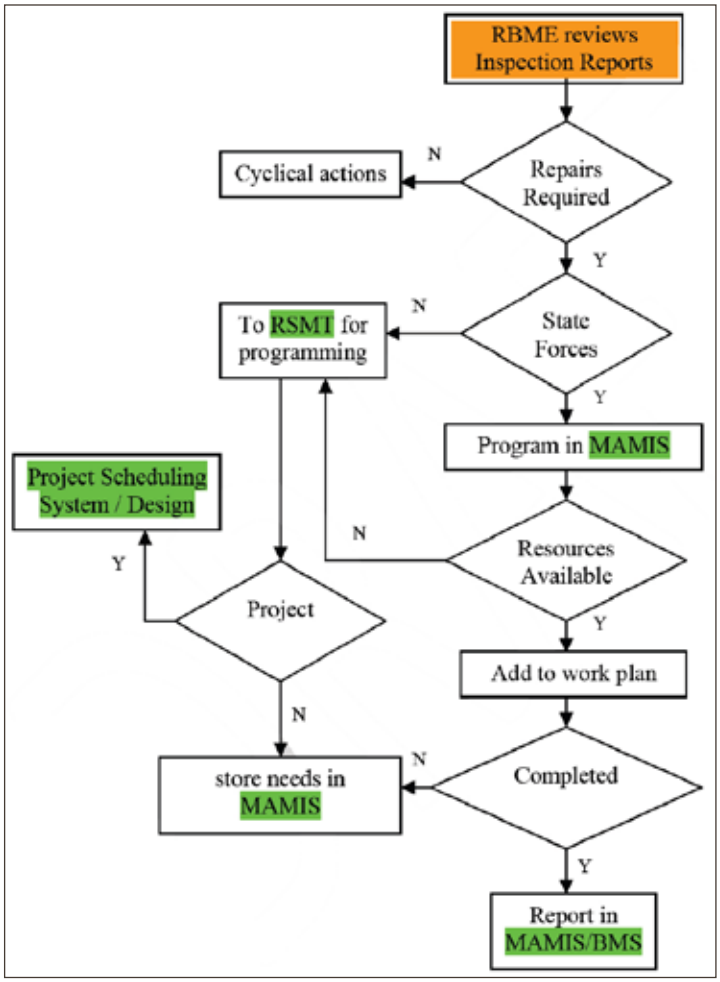

Figure 9.1 *New York maintenance needs and actions process*[53]

Programming Process

RBMEs develop work plans for DOT crews. Planning is completed in winter months when field personnel are engaged in winter operations and executed in summer months when they are transferred to repair activities. Work plans are subject to approval by the regional directors of operations.

Regional structures engineers develop contract programs for capital bridge maintenance and work with regional structural management teams in selection of bridges and maintenance actions. These teams include the regional structures engineer, the RBMEs, and other staff engaged in structures management.

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[53] Weykamp P, *Draft Response to Amplifying Questions*, New York State Department of Transportation, 2009

[54] *Maintenance and Operations First Guidance*, New York State Department of Transportation, Operating Division, 2004, 28 pp

Priorities of Maintenance Needs

NYSDOT uses a system of structural flags to indicate urgency of conditions at bridges.

- **Red structural flags** indicate failures or potentially imminent failures of primary structural components. Potentially imminent means that failure is likely before the next scheduled inspection. Red flags must be resolved within 42 days.
- **Yellow structural flags** indicate potentially hazardous conditions that will probably become clear and present dangers if left unresolved beyond the next scheduled inspection. Yellow flags can indicate actual or imminent failures of noncritical structural components, if failure of those components would reduce bridges' reserve capacity or redundancy. Yellow flags are not used for needs in routine maintenance or repair. Yellow flags must be resolved by the next inspection cycle, typically two years.
- **Safety flags** indicate conditions that are clear and present dangers to vehicular or pedestrian traffic. Safety flags do not imply structural deficiencies. Safety flags may be used for closed bridges when bridge conditions threaten vehicles or pedestrians passing beneath them.

Inspectors may recommend prompt interim action when red flags or safety flags are extremely serious and need immediate attention. Action must be taken within 24 hours and may impose closures or load restrictions until permanent repairs are made.

NYSDOT's bridge program is part of the statewide capital program and is developed by the DOT's regional and main office bridge managers using statewide guidance on strategic goals set by DOT executives. Using computer applications, various asset-oriented groups of staff contribute to program development. Computer applications include the Bridge Program Worksheet and the Needs Assessment Tool (both Microsoft Access applications) and the Bridge Needs Assessment Model (BNAM). The tools are complementary and are used to identify individual bridge needs as well as network-level needs.

NYSDOT's computer applications implement the DOT's bridge management decision logic developed in the mid-1990s. Decision logic is based on inspection data that are aggregated into bridge component indices that are the basis for identification of bridge capital and maintenance needs.

Project Selection

New York selects bridge projects to keep bridges on interstate routes at condition ratings 4.5[55] or better, to provide adequate vertical clearances (again with priority for bridges over interstate routes), and to incorporate priorities of metropolitan planning organizations. Programs are formed within constraints of available funding.

[55] NYSDOT uses a 0 to 7 condition rating scale, with 7 being the best condition.

Effect of Cost, Urgency, and Traffic Impacts

Along routes with high traffic and for nearly all state-owned bridges in large metropolitan regions, maintenance work is done at night or on weekends to reduce impacts to traffic.

DOT Staff Involvement in Programming Decisions

Regional DOT staff participates in regional structures management teams to plan maintenance work. Regional program and planning engineers determine the final programs.

Maintenance Programming Administration

DOT executive management sets regional budget allocations. Regions develop their capital programs in keeping with DOT goals, the goals of metropolitan planning organizations, and the needs identified by regional structures management teams. Final capital programs are reached in an iterative input and review process to satisfy needs and remain within budget. Longer-term plans are frequently revised.

DOT Regional Administration

RBMEs report directly to regional directors of operations. RBMEs oversee two to three assistants who, in turn, oversee two to five field crews. A typical crew includes 12 to 15 people; there are 41 crews across the state. The NYSDOT regional organization is illustrated in Figure 9.2.

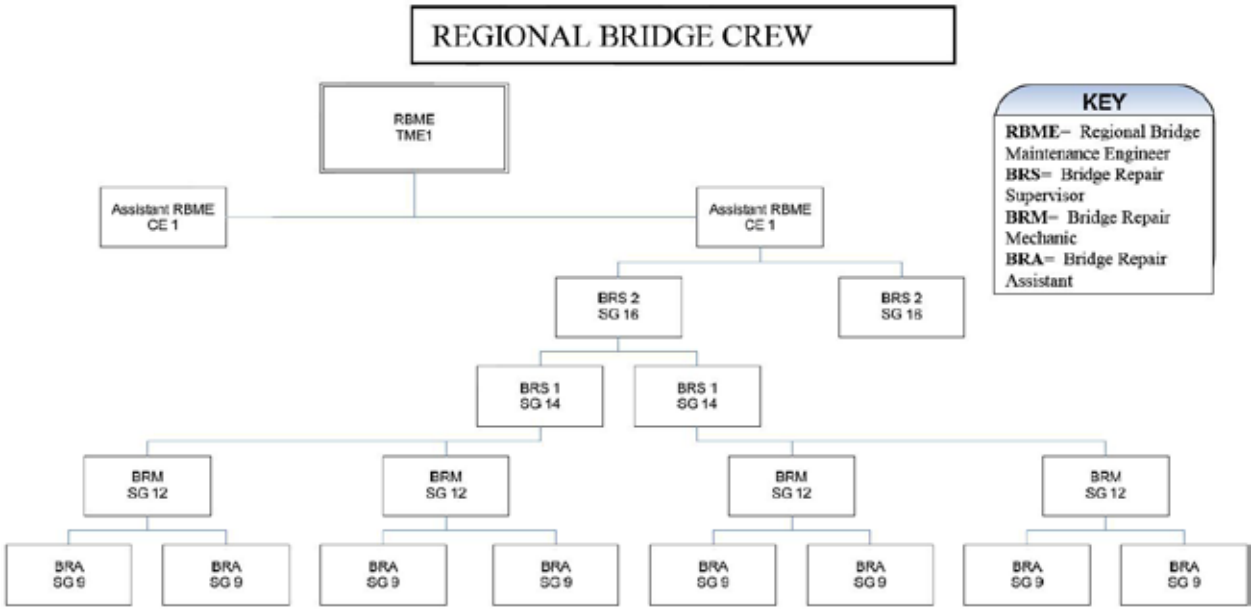

Figure 9.2 *New York regional bridge maintenance staff*[56]

[56] Weykamp P, *Draft Response to Amplifying Questions*, New York State Department of Transportation, 2009

Highway Maintenance Versus Bridge Maintenance

Within each DOT region, a resident engineer is assigned to each county for highway (pavement) maintenance work. Regions' bridge maintenance engineers have region-wide responsibility.

Performance Measures and Priority Indicators

NYSDOT tracks the state's bridge condition ratings as indicators of needs and as performance measures. The bridge condition rating is a weighted average of 13 structural bridge component ratings assigned during bridge inspections. Bridges with an average condition rating less than NYS 5 are considered deficient, while bridges with an average condition rating less than NYS 3 are considered critically deficient.

Optimization of Maintenance Programs

NYSDOT focuses on deficiencies in development of bridge programs. New York has a bridge safety assurance (BSA) group within the structures division that identifies bridges that are vulnerable to scour, seismic, impact, overload, or fatigue events. Vulnerabilities are considered when prioritizing bridge projects.

Outcomes of Maintenance

Maintenance Tracking

Work done by DOT crews is recorded in a maintenance asset management information system (MAMIS), which provides detailed data on activities, hours, equipment, materials, and labor costs. MAMIS stores maintenance needs identified by RBMEs and regional work plans for crews. It provides a year-end summary of completed work that is transferred to New York's bridge inspection database. Work done by contract is tracked by project designers and stored with bridge inventory data.

Inventory Data and Maintenance Work

Significant changes to in-service bridges are recorded as as-built modifications to design plans. Generally, most maintenance-related work does not involve design changes. RBMEs are included in reviews of detailed plans prior to letting of bridge projects. Bridge designers may use RBME input in revisions to detailed plans.

Maintenance Backlog

NYSDOT estimates costs of maintenance needs that remain unmet. The current maintenance backlog is $2.69 million.

Effectiveness of Maintenance

Bridge maintenance and repair methods are evaluated both by the RBMEs and staff, and also through the bridge inspection process.

Communication

New York holds quarterly meetings of RBMEs, field supervisors, and interested personnel from NYSDOT and from other agencies. In addition, NYSDOT's bridge maintenance group publishes a bimonthly bridge maintenance newsletter.

Bridge Design Practice

Designated liaisons from the DOT Structures Division and the DOT Technical Services Division attend statewide RBME meetings. Minutes are taken and posted on the bridge maintenance Internet site. Recently, some of the proceedings have been made available as webinars. Suggested modifications to existing specifications and/or design details, new products used by DOT maintenance crews, and other topics are discussed during meetings and conveyed to program areas by liaisons.

Maintenance Accomplishments

NYSDOT uses its BNAM to demonstrate the success of bridge maintenance. BNAM provides distinct deterioration curves for each bridge construction material and each of the state's DOT regions. BNAM allows NYSDOT to study the outcomes in conditions in the bridge network as a function of funding levels and allocations to preventive or corrective maintenance. BNAM indicates outcomes as deficient inventory, average condition ratings, and user costs for various work strategies. BNAM's forecasts for the 2008–2015 planning period are shown in Table 9.5.

	Bridges					
Investment priority	**Percent deficient by number**	**Average condition rating by number**	**Percent deficient by area**	**Average condition rating by area**	**Excess user cost ($mm)**	**Cumulative # of bridge projects**
March 2008	24.61	5.367	18.67	5.47	404.70	1,651
B/C ratio	27.61	5.375	20.01	5.524	153.4	1,437
Worst condition rating first	21.28	5.545	22.82	5.544	315.47	1,891
Best condition rating first	5.43	5.635	12.9	5.428	2991.89	3,226
Avoid backlog growth	2.38	5.732	18.47	5.492	1098.65	3,459
Costliest bridge work first	38.57	5.176	22.11	5.484	365.37	586
Most expensive user cost first	21.28	5.545	22.82	5.544	315.47	1,891
Least expensive bridge work first	0.38	5.751	14.22	5.48	2746.07	3,611

Table 9.5 *New York BNAM output*

Maintenance Budget

Budget allocations to the bridge program in fiscal year 2007–08 improved 296 bridges at a cost of $450 million. This amount does not include the locally administered federal-aid program that improved 53 bridges at a cost of about $257 million. Preventive maintenance activities by in-house and contract forces addressed more than 5,812 bridges at a cost of about $142 million.

The State Dedicated Fund is the primary source for funds for capital maintenance projects other than bridge-painting projects. Painting projects are funded using HBP funds. The bridge-painting program typically accounts for the largest cost in the bridge maintenance capital program.

NYSDOT's proposed capital allocations for 2009 to 2014 provide $4.486 billion for highway bridges. This proposal allocates $3.337 billion to capital construction and $1.149 billion to contract preventive maintenance. Proposed bridge capital funding provides for rehabilitation or replacement of 533 state-owned bridges. The preventive maintenance budget provides corrective and demand maintenance for 2,285 state-owned bridges and painting for an additional 1,670 bridges.

Long-Term Budgeting

NYSDOT has completed a preliminary analysis of the magnitude and impact of future long-term infrastructure needs for the years 2010 to 2030. Bridge assets in the analysis

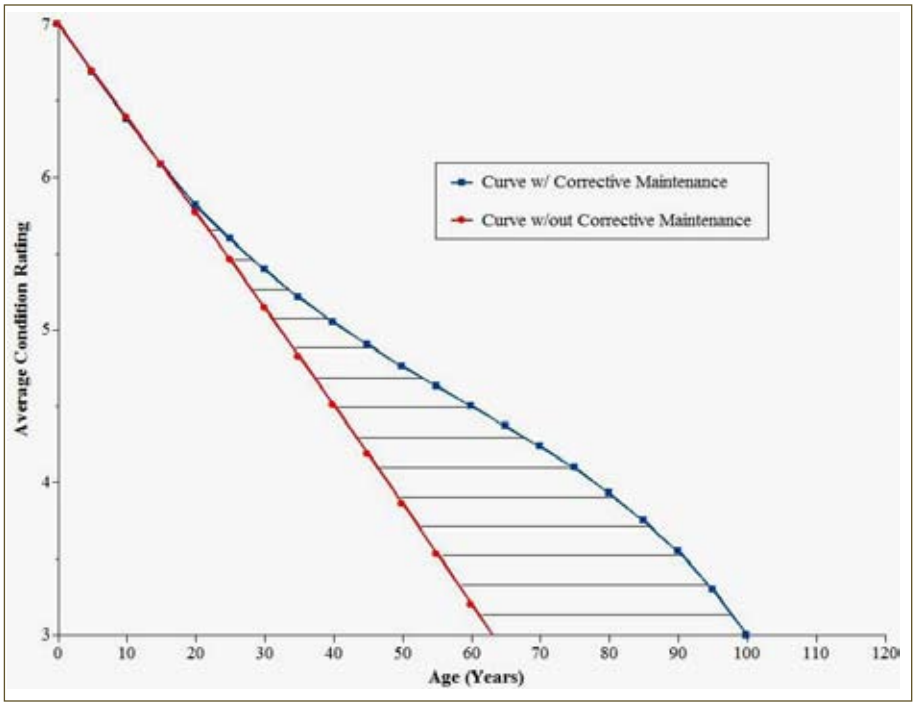

Figure 9.3 *New York forecasts of service life*[57]

[57] *Bridge Decision Making in NYSDOT*, 2009, PowerPoint

include 7,602 state-owned highway bridges and 8,551 local highway bridges. The analysis excludes bridges owned by toll authorities. Performance is measured as percentage of bridges in good and excellent condition. Recent trends show a decline in overall bridge conditions. Bridge conditions will continue to decline at current program funding levels (see Figure 9.3).

Based on the 20-year needs analysis, DOT proposes a strategy for bridges that emphasizes preservation and maintenance to keep bridges from falling into the deficient category. This strategy will help overcome the deterioration of bridges as they age and will ensure that New York gets full service life out of bridges. The bridge strategy includes major reconstruction or replacement of more than 2,800 critically deficient state-owned and locally owned highway bridges.

Funding for Maintenance and Preservation

Approximately 7.3% of the highway portion of the capital program is directed to bridge maintenance and preservation activities, mostly as cyclical and corrective maintenance by contract. This percentage will increase to approximately 8.6% in the next 5 years. The numbers do not include labor, equipment, or overhead costs for in-house bridge crews. Crew costs are estimated to be $40 million per year.

DOT maintenance crews are substantially funded through the transportation maintenance budget. An average annual allotment of $6.0 million from the state transportation funds is dispersed to regional bridge maintenance engineers. These funds are used to purchase repair materials, small tools, and other items used by the DOT bridge crews.

Research on asset management indicates that 2% of the replacement cost of an asset class should be allotted for annual maintenance. Because the replacement cost of the state-owned bridge network is estimated to be $42 billion (1997), the amount that should be allotted is approximately $840 million annually.

Average Costs for Maintenance Actions

NYSDOT's bridge maintenance group tracks project-level costs. Element-level repair contracts are used in determining activity costs. Total project costs are divided by the number of units (e.g., bridge or joints replaced) to obtain average repair costs (see Table 9.6).

Activity	Unit cost	Unit
Joints	$7,600	Joint
Deck sealing	$6,200	Bridge
Bridge cleaning	$1,500	Bridge
Corrective repairs, includes 5-7 and vertical-down	$238,000	Bridge
Bridge painting	$288,000	Bridge
Replace bearings	$3,400	Bearing
AC overlay with membrane	$86,000	Bridge

Table 9.6 *New York maintenance unit costs*

Relative Costs of Bridge Projects

Costs of treatments (minor repairs) for good bridges average $5,000 per bridge. Treatments for fair bridges average $250,000 per bridge. For deficient bridges, fixes such as rehabilitations or replacements average $3.7 million per bridge.

Federal HBP Funds for Bridge Preventive Maintenance

NYSDOT's systematic process for selection of preventive maintenance projects was approved by FHWA in 2005. Approved actions range from bridge washing to structural concrete repairs. NYSDOT forecasts a longer service life for bridges that receive preventive maintenance.

Data Systems

Bridge Needs Assessment Model

NYSDOT's BNAM is an in-house forecasting system composed of two modules: module 1 identifies needs, and module 2 analyzes outcomes. In module 1, BNAM examines conditions of existing bridges and identifies proposed work, along with associated costs. In module 2, BNAM determines the future condition of the bridge population as affected by proposed work. BNAM uses data from New York's BDMS to predict conditions in the bridge network at the end of the user-specified planning period.

BNAM uses element-level condition data in its various calculations. BNAM models are based on New York's historic bridge data. BNAM uses New York's structural rating, the weighted combination of 13 component ratings, in predictions of future conditions of bridges. Future conditions of individual components are not predicted.

Needs Assessment Tool

New York's Needs Assessment Tool identifies candidates for bridge work by region, by work type, or by route. Work types include:

- Replacement
- Major rehabilitation
- Minor rehabilitation
- Deck replacement
- Element-specific preventive maintenance (PM)
- Vertical-down PM
- Cyclical PM, such as washing, deck sealing, and painting

Prescriptive rules in the needs assessment tool follow BMS logic, incorporating existing condition rating data. Assessments are done without cost constraints. The tool can be used to forecast deteriorated condition ratings and work types for bridges at 5, 12, or 20 years. Users select deterioration models derived from the state's historical deterioration rates or

deterioration rates developed in recent research performed at the City College of New York.

Bridge Program Worksheet

New York's Bridge Program Worksheet assists in the development and presentation of regions' bridge programs. The worksheet accesses bridge condition data from the BDMS, bridge vulnerability data from the BSA database, and bridge project information from NYSDOT's Program Support System. The worksheet provides:

- Lists of bridges that require work in each of three categories: safety, preservation, and serviceability
- Indicates bridges that are currently programmed for work, flagging bridges that are not yet programmed
- Yields estimates for future network-level bridge conditions if recommended bridge projects are executed
- Gives DOT regions a network-level assessment of their bridge maintenance programs

Maintenance Asset Management Information Management System

New York's Maintenance Asset Management Information Management System (MAMIS) is a work reporting system that captures labor, equipment, activity, and materials costs by asset for all work done by in-house forces. MAMIS also stores work needs, generates work orders, and records work completion. MAMIS uses an Oracle database.

Materials and Methods

NYSDOT uses its maintenance crews to try new products and innovative techniques in bridge repair. It has been successful with its job-order contracts for maintenance work and is now trying task-oriented contracts that can provide similar projects at multiple locations with detailed designs completed as the contract proceeds. NYSDOT's use of regional structural management teams allows the department to engage staff knowledge and experience in development of bridge maintenance programs.

CHAPTER 10

Ohio

The scan team met with staff from the Ohio Department of Transportation's (ODOT's) Office of Structures and Office of Maintenance at the ODOT central office in Columbus Ohio.

ODOT has 12 districts and 88 county maintenance garages. Most of ODOT's more than 5,600 DOT personnel are based in DOT districts.

ODOT's work activities are focused on maintenance more than on new construction. About 78% of Ohio's bridge program is directed to maintenance using a fix-it-first concept. ODOT defines maintenance generally as work on bridge components, including deck, superstructure, substructure, and culverts, but excluding approach embankments and approach slabs (see Table 10.1). Ohio state statutes define terms and responsibilities in maintenance of bridges (see Table 10.2).

Major and routine maintenance and repair relates to all elements of a bridge, including abutments, wing walls, and headwalls, but excluding approach fill and approach slab, and appurtenances thereto.
■ **Major maintenance** includes the painting of a bridge, and the repair of deteriorated or damaged elements of bridge decks, including emergency patching of bridge decks, to restore the structural integrity of a bridge.
■ **Routine maintenance** includes, without limitation, clearing debris from the deck, sweeping, snow and ice removal, minor wearing surface patching, cleaning bridge drainage systems, marking decks for traffic control, minor and emergency repairs to railing and appurtenances, emergency patching of deck, and maintenance of traffic signal and lighting systems, including the supply of electrical power.

Table 10.1 *Ohio maintenance terms*

Ohio Revised Code[58]	
Article	**Heading**
5501.14	District responsibilities for maintenance; general maintenance provisions
5501.31	Director's authority to construct, maintain, etc.
5501.47	Bridge inspections
5501.49	Lift bridge inspection
5511.01	State not required to maintain within municipalities
5511.02	Authority to construct and maintain limited access highways
5515.03	Authority to remove obstructions

Table 10.2 *Ohio statutes related to bridge maintenance*

[58] *Ohio Revised Code,* http://codes.ohio.gov/orc/; see Title [55]

5517.03	Authority to close highways
5517.04	Maintenance of detour and local detour
5521.01	Authority to improve or maintain inside municipal limits with consent
5543.17	County engineer duty to avoid closures during construction

Table 10.2 *Ohio statutes related to bridge maintenance (continued)*

ODOT identifies several categories of bridge maintenance work (see Table 10.3). Categories are related to costs. State statute requires that ODOT seek competitive bids on any project at one bridge that will cost more than $50,000. The cost limit applies to direct expenditures for DOT crew work and to total amounts for contract work. As a result, routine, nonbid maintenance work is limited to deck patching and other minor repairs or local treatments.

Maintenance Category	Maintenance Actions (examples)
Cyclic maintenance	Bridge cleaning
Preventive maintenance	Cleaning, minor repairs, major repairs, component treatments, component replacements, and sealing concrete surfaces
Scheduled maintenance	Expansion joint replacement, deck replacements and overlays , painting structural steel, paving flowlines, and replacing headwalls on culverts
Reactive maintenance	Deck patching and corrective repair from accidents, weather, etc.
Minor maintenance	Work that has no effect on general appraisal or load rating of structure
Major maintenance	Work that has an effect on general appraisal or load rating of structure

Table 10.3 *Ohio maintenance categories*

Documents

Ohio's documents related to structures maintenance include Ohio's *On-Line Bridge Maintenance Manual*[59], the *Maintenance Administration Manual*[60] , the *TMS Foreman's Manual*[61], the *Routine Bridge and Culvert Maintenance Coding Guide*[62], and the *Culvert Management Manual*[63].

Bridge Maintenance Program

Inventory

ODOT owns more than 10,000 bridges and culverts that meet the NBI definition and another 3,500 structures of shorter span. The number of bridges in Ohio among all owners is more than 28,000 NBI-length bridges and another 15,000 short-span bridges (see Table 10.4).

[59] *On-Line Bridge Maintenance Manual,* http://www.dot.state.oh.us/Divisions/HighwayOps/Structures/bridge%20operations%20and%20maintenance/PreventiveMaintenanceManual/Pages/default.aspx

[60] *Maintenance Administration Manual,* Ohio Department of Transportation, Vols 1 and 2, no date, 112 pp and 127 pp

[61] *TMS Foreman's Manual,* Ohio Department of Transportation, 2009, 178 pp

[62] *Routine Bridge & Culvert Maintenance Coding Guide,* Ohio Department of Transportation, no date, 28 pp

[63] *Culvert Management Manual,* Ohio Department of Transportation, 2003, 78 pp

Among U.S. states, only Texas has more bridges. The deck area of bridges in Ohio is more than 144 million square feet (see Table 10.5). The Ohio Turnpike owns 560 bridges; however, the Ohio Turnpike is not a part of ODOT.

Maintenance Responsibility	NBIS length	Short bridges
ODOT	10,367	3,543
Other Ohio state agencies	468	80
County agencies	15,815	10,291
City and local agencies	1,280	811
Other federal agencies	3	2
Railroads	40	3
Private	23	34
Combination	76	21
Ohio DNR	66	60
Ohio Park District	46	12
Local transit authorities	2	–
Townships	2	177
National Park Service	1	–
Military reservations/U.S. Army Corps	7	11

Table 10.4 *bridges*[64]

Maintenance responsibility	Bridge deck area (ft^2)
Counties	30,361,072
Municipalities	9,612,509
Others	180,101
State	104,594,667
Total	**144,748,349**

Table 10.5 *Ohio bridge deck area*[65]

Maintenance Execution

ODOT executes bridge maintenance work using DOT crews and site contracts. DOT crews, most of which include four people, are deployed in each of Ohio's 88 counties. Crews only work on state-owned bridges; county governments maintain county–owned bridges. Work by ODOT crews is tracked with Ohio's TMS.

[64] *Bridge Inspection and Maintenance Collection,* Ohio Department of Transportation, 2009, PowerPoint
[65] *Bridge Inspection and Maintenance Collection,* Ohio Department of Transportation, 2009, PowerPoint

Site contracts are used for bridge work that is greater in cost or in complexity than normal crew work. Site contracts for bridges are tracked in Ohio's Ellis[66] system. DOT districts can use force-account contracts for projects that cost less than $50,000. Larger contracts require competitive bids.

Major Bridge Program

Maintenance for Ohio's major bridges is managed in a special program. Major bridges include[67]:

- Bridges more than 1000 feet in length
- Single bridges with a deck area of 81,000 ft^2 or greater
- Twin bridges with deck area of 135,000 ft^2 or greater
- Ohio river bridges
- Movable bridges
- Continuous/cantilever truss bridges
- Suspension bridges

The population of major bridges includes 160 bridges owned by ODOT and 28 bridges with maintenance responsibilities shared with either the Kentucky Transportation Cabinet or the West Virginia Department of Highways.

Ohio develops 30-year plans for maintenance of major bridges. The 30-year plans include specific recommendations for bridge projects in five-year segments (e.g., 2010–2015, 2015–2020, and 2020–2025). Plans identify specific bridges and general types of work, including component replacements, bridge rehabilitations, and bridge replacements. Proposed funding for Ohio's major bridge program is shown in Table 10.6.

	Major bridge program funding ($mm)							
	2008	2009	2010	2011	2012	2013	2014	Total
Budget	60	72	78	73	70	88	80	521

Table 10.6 *Ohio funding for major bridge program*[68]

Preventive maintenance activities for major bridges include deck sealing, concrete patching, drainage repair, bearing work, spot painting, and lift bridge maintenance.

[66] Ellis is an allusion, not an acronym. Ellis is the point of entry to Ohio project data.

[67] *30 Year Major Bridge Asset Management Plan,* Ohio Department of Transportation, 2009, 36 pp

[68] *30 Year Major Bridge Asset Management Plan,* Ohio Department of Transportation, 2009, 36 pp

Maintenance Staffing Levels, Training, and Longevity

Crews

Each DOT maintenance garage is staffed with an administrator, one or two managers, and 10 to 15 highway technicians (HTs). ODOT keeps a garage in each of Ohio's 88 counties.

Training

ODOT has a Highway Technician Academy that provides training in maintenance operations for field personnel and allows personnel to advance through job titles as they advance in training (see Figure 10.1).

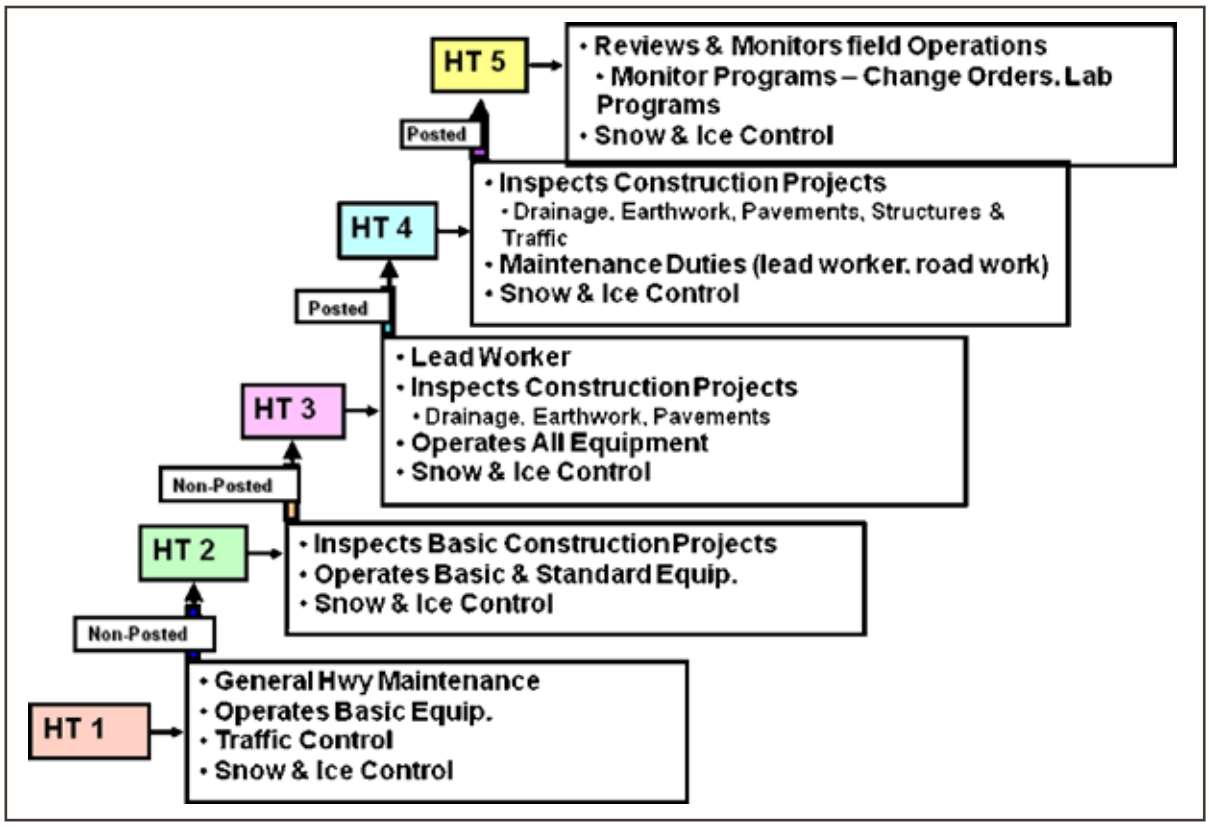

Figure 10.1 *Ohio highway technician levels*[69]

Ohio has five HT levels, with HT 1 being entry level. Each level has requirements in training, testing, and work experience. Ohio's Highway Technician Academy provides instruction in basic field repair methods, inspection of structures, and inspection of repair work at structures. Training for the highest HT levels includes topics in contract administration. The usual time period for HT 1 personnel to reach the middle-level HT 3 is between four and five

[69] Lee C, *Highway Training Academy*, Ohio Department of Transportation, 2009, PowerPoint.

years. Each higher level commands a higher salary and has greater authority. Testing is administered online.

District Engineers

Each ODOT district has a bridge engineer who is responsible for bridge maintenance and project planning. Many district bridge engineers have long experience in bridge engineering and maintenance and substantial experience in their administrative functions (see Table 10.7).

ODOT District	Years in position	Years of experience
1	12	28
2	13	30
3	12	22
4	6	27
5	8	21
6	9	14
7	1	–
8	5	13
9	12	27
10	9	22
11	4.5	22
12	5	20
Central Office	2	16

Table 10.7 *Ohio experience among district bridge engineers*

Staff Meetings

ODOT holds annual conferences for HTs. Conferences include technical presentations and a trade exhibition with vendors of materials and equipment. ODOT holds monthly meetings of district maintenance administrators and DOT central office staff for bridge operations and maintenance.

Maintenance Decisions

Identification of Maintenance Needs

ODOT makes annual inspections of all state-owned bridges with span greater than 10 feet. County supervisors make biweekly inspections of state and federal routes.

Maintenance needs are identified primarily by inspectors in their reports of annual safety inspections. Inspectors list repair needs and perform a QA review of repairs completed since the previous inspection. Inspectors make recommendations using a set of routine bridge maintenance (RBM) codes (see Table 10.8). Inspectors report the urgency and status of each recommendation

using a standard list of urgencies (see Table 10.9). Ohio's electronic inspection forms, accessed through Ohio's Bridge Management Remote Inspection (BMRI) system, provide drop-down lists for standard actions and standard urgencies.

6124 Filling and sealing joints and cracks	6156 Superstructure repair
6132 Repairing curbs, gutters and paved ditches	6157 Railing repair
6133 Repairing slopes	6160 Add channel protection
6135 Ditch and shoulder relocation	6161 Sealing decks
6142 Cleaning channels	6162 Sealing substructures
6143 cleaning drainage structures	6163 Concrete spalls

Table 10.8 *Ohio routine bridge maintenance codes*[70]

Priority			Status	
1	Immediate		1	New need
2	Schedule		2	Successful repair
3	Preventive		3	Recurring need
			4	Same (unmet) need

Table 10.9 *Ohio repair priority and status*

Maintenance needs identified during safety inspections drive much of the maintenance work program. Inspectors are based in DOT districts and work under district bridge engineers.

Ohio makes element-level inspections and reports element conditions using a 1 to 4 scale, where a condition rating of 1 is good and 4 is failed or critical condition. Among a set of similar elements in a bridge, the condition rating is reported for the worst condition observed.

County supervisors can report maintenance needs. ODOT also operates a Web site for public input on bridge and road conditions.

Programming

Bridge engineers in DOT districts examine maintenance work recommendations from bridge inspection reports and other sources and identify work as crew work or contract maintenance work. Repairs needed in response to poor ratings in bridge general appraisal, floor condition, wearing surface condition, or paint condition are performed by contract and funded under ODOT's capital bridge program. Priorities among maintenance needs are reviewed annually when the full list of maintenance needs is assembled.

[70] *Bridge Maintenance*, Ohio Department of Transportation, 2009, PowerPoint

Work items for DOT crews are passed on to DOT garage managers for their scheduling and implementation. Contract needs are handled through project development at the district level.

District Work Plans

ODOT districts develop multiyear work plans within known fiscal constraints to ensure mobility and safety and to meet target performance levels. District work plans list bridge rehabilitation and maintenance projects and the current and (forecast) future bridge conditions. Each district develops its multiyear work plan in a collaborative exercise involving staff for district planning, production, highway management, business administration, and human services.

ODOT's central Program Funds Committee uses district work plans to allocate funds. The central Division of Planning becomes administrator for financing of districts' multiyear work plans and advises districts on their projects' status. The ODOT central office publishes annual reports of projects and conditions in the highway network.

County Work Plans

ODOT develops county work plans for maintenance of state-owned bridges in each Ohio county. County work plans list the work to be performed in the current year, the three-year goals for its Organization Performance Indicator (OPI), the available resources, the level and distribution of work effort, and the expected bridge conditions that will result from the work plan. Plans report the current numbers of deficiencies in highway assets, including bridges, and indicate the expected (lower) numbers of deficiencies to be achieved.

County work plans include a section on preventive maintenance that lists cycles of application for specific work activities. County work plans are combined into district-wide work plans.

Maintenance Programming Administration

Most decisions on programming for bridge work are made in the DOT districts. The ODOT central office provides policy guidance and technical support, coordinates statewide aspects of bridge programs, keeps databases of bridge information, and tracks budgets for bridge programs.

ODOT's central office has a bridge inspection group and a bridge maintenance group. The bridge inspection group advises DOT districts on field inspection procedures, makes QA reviews, and prepares ODOT's bridge inspection manual. The bridge inspection group coordinates the schedules for reach-all units (i.e., various types of motorized lifts), oversees consultants performing bridge inspections, and provides training for county and municipal bridge inspectors.

ODOT's central bridge maintenance group develops maintenance policies and standards, monitors use of new products and methods, assists districts in assessment of structures, assesses bridge designs for maintenance and maintainability-related issues, keeps the

database of bridge maintenance costs, and provides statewide training for bridge maintenance personnel. The bridge maintenance group makes QA reviews of district programs for maintenance and repair of bridges.

Permitting and compliance with environmental regulations are coordinated through each district's environmental office, a part of DOT district planning.

Performance Measures and Priority Indicators

ODOT tracks the network-level status of roads with its OPI, which combines scores in seven aspects of condition of roads and bridges (see Figure 10.2). Bridge conditions make up 40% of ODOT's OPI.

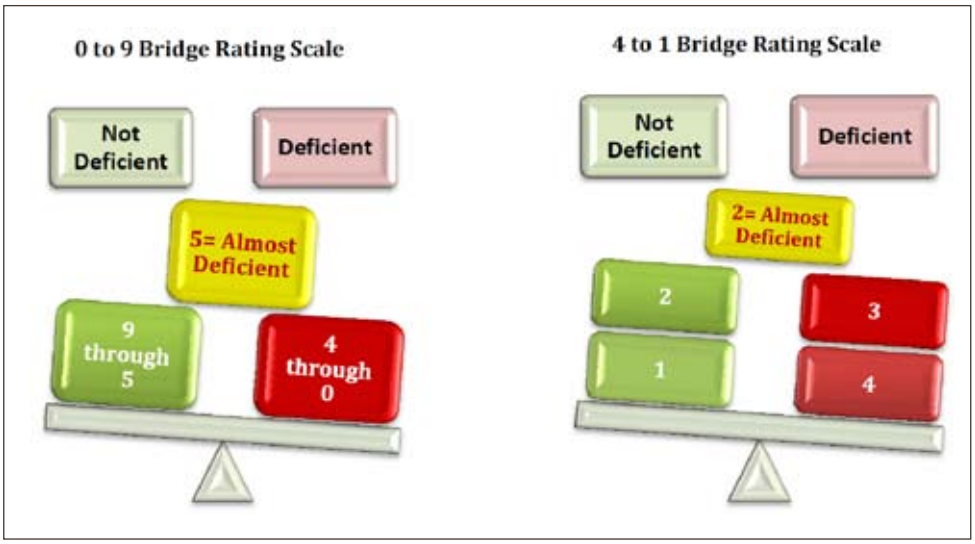

Figure 10.2 *Ohio condition rating scales*[71]

The OPI includes four bridge condition measures: general appraisal, floor condition, wearing surface condition, and paint condition. Two rating scales are used[72]. General appraisal and paint ratings are reported on a 0 to 9 scale, where 0 is poor condition and 9 is excellent condition. Floor condition and wearing surface condition are reported on a 4 to 1 scale, where 4 is poor condition and 1 is excellent condition. For the 0 to 9 scale, 4 rating is deficient; for the 4 to 1 scale, a 3 rating is deficient.

Ohio's statewide goals for bridge condition measures are:

- Nondeficient general appraisal at 96% of bridges
- Nondeficient floor condition at 96.2% of bridges
- Nondeficient wearing surface condition at 97% of bridges
- Nondeficient paint condition at 90% of bridges.

[71] *30 Year Major Bridge Asset Management Plan,* Ohio Department of Transportation, 2009, 36 ppoint
[72] *30 Year Major Bridge Asset Management Plan,* Ohio Department of Transportation, 2009, 36 ppoint

Deficient condition ratings indicate both needs for work and the general types of work (e.g., a need for deck structural work, deck surface work, bridge painting, or some other repair).

Emergency Maintenance

Needs for emergency maintenance at bridges are identified during damage inspections after extreme events, such as storms, earthquakes, or vehicle impacts. Damage inspections determine the scope and urgency of repairs and are the bases for recovery of costs of repairs, if the damage is attributed to a responsible party. Emergency repairs, when needed, are delivered by one of three types of emergency contracts:

- **Type A:** A state project to mitigate immediate public safety issues. The work is normally performed by a contractor using force account payments and can start within days of the emergency declaration.
- **Type B:** A state project to mitigate public safety issues that requires action in less than 3 weeks. Bids are collected from a short list of contractors responding to simplified plans.
- **Type C:** A state project to mitigate public safety issues that require action in less than 6 weeks. Bids are collected from a short list of contractors responding to simplified plans.

Outcomes of Maintenance

Maintenance Tracking

Completion of bridge maintenance work by DOT crews is reported through Ohio's TMS. Crews do not close out work orders. Instead, the crews' reports are sent to the bridge inspection database, and bridge inspectors verify repairs in the next safety inspection. Completion of maintenance contract work is tracked through Ohio's Ellis system.

Effectiveness of Maintenance

ODOT tracks both the OPI and the average costs of maintenance actions based on bridge deck area.

Quality Assurance

As one part of QA for bridge inspections, Ohio's central office attaches stickers to a few, randomly selected bridges. Inspectors must note the discovery of a sticker in their inspection report. The central office tracks the percentage of stickers discovered as a measure of thoroughness of bridge inspection work. About 15 bridges in each district are fitted with stickers each year.

Maintenance Budget

ODOT's programs for roads and bridges have a budget of $1.9 billion for the 2010–11 biennium (see Table 10.10). ODOT, using federal economic recovery funding, places an emphasis on projects for maritime, rail, and multimodal transportation. The budget for bridge preservation is $193 million in 2009 and is expected to increase to $235 million by 2013. Ohio's allocations

of funds are shifting from new construction to preservation and to ODOT's fix-it-first approach to bridge maintenance.

Spending categories	2008	2009	2010	2011
Fix-it-first	56%	60%	73%	78%
Safety, statewide, and local preservation	19%	20%	21%	21%
Major new construction	25%	20%	6%	1%

Table 10.10 *Ohio budget allocations*[73]

Bridge Preservation

ODOT allocates bridge preservation funding in proportion to the bridge inventory that is expected to become deficient if maintenance is not performed. Deficiency may be in any of the four OPI factors: general appraisal, floor condition, wearing surface condition, or paint condition.

Funds Management Committee

ODOT's Funds Management Committee makes recommendations on allocations of DOT funds. The committee includes the DOT deputy director of planning, senior leadership for DOT districts, and representatives from central office groups for finance, highway operations, facilities, local programs, safety, traffic, and structures. The committee monitors capital programs as these are affected by cost modifications and inflation, as well as by changing pavement and bridge conditions.

Capital Balance Committee

ODOT's Capital Balance Committee meets weekly to track the financial impact of district work plans, to monitor program cost overruns, and to adjust funding balances to meet department goals.

Federal HBP for Preventive Maintenance

ODOT does not have an approved agreement for the use of federal HBP funds for preventive maintenance work on bridges. Ohio uses federal funds for rehabilitations and replacements and for projects meeting FHWA requirements in condition or deficiency

Data Systems

ODOT's BMS is used to collect and store bridge inventory and appraisal data. Ellis is used to track the project development, funding, and execution. The TMS is used to track bridge

[73] *AASHTO Scan for NCHRP 20-68A,* Ohio Department of Transportation, 2009, PowerPoint

inspection and maintenance work by DOT crews. Excel spreadsheets are used to determine bridge maintenance needs.

Bridge Maintenance Remote Inspection (BMRI)

Ohio's BMRI is used for field reporting of bridge safety inspections. BMRI is a laptop application with a tabbed interface for groups of related data entries. BMRI on-screen forms show data from previous inspections. BMRI accepts notes written by inspectors and allows cut-and-paste insertions from previous inspection reports or other electronic documents.

Ellis

Ohio's Ellis system supports project programming, tracking, and management. Ellis contains six-year plans for bridge projects. Ellis collects data from ODOT's BMS and from DOT financial databases. The data in or linked to Ellis include project descriptions, project milestones, bridge locations and photos, structural condition information, and the type and scope of work planned for structures. Ellis is a Web-based application.

Ellis uses work activity codes (see Table 10.11) that differ from Ohio's RBM codes.

001	Structure (new)	049	Deck patching (concrete)
002	Structure(replacement)	050	Deck patching (asphalt)
003	Superstructure replacement	051	Deck sealing
004	Deck replacement	052	Spall removal
005	Structure widening	059	Deck surface
006	Graffiti removal	060	Sidewalk repair/replacement
007	Movable bridge (fix costs)	061	Bridge railing upgrade/repair
008	Movable bridge (repair)	062	Fence installation/repair
009	Collision damage	063	Bridge light installation/repair
010	Concrete patching (non-deck)	080	Foundation stabilization
011	Bridge inspection (consultant)	081	Channel drift removal
012	Bridge analysis	082	Slope repair and protection
013	Structure removal	083	Scour prevention and correction
014	Heat straightening after an under-bridge hit	084	Pile encasement
015	Raising bridge	085	Pier replacement/repair
020	Painting structural steel	086	Abutment replacement/repair
021	Spot painting structural steel	087	Channel clean out
022	Structure steel repair	088	Substructure sealing
023	Fatigue retrofit	089	Semi-integral abutment conversion
024	Pin and ganger retrofit	099	Substructure (other)

Table 10.12 *Ohio Ellis codes for bridge treatments*[74]

[74] *Ellis and Funding,* Ohio Department of Transportation, 2009, PowerPoint

025	Bearing reset/replaced	100	Approach slab replacement/repair
026	Overhead concrete spall removal	101	Approach roadway grade profile correction
027	Bridge diapering installation	102	Approach railing repair
028	Drainage system cleaned/repaired	103	Pressure relief joint installation
029	Backwall replacement/repair	119	Approach (other)
039	Superstructure (other)	120	Culvert invert repair
040	Deck overlay(concrete)	121	Tunnel liner installation
041	Deck overlay(asphaltic concrete)	122	Culvert linear repair
042	Deck overlay(asphaltic concrete with waterproofing)	139	Culvert (other)
043	Deck overlay(epoxy)	141	Culvert replace/non-bridge
044	Deck overlay(other)	142	Culvert new/non-bridge
045	Deck skid resistance retrofit	143	Culvert extension/non-bridge
046	Deck cathodic protection installation	144	Culvert repair/non-bridge
047	Deck and abutment seat cleaning	159	Culvert other/non-bridge
048	Expansion joint repair/replacement		

Table 10.11 *Ohio Ellis codes for bridge treatments*[74] *(continued)*

Transportation Management System

ODOT's TMS is a work accomplishment system that records crew hours, materials usage, resource usage, and costs. From these inputs, TMS generates estimates of project costs as both unit costs and extended costs.

Interaction of Data Systems – Workflow

ODOT's bridge maintenance program makes sequential use of data systems (see Figure 10.3). Inspection data are reported to the BMS and can include recommendations for RBM activities. Ohio districts then assign some work to DOT crews, and the corresponding RBM codes are sent to the TMS for tracking and reporting. Other work is assigned to contract maintenance and goes to Ellis for scoping and assignment of new work codes. After that, Ellis tracks project programming, management, and completion.

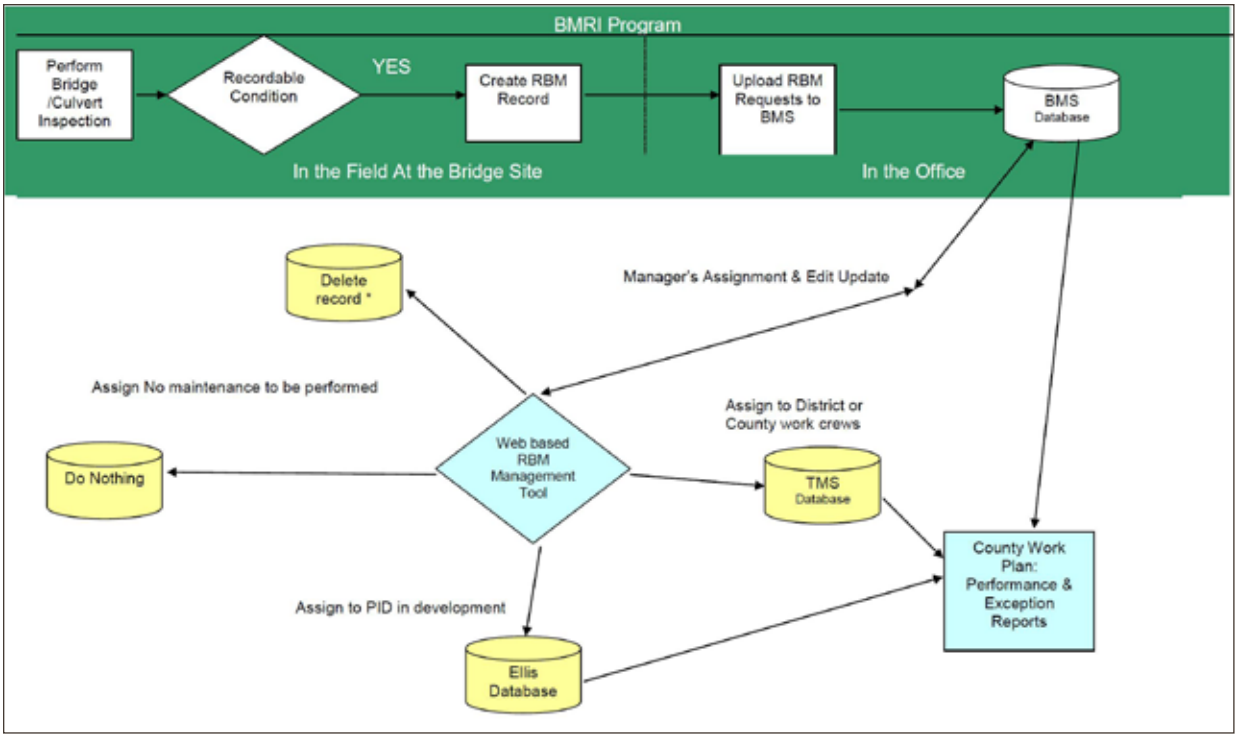

Figure 10.3 *Ohio bridge/culvert work request flowchart*[75]

Deterioration Rates for Bridges

In research for ODOT, the University of Cincinnati is developing deterioration models using condition data from Ohio's BMS[76]. Conditions are expressed as Ohio's OPI network-level performance measures, and models are developed as Markov chains. The outputs are percentages of deficient bridges in the network. Models are developed for predictions of statewide conditions and conditions within each ODOT district[77].

[75] *BMRI Flowchart, Ohio Department of Transportation, 2009, 2 pp*

[76] *Helmicki A, Hunt V, and Swanson J, Modeling of Degradation Rates for Bridges in the State of Ohio, University of Cincinnati, 2009, PowerPoint*

[77] Bridge Design Manual, Ohio Department of Transportation, 2007, 374 p

CHAPTER 11

Oregon

The scan team collected information on the Oregon DOT's (ODOT's) bridge maintenance practices from presentations and documents provided by Oregon State Bridge Engineer Bruce Johnson.

ODOT is organized into 15 maintenance districts and has 18 bridge maintenance crews. DOT maintenance districts overlay a set of five highway regions.

For repair and preservation of existing bridges, ODOT has programs for bridge maintenance, bridge repair, and major bridge maintenance (MBM) (see Table 11.1). Maintenance is performed by ODOT crews, repairs are performed most often by contract, and MBM work is done either by maintenance crews or by contract.

Category	Actions
Bridge maintenance	Cutting back brush; drift removal; channel clearing for fish restoration; patching concrete caps or sills; patching concrete superstructure members; patching concrete superstructure members; spot painting of steel superstructure members; concrete deck patching; patching curbs, rail, and felloe guards; patching concrete piling or posts; painting steel piling or posts; sealing or patching approach roadways; cleaning or replacing deck joints; cleaning or painting bearings and seats; cleaning catch basins and other drainage; patching and cleaning bridge protective screening
Bridge repair	Repair/replace timber caps/sills, steel caps/sills, concrete caps/sills, concrete superstructure members, steel superstructure members, timber superstructure members, concrete deck, wood deck, curbs, rails, felloe guards, timber pilings/posts, concrete piling/posts, steel piling/posts, bracing, and metal decking; fill-in or repave approach roadways; repair/replace deck joints; diving, sounding, other structure repair; repair/replace bearings and seats, rivets, catch basins, rip rap or bioremediation, slope paving, other drainage, fender systems, or fish restoration structure; painting; transient camp cleanup; drawbridge operations; graffiti removal; other structure maintenance
Major bridge maintenance	Replacing deteriorated timber elements, repairing/replacing joints, jacking end panels, installing deck overlays, deck sealing, strengthening, washing steel bridges, heat-straightening bent steel, spot painting, and cleaning bearings

Table 11.1 *Oregon maintenance categories*

ODOT's program for MBM provides major and emergency repairs that are beyond the scope of work normally performed by DOT crews. The MBM program is administered by Oregon's central bridge engineering section. Contracts under MBM are usually less than $250,000. Larger projects are funded under Oregon's Statewide Transportation Improvement Program (STIP). Much of Oregon's MBM program is directed to critical or urgent needs at bridges.

Critical needs and urgent needs are identified by regional bridge inspectors.

ODOT also identifies maintenance work as routine maintenance, which includes both minor and major repairs (see Table 11.2), or preventive maintenance, which includes actions that protect capital investment and prevent deterioration. Routine maintenance is applied as defects emerge. Preventive maintenance is a systematic process to avoid defects.

Minor repairs	Actions that arrest and correct deterioration before it becomes a serious problem. Depending on the extent of the deterioration, minor repairs may be more expensive than preventive maintenance.
Major repairs	Actions that correct extensive deterioration or provide minor betterment to the bridge. Cost effectiveness of major repairs depends on the additional service life expected. Initial costs will usually be less than rehabilitation

Table 11.2 *Oregon routine maintenance*

ODOT further identifies maintenance actions as being reactive or proactive (see Table 11.3).

Reactive	Maintenance activities to fix an existing problem or concern. This type of maintenance is incident-driven.
Proactive	Maintenance activities including inspection, upkeep, preservation, or restoration that prevent problems or damage to highways or reduce life-cycle costs. This type of maintenance considers the amount of the benefit versus the cost.

Table 11.3 *Oregon reactive and proactive maintenance*

Documents

ODOT's *Maintenance Guide*[78] provides instructions on administration and execution of maintenance activities for all highway assets.

Bridge Maintenance Program

Inventory

Oregon has 2,681 state-owned bridges that meet the NBI definition of a bridge (see Table 11.4). Among the bridges listed in Table 11.4, some are owned and maintained by authorities such as the Port of Hood River, the Port of Cascade Locks, or by agencies such as Oregon State Forestry and Oregon State Parks.

[78] *Maintenance Guide,* http://www.oregon.gov/ODOT/HWY/OOM/guide_index.shtml, Oregon Department of Transportation, 2004

State-owned highway bridges > 20 feet	2,681
State-owned highway bridges ≤ 20 feet	1,914
Toll authority owned highway bridges > 20 feet	2
County or locally owned highway bridges > 20 feet	3,983
County or locally owned highway bridges ≤ 20 feet	726
Other highway bridges > 20 feet	41
Other highway bridges ≤ 20 feet	5
Pedestrian bridges	71
Railroad bridges	68
Overhead sign structures	666
Tunnels	9

Table 11.4 *Oregon structures*

Maintenance Execution

ODOT crews perform tasks that include concrete patching, deck sealing, joint replacement, epoxy injection, pile/cap replacement, spot painting, heat straightening, and application of thermal-sprayed zinc metalizing.

Professional Engineer Review of Repairs

ODOT's Maintenance Guide[79] directs that approval of ODOT's Bridge Section is needed for repairs that change structural elements. Information on repairs must be shared with the region bridge inspectors. At completion of repairs, district bridge maintenance crew supervisors or bridge coordinators notify the ODOT Bridge Section.

Maintenance Goals

The goals for ODOT's bridge maintenance program include:

- Improve safety
- Move people and goods efficiently
- Improve Oregon's livability and economic prosperity

Maintenance Staffing Levels, Training, and Longevity

Staff Numbers

ODOT has approximately 106 full-time personnel assigned to 18 maintenance crews. The average bridge maintenance crew has six people, five general workers (TMS2) and one crew coordinator (TMC1). The bridge crews report to bridge maintenance supervisors (TMS). There are approximately 82 TMS2 positions, 14 TMC1 positions, eight TMS positions, and two principal managers.

[79] *Maintenance Guide,* http://www.oregon.gov/ODOT/HWY/OOM/guide_index.shtml, Oregon Department of Transportation, 2004

Training for Maintenance Personnel

ODOT's crews and crew supervisors are trained and certified in equipment operation, flagging, first aid, and CPR. All maintenance field personnel hold a Class A commercial driver's license (CDL) with tanker endorsement. Crews and supervisors must be familiar with ODOT manuals and guidelines that address emergency response, hazardous materials handling, bridge repair methods, and procedures for traffic control (see Table 11.5).

Certifications	Boom truck certification; chain saw certification; flagging certification; first-aid/CPR card; forklift certification; crane certification; and Class A CDL, including air brakes and tanker endorsements
Manuals and guidelines	Defensive driving course, DEQ regulations, EPA regulations, FCC regulations, *Emergency Response Guidebook, Equipment Operation and Service Manual, Hazardous Material Handling Manual,* bridge/maintenance guidelines, maintenance signing and guidelines, *Maintenance and Design of Bridges on State Highway System, Manual of Uniform Traffic Control Devices*, personnel policies and procedures, collective bargaining agreements, pesticide/herbicide guidelines, *Safety Manual*, safety rules and regulations, signing policy and procedures, Oregon public health rules – landscape, drawbridge operations instructions, drawbridge policies, U.S. Coast Guard navigation rules

Table 11.5 *Oregon certifications*

The major bridge maintenance engineer must have passed the Fundamentals of Engineering examination. The position of bridge maintenance engineer is the second of four levels in Oregon's series of engineering job titles. Because of the examination requirement, many maintenance field personnel do not qualify. At the same time, higher salaries are available in job titles that require a PE license. As a result, ODOT has difficulty keeping field-experienced personnel in the major bridge maintenance engineer position.

Annual Bridge Maintenance Conference

The ODOT Bridge Section brings maintenance crews together each year to share information and ideas. In addition, ODOT cosponsors a biennial Pacific Northwest Maintenance Conference to share information and new practices among participating DOT maintenance crews from Oregon, Washington, Idaho, and Alaska, as well as many local agency crews from Oregon and Washington.

Maintenance Decisions

Bridge inspectors, maintenance crews, and ODOT's bridge preservation engineering team identify routine and repair maintenance needs. District crew supervisors rank these maintenance needs and identify which will be completed by DOT crews and which will be executed by contract. Major bridge maintenance needs are identified by queries of inspector-recommended needs in Pontis and by input from maintenance crews. Oregon's Bridge Program Office prioritizes MBM needs and allocates MBM funding for selected projects.

ODOT makes regular inspections of all spans greater than 6 feet[80].

Identification of Maintenance Needs

Bridge maintenance needs are identified and programmed by a process that involves regional bridge inspectors, the bridge diving inspection team, bridge maintenance crews, ODOT's bridge preservation engineering team, and ODOT's bridge program team. The roles of each are outlined in Table 11.6.

ODOT staff	Responsibilities
Regional bridge inspectors	■ Inspect all state-owned bridges in assigned region ■ Coordinate and update all inspection field reports (timber boring, diving inspection, fracture critical inspections); enter information in Pontis. ■ Offer maintenance suggestions; ensure that maintenance items are completed correctly
Bridge maintenance crews	■ Perform maintenance activities on assigned bridges ■ Report maintenance issues to the bridge maintenance crew supervisor ■ Offer maintenance suggestions; ensure that maintenance items are completed correctly
Bridge preservation team	■ Inspect special bridge maintenance items for signature bridges ■ Offer maintenance designs and specifications for key items, including rehabilitation and cathodic protection of coastal bridges, rehabilitation and upgrade of movable bridges, heated-deck bridge deicing systems, coating and metallization of steel bridges, fracture mitigation and repair, and instrumentation and remote communication for seismic and other data collection systems for structures ■ Ensure that special maintenance repairs are completed correctly
Bridge dive inspection team	■ Inspect submerged substructures and in-water components ■ Update diving inspection reports ■ Offer maintenance suggestions; ensure that maintenance items are completed correctly
Bridge operations unit	■ Maintain the Pontis database ■ Manage the bridge inspection program
Bridge program team	■ Manage the MBM program ■ Provide engineering assistance and inspections ■ Communicate with the districts about critical and urgent maintenance needs

Table 11.6 *Oregon staff roles in bridge maintenance*

[80] *Maintenance Guide,* http://www.oregon.gov/ODOT/HWY/OOM/guide_index.shtml, Oregon Department of Transportation, 2004

Regional bridge inspectors verify completed maintenance work and make new recommendations for work. Inspectors identify conditions of bridge elements, work needed at elements, and work priorities. Bridge maintenance crews perform work and report additional needs that they observe during their work. Oregon's bridge preservation team investigates bridges with special needs and bridges programmed for rehabilitation. ODOT's bridge program team manages the bridge inspection program, provides engineering assistance to regions, and manages funds for the MBM program.

Needs in bridge maintenance are communicated among ODOT staff by using Pontis BMS and by direct contact among region bridge inspectors and supervisors of bridge maintenance crews. DOT regions can query the Pontis database over the Internet. The central bridge engineering section makes annual queries of the Pontis database to compile statewide lists of maintenance needs.

Urgency of maintenance repairs is related to condition ratings. ODOT uses four levels of urgency (see Table 11.7).

Urgency	Description
Critical	Need for maintenance repair to prevent the structure from being posted for load. NBI ratings of 3 or less.
Urgent	Need for maintenance repair as soon as possible to address a specific safety concern. NBI 4 or greater.
Routine	Need for maintenance repair in normal work schedule
Monitor	Need for periodic site visits by bridge maintenance personnel when in the area

Table 11.7 *Oregon urgency of maintenance*[81]

Maintenance categories for recommended work are tied to NBI condition ratings and element-level condition reports (see Table 11.8).

Maintenance category	Component / work type	Condition criteria
Rehabilitation	Superstructure	Superstructure steel element with condition states 4 or 5 > 0% OR Steel fatigue smart flag with condition state 3 > 0% OR Section loss smart flag with condition state 3 or 4 > 0% OR Pack rust smart flag with condition state 3 or 4 > 0%
Retrofit	Bridge rails	NBI bridge railing adequacy = 0 AND Bridge built before 1964

Table 11.8 *Oregon decision guidelines for maintenance recommendations*

[81] *BMS Domestic Scan, Oregon Summary,* Oregon Department of Transportation, 2009, PowerPoint

Rehabilitation	Deck	NBI deck condition rating < 5 AND Deck element with condition state 3, 4, or 5 OR Slab element with condition state 4 or 5 OR Modular joint assembly element with condition state 3 > 0% OR Soffit cracking smart flag with condition state 5 > 24%
Rehabilitation	Scour countermeasures	NBI scour critical rating < 5
Replacement	Culverts	NBI culvert rating < 4 AND Culvert element with condition state 4 > 10%

Table 11.8 *Oregon decision guidelines for maintenance recommendations (continued)*

Emergency Maintenance

After extreme events, regional bridge inspectors and bridge maintenance crews make visual inspections of bridges and report their observations to the DOT's central Bridge Engineering Section.

Programming Process

Work plans for bridge maintenance are developed by bridge maintenance crew supervisors working with lists of needs generated from the Pontis database and needs identified by DOT crews. Supervisors use the reported urgency of needs to develop weekly, monthly, and yearly work programs. For larger needs, supervisors apply to ODOT's MBM program for funds or apply for work under the capital program (STIP). Applications are made to the central Bridge Engineering Section.

The (relative) costs of maintenance projects determine whether work is completed by DOT crews, by small district-administered contract, or by larger contract under the MBM program. Small contracts are funded by the DOT district and, if they are less than $5,000, they can be let to contractors without competitive bids. Projects less than $75,000 are awarded by competitive bid process and can be managed in DOT districts. Projects larger than $75,000 are sent to ODOT's central procurement office. Projects as costly as $250,000 are routinely part of Oregon's MBM program. Projects larger than $250,000 become part of ODOT's STIP program.

Local Agencies

Oregon has a Local Agency Bridge Selection Committee[82] that is a partnership between ODOT and Oregon cities and counties. The committee oversees the use of HBR and STIP funds for local agency bridges. Committee membership includes the ODOT state bridge

[82] *Local Agency Bridge Selection Committee Charter,* Oregon Department of Transportation, no date, 1 p

engineer, two other ODOT staff members, three county representatives, and three city representatives. County representatives are selected by the Association of Oregon Counties[83]. City representatives are selected by the League of Oregon Cities[84]. Nonmembers who often participate in committee meetings include the FHWA division bridge engineer, ODOT bridge section staff, and ODOT regional liaisons for local agencies.

ODOT uses a formula for priority points to rank capital projects for small, local agency bridges[85]. (A small bridge is one with deck area less than 30,000 ft^2.) The ranking formula includes NBI sufficiency ratings; timber deficiencies; load deficiencies; user benefits (related to ADT and detour length); status, such as sole access; and functional classifications of routes.

Maintenance Programming Administration

Bridge maintenance programming decisions occur in DOT central, regional, and district offices. District offices initiate maintenance programming and seek assistance from central or regional offices on issues in funding, scheduling, or permits. Region offices participate in programming decisions through their allocations of yearly bridge maintenance funding. Regions also affect programming through changes to project priorities. The DOT central office assists districts by use of MBM funding and by engineering design and bridge inspection assistance.

Environmental and Permits

The DOT environmental liaison is contacted to verify permits needed prior to commencing any in-water work or whenever maintenance work might impact areas surrounding bridges. Maintenance crews practice all activities in accordance with the *Oregon Maintenance Guide*[86], which outlines best management practices (BMPs), permitting processes, and other environmental requirements.

Performance Measures and Priority Indicators

Maintenance needs priorities are linked to condition ratings as stated in *Oregon's Bridge Inspection Coding Guide*[87]. Element-level ratings are inputs to prioritizing maintenance work.

ODOT tracks the numbers and percentages of bridges that are structurally deficient or functionally obsolete as measures of network condition. In its 20-year bridge needs study , ODOT identified 13 categories of bridge deficiencies (see Table 11.9).

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[83] http://www.aocweb.org/aoc/default.aspx
[84] http://www.orcities.org/
[85] *Bridge Priority Selection Policy*, Oregon Department of Transportation, 2007, 7 pp
[86] http://www.oregon.gov/ODOT/HWY/OOM/MGuide.shtml
[87] *2009 Bridge Inspection Pocket Coding Guide,* Oregon Department of Transportation, 2009, 186 pp
[88] *Bridge Needs Study,* Oregon Department of Transportation, Bridge Engineering Section, 2008, 242 pp

Preservation Need	Deficiency
Seismic	Susceptibility to collapse in moderate earthquakes
Scour	Susceptibility to undermining of bridge foundations in stream beds
Load capacity	Deficiency in carrying capacity for legal or permit loads due to deterioration or design
Substructure	Spalling, cracking, and other forms of deterioration in abutments, piers, columns, and footings
Superstructure	Spalling, cracking, and other forms of deterioration in girders and truss members
Deck condition	Rutting, cracking, delaminating, and other forms of deterioration in bridge decks
Rails	Rail safety hazard, including inadequate crash resistance
Vertical clearance	Inadequate vertical clearance due to obsolete design or asphalt overlays on the roadway below
Movable bridges	Obsolete or deteriorated mechanical or electrical systems
Coastal bridges	Coastal bridges subject to corrosion from salt intrusion
Paint	Steel structures in need of protective coating and lead abatement
Deck width	Insufficient width for traffic types, volumes, and speeds
Historic	Deficient bridges on or eligible for inclusion on the National Historic Register

Table 11.9 *Oregon bridge deficiency categories*[89]

Optimization of Maintenance Programs

Maintenance priorities are based on needs that are critical or urgent and correspond to condition ratings for bridge components. Using a 0 to 9 scale, ratings at 3 or lower indicate critical needs for repair; ratings at 4 indicate urgent needs.

Risks, like maintenance needs, are correlated with NBI condition ratings. Risks are increased for structures that lack load path redundancy. Construction materials are important, too. Timber structures are particular concerns once they have widespread damage, since inspection methods are not exact.

Outcomes of Maintenance

Maintenance Tracking

Completed maintenance work is reported to the Pontis database. Crew supervisors perform data entry for work completions. Work is verified as completed by region bridge inspectors. Pending maintenance needs are tracked both in Pontis and in district-level spreadsheets. ODOT's Pontis database includes a field for cost estimates of maintenance needs.

[89] *Bridge Needs Study, Oregon Department of Transportation, Bridge Engineering Section, 2008, 242 pp*

Unmet (i.e., uncompleted) work recommendations remain in Pontis and appear in each annual compilation of maintenance needs until the need is resolved or becomes obsolete (e.g., as by component or bridge replacement).

Design Changes Due to Maintenance

Changes to bridge design and associated changes to bridge inventory data are tracked through as-built drawings developed for maintenance repairs and linked to bridge identification. Element-level data in Pontis are updated during the next inspection.

Effectiveness of Maintenance

ODOT's bridge inspectors validate completed maintenance work and provide the basic findings of the work's effectiveness.

Communication and Sharing Knowledge

ODOT participates in a biennial Pacific Northwest Bridge Maintenance Conference. This multistate conference provides an information exchange among maintenance personnel on methods, materials, and practices. During the off years, Oregon holds intrastate meetings of DOT maintenance personnel for the same purpose.

ODOT crews from different districts are sometimes brought together on special projects where individual crews can offer needed skills.

Quality Assurance Review

Annually, a portion of ODOT's bridge inventory is subject to QA review. The QA teams include bridge designers and bridge inspectors. This field experience and up-close view of bridges in service informs future bridge design.

Maintenance Accomplishments

Annually, the MBM program identifies bridges that have critical or urgent needs for maintenance. The list of these needs is sent to DOT regions and districts, and the districts are invited to apply for MBM funds for these needs.

ODOT tracks its lists of structurally deficient bridges and work programmed at deficient bridges to assess progress in the bridge network. It measures program effectiveness by the number of critical needs and urgent needs that are addressed on time each year.

Maintenance Budget

Funding for ODOT's bridge maintenance crews is $6.8 million in the current (2009) fiscal year. Funding for the MBM program will reach $7 million by 2011. Funding for the STIP is $78 million.

As of 2007, Oregon's backlog of bridge work in numbers of bridges and estimated costs is shown in Table 11.10.

Need category	Number of bridges with needs	Estimated 2007 cost
Deck condition	1,001	$1,038,000,000
Replacement (age-related)	122	$497,000,000
Historic rehabilitation	38	$274,000,000
Deck width	85	$253,000,000
Seismic	225	$158,000,000
Painting	51	$127,000,000
Scour	268	$53,000,000
Strengthen	24	$44,000,000
Vertical clearance	49	$35,000,000
Bridge rails	255	$22,000,000
Super/substructure rehab	18	$21,000,000
TOTAL	**2,136**	**$2,522,000,000**

Table 11.10 *Oregon bridge needs back log by deficiency categories*[90]

Costs of work backlogs are computed with estimated unit costs for projects for various deficiencies (see Table 11.11).

Project	Unit Cost
Seismic (retrofit)	$30/ft^2 deck area
Scour (countermeasures)	$200,000 each
Load capacity (strengthen)	$150/ft^2 deck area
Substructure (rehab)	$200/ft^2 deck area
Superstructure (rehab)	$100/ft^2 deck area
Deck condition (rehab)	$70/ft^2 deck area
Rails (retrofit)	$500/ft bridge length
Vertical clearance (raise)	$60/ft^2 deck area
Paint	$30/ft^2 surface area
Deck width (widen)	$70/ft^2 deck area
Replacement small bridge	$3 million each
Replacement average bridge	$250/ft^2 future deck area
Replacement big bridge	$600/ft^2 future deck area
Culvert replacement	$3 million each

Table 11.11 *Oregon unit costs for bridge needs estimates*[91]

[90] *BMS Domestic Scan, Oregon Summary,* Oregon Department of Transportation, 2009, PowerPoint

[91] *Bridge Needs Study,* Oregon Department of Transportation, Bridge Engineering Section, 2008, 242 pp

Funding in ODOT's MBM program is allocated to emergency work, urgent needs, and other bridge needs (see Table 11.12).

Work category	MBM funding share
Emergencies and bridges on OTIA[93] detour routes	30%
Urgent and critical elements	30% to 50%
Other bridge needs	20% to 40%

Table 11.12 *Oregon MBM funding shares*[92]

In a 20-year needs study[94], ODOT estimates bridge needs of $7 billion, or $350 million annually (these amounts are without inflation). The study addresses all structural deficiencies. Some functional deficiencies will persist and must persist if historic structures remain in service.

Bridge Preservation

ODOT considers bridge preservation and bridge maintenance to be a single program. Oregon has a bridge preservation team that develops plans and specifications for rehabilitation projects for coastal bridges and movable bridges. Projects include repairs, cathodic protection, deck heating systems (for deicing), metallization of steel bridges, fracture mitigation, and installation and use of remote data-collection systems. The preservation program is directed at a small group of signature bridges. Funding is provided by Oregon's MBM program and by the STIP.

ODOT plans to direct 20% of HBP funding to bridge painting and another 20% to border bridges, historic bridges, movable bridges, and coastal bridges.

Federal HBP Funds for Preventive Maintenance

ODOT does not have an agreement with FHWA for use of HBP funds for preventive maintenance.

Data Systems

Pontis

ODOT uses Pontis to store bridge inventory and condition data, but does not use it to assist in programming bridge projects. Inspectors use the work candidate section of Pontis to list their maintenance recommendations and identify specific work, priorities, and estimated costs.

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[92] *Major Bridge Maintenance Program,* Oregon Department of Transportation, no date, 1 p

[93] Oregon Transportation Investment Act (OTIA) is an Oregon state program to improve bridges over a 10-year period that began in 2003. The Act places an emphasis on deficient bridges that affect freight mobility.

[94] *Bridge Needs Study,* Oregon Department of Transportation, Bridge Engineering Section, 2008, 242 pp

Crews report the completion of work to Pontis. Needs are closed out once inspectors verify repairs, usually at the next inspection cycle.

Maintenance Management System

ODOT's MMS tracks budgets and expenditures for DOT maintenance crews. MMS offers monthly reports on work and costs using automated time cards and information from service and supply invoices. Crews, crew supervisors, regional engineers, and maintenance operations managers use ODOT's MMS.

The maintenance actions recorded in Oregon's MMS are not Pontis actions[95].

Spreadsheets

Cost estimating and work tracking are performed in spreadsheets both in district offices and in the DOT central office. Each project is assigned an EA/Subjob number so that information from Oregon's financial systems can be collected for use in spreadsheets. Spreadsheets are used by Oregon's MBM engineer and Oregon's STIP coordinator.

Materials and Methods

ODOT has construction specifications and qualified product lists to guide maintenance operations and materials selections.

ODOT is developing a maintenance manual, complete with technical drawings, to guide maintenance crews in their work on bridges[96].

[95] *Connecting Bridge Data and Maintenance Actions,* Oregon Department of Transportation, no date, 6 pp

[96] *2001–2003 Budget Narrative*, Oregon Department of Transportation, no date, 5 pp
Maintenance Guide, Chapter 10, Oregon Department of Transportation, 17 pp

CHAPTER 12

Virginia

The scan team met with engineers from the Virginia Department of Transportation's (VDOT's) Structure and Bridge Division and from VDOT districts. VDOT has a central office, nine district offices, and 42 DOT maintenance residencies, each of which is responsible for one to four counties.

Bridge staff number nearly 290. About 50 people are based in the DOT central office. VDOT has 108 bridge inspectors. Virginia has a central team for underwater inspections and 10 to 12 inspectors based in each DOT district.

Nearly 450 maintenance personnel are based in districts. Maintenance crews are assigned to DOT residencies within districts. Five of the nine districts have district bridge crews. Each DOT district has a bridge engineer who manages safety inspections, responds to issues in construction projects, makes final inspections of bridge work completed by contractors, and manages bridge maintenance programs. VDOT is currently transitioning the reporting structure of the residency bridge crews from the resident engineer to the district bridge engineer. District bridge engineers report to district maintenance engineers. District administrators and managers are responsible for districts' compliance with guidelines set by the DOT central office.

VDOT has separate organizational branches for bridge design and bridge maintenance. Career advancement for bridge staff often includes switches between design and maintenance branches to follow opportunities for promotion. This provides useful cross-training for engineers involved with bridges.

Bridge Maintenance Program

Inventory

VDOT inspects and maintains 21,000 structures, which includes 13,000 bridges and 8,000 culverts. VDOT inspects all bridges, regardless of length, and all culverts with a hydraulic opening of 36 ft2 or greater. VDOT tracks conditions and maintenance needs of 29,000 ancillary structures, such as overhead signs, high mast lights, luminaires, and signal mast arm structures. The ancillary structural assets belong to VDOT's traffic engineering division. The DOT bridge division provides inspection and technical review for ancillary structures. VDOT performs bridge inspections for most county agencies.

VDOT's inventory data (see Table 12.1) show approximately 4,000 bridges built in the 1930s, although these bridges may be older. In the 1930s, Virginia state government took

responsibility for secondary roads from the counties. For many existing structures, the year of construction is not known; instead, inventory data show the year of accession.

State-owned highway bridges > 20 feet	10,138
State-owned culverts > 20 feet	2,965
State-owned highway bridges ≤ 20 feet	2,954
State-owned culverts ≤ 20 feet	4,898

Table 12.1 *Virginia structures*

VDOT's bridge maintenance program is responsible for the inventory of bridges and culverts and also maintains four underwater crossings, two mountain tunnels, one toll bridge, four ferry service routes, 41 rest areas, 10 welcome centers, and 107 commuter parking lots.

Bridge Work Categories

VDOT funds bridge work in five categories:

- **Preventive maintenance** (15%) includes bridge cleaning, deck sealing, joint repairs, and thin deck overlays.
- **Restoration work** (25%) includes rigid deck overlays, superstructure repairs, substructure repairs, fatigue retrofits, and scour repairs.
- **Rehabilitation work** (50%) includes superstructure replacement, deck replacement, and culvert rehabilitation.
- **Replacement projects** (funded from a separate, dedicated bridge fund) are applied to bridges that are structurally deficient or functionally obsolete.
- **Painting projects** (10%)

Codes for VDOT maintenance activities are listed in Table 12.9, which appears at the end of this section.

Preventive Maintenance

VDOT defines preventive maintenance as activities that are performed in advance of a need for repair or in advance of accumulated deterioration to reduce or retard future deterioration. Preventive maintenance activities, which are planned and cyclical, may correct minor defects. Candidates for preventive maintenance are in good condition. Virginia's intervals for preventive maintenance are shown in Table 12.2.

Action	Interval
Bridge deck washing (concrete)	1 year
Bridge deck sweeping	1 year
Seats and beam ends washing	2 years
Cutting and removing vegetation	2 years

Table 12.2 *Virginia preventive maintenance intervals*

Action	Interval
Routine maintenance of timber structures	2 years
Scheduled replacement of compression seal joints	10 years
Scheduled replacement of pourable joints	6 years
Cleaning and lubricating bearing devices	4 years
Scheduled beam ends painting	10 years
Installation of thin epoxy concrete overlay	15 years
Removing debris from culverts	5 years

Table 12.2 *Virginia preventive maintenance intervals (continued)*

Maintenance Execution

District-Wide Bridge Repair Contracts

VDOT uses district-wide contracts for as-needed maintenance work. As-needed maintenance contracts are set-up with 95 bid items for commonly needed preventive and ordinary maintenance work at bridges[97]. Contracts are awarded for one year, with options for two one-year extensions; potential contract duration is three years. The limit on contract duration does not preclude the same contractor winning consecutive awards.

As-needed contracts are funded at about $2 million per year and typically perform work at about 100 structures per year. Contracts contain a mix of bid items. In a single contract, some bid items provide preventive maintenance work that is eligible for federal HBP funds, and some work that is not eligible. Work codes in the contract identify the eligible and ineligible work activities.

Contractors sometimes perform repairs on their own and sometimes provide equipment or perform support activities for repairs performed by DOT crews. Contracts include items for traffic maintenance. The district repair contracts include a collection of details for common repairs. There is little need for additional engineering support.

Dedicated inspectors in each district verify work completed under as-needed contracts. Inspections for maintenance contracts are similar to inspections for acceptance of construction work.

Engineering Support

VDOT keeps three regional contracts for consulting engineers to provide assistance to DOT districts.

[97] *District-Wide Bridge Repair Contract,* Virginia Department of Transportation, 2009, PowerPoint

Turnkey Asset Management

Operational maintenance of interstate routes is performed under turnkey asset management contracts, which provide snow plowing, grass mowing, guardrail repairs, and pothole patching. These contracts do not much affect districts' maintenance programs for bridges.

Small Bridge Program

Virginia uses DOT crews for major maintenance and replacement of small bridges. Bridges are eligible if bridge length is less than 60 feet and project cost is less than $300,000. Virginia has 13,400 small bridges and culverts, about one fourth of Virginia's structure inventory. Many small structures have spans less than NBI length. Eighty-two percent of the small structure inventory is on secondary routes. Virginia's short-bridge program provides a needed funding mechanism for these structures.

DOT crews employed in the small-bridge program include residency and district office crews. The crews can install temporary bridges, place/replace prestressed beams, and fabricate reinforced concrete components. Contractors perform prestressing, when needed. Two districts have concrete casting yards and produce reinforced concrete slab sections up to 40 feet long.

Culvert replacements are the major part of the small-bridge program. VDOT crews have also built short-span suspension bridges for pedestrian use. Crews build or reconstruct about 140 structures each year.

Unit costs are higher for the smallest projects. Costs for structure replacements range from $\$400/ft^2$ for a 400 ft^2 structure down to $\$200/ ft^2$ for a 1,400 ft^2 structure. Costs for culvert replacements range from $2,000/linear foot for short culverts to $\$1,200/ft^2$ for culverts 120 feet long. Superstructure replacement costs range from $\$200/ft^2$ for small deck area to $\$150/ft^2$ for 1,000 ft^2 deck area.

Maintenance Decisions

Bridge Inspection

VDOT performs NBI and element-level inspections on state-owned bridges. Local agencies must perform and report NBI inspections but are not required to perform element-level inspections. Each DOT district has an inspection manager who is a licensed professional engineer. All bridges are inspected at two-year intervals or less. Short culverts are inspected at four-year intervals or less.

Identification of Maintenance Needs

VDOT uses element-level condition data to identify bridges needing work. Condition data are collected into spreadsheets, and the entries are sorted to identify bridges and elements in poor condition. The use of element-level data allows VDOT to examine needs for particular kinds of maintenance work.

The selection of projects for maintenance activities is based in part on element-level condition state. Selection criteria for preventive maintenance projects are shown in Table 12.3. Selection criteria for painting projects are shown in Table 12.4. Criteria for restoration projects are shown in Table 12.5. Selection criteria for rehabilitation projects are shown in Table 12.6. Structures are replaced only if they are structurally deficient or functionally obsolete.

Action	Bridge elements	Criteria
Bridge cleaning	12, 18, 22, 26, 27, 39, 40, 44, 48, 52, 53	All interstate bridges Primary route bridges, length > 100 feet Secondary route bridges, length > 100 feet and ADT > 100 feet 100% of element quantity in condition states 1 and 2
Deck sealing	358	0% of element quantity in condition state 1
Joints	300, 301, 302	< 50% of element quantity in condition state 1
Thin deck overlays	12,18, 26, 38, 44, 52	100% of element quantity in condition state 3

Table 12.3 *Virginia criteria for preventive maintenance*

Action	Bridge elements	Criteria
Painting	107	0% of element condition in state 1 AND < 20% of element condition in state 2

Table 12.4 *Virginia criteria for painting*

Action	Bridge elements	Criteria
Rigid deck overlay	12, 18, 22, 26, 27, 39, 40, 44, 48, 52, 53	100% of element quantity in condition states 4 and 5
Superstructure repairs	104, 105, 109, 110, 115, 116, 143, 144, 154, 155	> 15% of element quantity in condition state 3
Substructure repairs	205, 210, 215, 234, 295	0% of element quantity in condition state 1 AND < 25% of element quantity in condition state 2
Fatigue retrofits	359	0% of element quantity in condition state 1
Scour repairs	361	100% of element quantity in condition state 3

Table 12.5 *Virginia criteria for restoration*

Action	Bridge elements	Criteria
Superstructure replacement		Superstructure NBI rating < 5 AND Substructure NBI rating > 5
Deck replacements		Deck NBI rating < 5 AND Superstructure NBI rating > 4 AND Substructure NBI rating > 5
Culvert rehabilitation	All	Culvert NBI rating ≤ 5
	240	> 50% of element quantity in condition state 3
	241	> 50% of element quantity in condition state 4

Table 12.6 *Virginia criteria for rehabilitation*

Programming Process

Bridge Replacement

Selections for bridge replacement projects are determined by priority rankings among eligible bridges (i.e., bridges that are structurally deficient or functionally obsolete). Priority rankings are based on ADT, detour length, general condition rating, load posting, and six additional factors.

VDOT's central office computes priorities and sends lists of ranked projects to DOT districts. In districts, bridge engineers coordinate with stakeholders, develop project estimates, and report districts' selection of projects back to the VDOT central office. Districts' project selections can differ from central office rankings. Projects are programmed after mutual agreement between the central office and the districts. The listing, review, and agreement process is done annually, and it becomes the sixth year of an evolving six-year plan for bridges.

Performance Measures

VDOT tracks the percentage of structurally deficient bridges as a network performance measure. Virginia's goal is to have not more than 8% structurally deficient bridges in the network. Performance measures such as general NBI condition rating and NBI sufficiency rating are used to rank projects.

VDOT's Salem district has goals to limit structurally deficient bridges to not more than 3% of bridges carrying interstate routes, 6% of bridges carrying primary routes, and 11% of bridges carrying secondary routes.

Priority Indicators

VDOT examines NBI condition ratings, bridge sufficiency ratings, and bridge deficiencies to determine the category of work needed (see Table 12.7).

Work category	NBI condition	Sufficiency rating	Deficiency
Preventive maintenance	7 or higher	> 80	–
Ordinary maintenance	6 or lower	> 50	–
Rehabilitation	5 or lower	< 80	–
Replacement	4 or lower	< 50	Yes

Table 12.7 *Virginia priority indicators*

Outcomes of Maintenance

Quality Control

VDOT district engineers are responsible for QC review of all inspections, both by DOT inspectors and by consultants. In most districts, DOT personnel perform inspections at about 80% of the bridge inventory. VDOT's central office makes annual QA reviews of district inspection programs and also reviews about 5% of all bridge inspection reports per year.

Maintenance Budget

In fiscal 2009, the budget for maintenance of state bridges was $160 million. This amount provides for staff salaries, consultants, inspections, materials, and equipment. This budget provides for all bridge work, short of bridge replacement. Bridge funds are allocated to districts based on a network analysis performed in BMS.

VDOT established a dedicated bridge replacement fund in 2004 and allocates approximately $50 million annually to this program. The funds are allocated to DOT districts based on deck area of bridges that are structurally deficient or functionally obsolete. The allocations support projects that do not exceed $20 million. Larger projects are funded separately, by the VDOT central office, because districts cannot accumulate sufficient funds. The budget for bridge replacement ranges between $40 million and $50 million.

Federal HBP Funds for Preventive Maintenance

VDOT has an agreement with FHWA for the use of HBP funds for preventive maintenance activities (see Table 12.8). Federal HBP funds are used for maintenance contract work.

■ Seal joints, replace joints, eliminate joints
■ Deck overlays, with deck repairs
■ Spot and zone painting
■ Painting of structural steel
■ Cathodic protection systems for decks, superstructures, or substructures, with concrete repairs
■ Electrochemical chloride extraction for decks and for substructure, with concrete repairs
■ Scour countermeasures
■ Removing large debris from channels
■ Retrofit of fracture-critical members
■ Retrofit of fatigue-prone details
■ Concrete sealants, coatings, and membranes
■ Bridge cleaning and washing
■ System preservation for metal culverts

Table 12.8 *Virginia HBP-qualified preventive maintenance actions*[98]

Data Systems

Pontis Development and Customization

VDOT has invested effort in practical use of the Pontis preservation model. Virginia has defined additional elements and modified the definitions of some commonly recognized elements. Virginia's changes match elements' condition states and actions to Virginia's maintenance work programs.

Virginia has focused on a subset of bridges and elements to develop costs, make detailed reviews of outputs from the Pontis preservation model, and adjust agency rules to get outputs from Pontis that are reasonably similar to real work programs for VDOT.

Pontis Optimizer

VDOT has developed an optimizer that works with outputs from the Pontis preservation model and generates possible bridge projects for a 10-year planning period. Reports from the optimizer show the projects proposed for each bridge and the bridge's health index and sufficiency rating over the duration of the work plan. Reports also indicate network-level performance in terms of percentages of structurally deficient and functionally obsolete bridges.

The optimizer works within a set of constraints (i.e., agency rules). Virginia allows only one substantial project per bridge in a 10-year period. All work recommendations must fit within one of VDOT's five bridge program areas (i.e., preventive, painting, restoration, rehabilitation, and replacement).[99]

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[98] *List of Preventive Maintenance Activities Eligible for Federal Bridge Funding That Provide a Significant Increase in the Service Life of Bridges,* Virginia Department of Transportation, 2005, 2 pp

[99] *Small Bridge Program Commissioner's Initiative Update,* Virginia Department of Transportation, 2009, PowerPoint
Ahmad AS, Bridge Management Program – Overview, Virginia Department of Transportation, 2009, PowerPoint

Ordinary and preventive maintenance Condition based		
70100	Preventive (condition based) maintenance	Each
70101	Debris removal	Cubic yard
70102	Litter patrol/pick-up	Acre
70103	Erosion stabilization	Cubic foot
70105	Haul, prep, paint (ferries)	Each
70141	Hand clean	Linear foot
70142	Machine cleaning/mechanical sweeping	Linear foot
70143	Cleaning/flushing	Each
70146	Painting	Square foot
70147	Graffiti removal	Each
70150	Pesticide application	Acre
70151	Tree removal	Each
70152	Turf, wildflowers, and roadside flowers	Acre
70153	Pruning	Linear foot
70154	Ornamental plants	Each
70155	Turf (hand mowing)	Acre
70156	Turf (mechanical mowing)	Acre
70157	Brush removal (hand)	Acre
70158	Brush removal (mechanical)	Acre
70160	Dust control	Lane mile
70162	Crack seal	Linear foot
70163	Slurry seal	Lane mile
70164	Latex overlay	Lane mile
70165	Thin (less than 1.5 inches) HMA overlay	Lane mile
70168	Sealing – joints or rumble strip	Linear foot
70170	Removing large trees and debris from channels	Cubic yard
70171	Install protection/sealant/coating system	Square foot
70172	Scour countermeasures installation	Cubic yard
70173	Timber bridge maintenance	Each
70174	Bearing devices maintenance	Each
70175	Approach slab maintenance	Each
70176	Bridge deck patching	Square yard
70199	Other ordinary and preventive (condition-based) maintenance	

Table 12.9 *Virginia maintenance activity codes*[100]

[100] *Small Bridge Program Commissioner's Initiative Update,* Virginia Department of Transportation, 2009, PowerPoint

Preventive maintenance Not condition based		
71100	Preventive (noncondition-based) maintenance	Each
61100 (Federal)	Preventive (noncondition-based) maintenance	Each
71111	Bridge inspection of non-NBI – interstate system	Each
61111 (Federal)	Bridge inspection of NBI – interstate system	Each
71122	Underwater bridge inspection of non-NBI – interstate system	Each
61122 (Federal)	Underwater bridge inspection of NBI – interstate system	Each
71211	Bridge inspection of non-NBI – primary system	Each
61211 (Federal)	Bridge inspection of NBI – primary system	Each
71222	Underwater bridge inspection of non-NBI – primary system	Each
61222 (Federal)	Underwater bridge inspection of non-NBI – primary system	Each
71311	Bridge inspection of non-NBI – secondary system	Each
61311 (Federal)	Bridge inspection of NBI – secondary system	Each
71322	Underwater bridge inspection of non-NBI – secondary system	Each
61322 (Federal)	Underwater bridge inspection of NBI – secondary system	Each
71141	Hand clean	Linear foot
61141 (Federal	Hand clean	Linear foot
71142	Machine cleaning/mechanical sweeping	Linear foot
61142 (Federal)	Machine cleaning/mechanical sweeping	Linear foot
71143	Cleaning/flushing (bridge/culvert or pipe)	Each
61143 (Federal)	Cleaning/flushing (bridge/culvert or pipe)	Each
71146	Zone painting	Square foot
61146 (Federal)	Zone painting	Square foot
71151	Tree removal	Each
61151 (Federal)	Tree removal	Each
71157	Brush removal (hand)	Acre
71158	Brush removal (mechanical)	Acre
71160	Dust control	Lane mile
61160 (Federal)	Dust control	Lane mile
71162	Crack seal	Linear foot
61162 (Federal)	Crack seal	Linear foot
71163	Slurry seal	Lane mile
61163 (Federal)	Slurry seal	Lane mile
71164	Latex overlay	Lane mile
61164 (Federal)	Latex overlay	Lane mile
71165	Thin (less than 1.5 inches) HMA overlay	Lane mile
61165 (Federal)	Thin (less than 1.5 inches) HMA overlay	Lane mile
71168	Sealing – joints or rumble strip	Linear foot

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

61168 (Federal)	Sealing – joints or rumble strip	Linear foot
71170	Removing large trees and debris from channels	Cubic yard
61170 (Federal)	Removing large trees and debris from channels	Cubic yard
71171	Install protection/sealant /coating system	Square yard
61171 (Federal)	Install protection/sealant /coating system	Square yard
71173	Timber structure maintenance	Each
61173 (Federal)	Timber structure maintenance	Each
71174	Bearing devices maintenance	Each
61174 (Federal)	Bearing devices maintenance	Each
71199	Other preventive (noncondition-based) maintenance	
61199 (Federal)	Other preventive (noncondition-based) maintenance	
Repair / corrective activities		
72205	Machining, grading, shaping, ditching	Linear foot
62205 (Federal)	Machining, grading, shaping, ditching	Linear foot
72206	Pipe/culvert repair	Linear foot
62206 (Federal)	Pipe/culvert repair	Linear foot
72207	Drop inlet repair	Each
62207 (Federal)	Drop inlet repair	Each
72210	Electrical repairs	Each
62210 (Federal)	Electrical repairs	Each
72211	Mechanical repairs	Each
62211 (Federal)	Mechanical repairs	Each
72214	Reset or replace sign post	Each
62214 (Federal)	Reset or replace sign post	Each
72215	Re-hang and repair signs	Each
62215 (Federal)	Re-hang and repair signs	Each
72216	Spot guardrail repair	Linear foot
62216 (Federal)	Spot guardrail repair	Linear foot
72220	Asphalt patching	Square yard
62220 (Federal)	Asphalt patching	Square yard
72222	Concrete patching/repair	Square yard
62222 (Federal)	Concrete patching/repair	Square yard
72225	Concrete joint repair	Square yard
62225 (Federal)	Concrete joint repair	Square yard
72226	Concrete grinding	Square yard
62226 (Federal)	Concrete grinding	Square yard
72230	Chip seal	Lane mile
62230 (Federal)	Chip seal	Lane mile
72233	Overlay (approx. 1.5 inches)	Lane mile

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

62233 (Federal)	Overlay (approx. 1.5 inches)	Lane mile
72239	Mill and overlay (approx. 1.5 inches)	Lane mile
62239 (Federal)	Mill and overlay (approx. 1.5 inches)	Lane mile
72240	Water infiltration repair	Linear foot
62240 (Federal)	Water infiltration repair	Linear foot
72241	Tile removal/repair	Linear foot
62241 (Federal)	Tile removal/repair	Linear foot
72242	Ventilation structure/egress shafts	Each
72245	Camera repair	Each
62245 (Federal)	Camera repair	Each
72250	Railing system repair	Linear foot
62250 (Federal)	Railing system repair	Linear foot
72261	Cable repairs (ferry)	Linear foot
72270	Painting	Tons
62270 (Federal)	Painting	Tons
72271	Bridge deck overlay (rigid)	Square yards
62271 (Federal)	Bridge deck overlay (rigid)	Square yards
72272	Bridge deck overlay (thin)	Square yards
62272 (Federal)	Bridge deck overlay (thin)	Square yards
72273	Bridge superstructure repairs	Each
62273 (Federal)	Bridge superstructure repairs	Each
72274	Bridge substructure repairs	Each
62274 (Federal)	Bridge substructure repairs	Each
72299	Other repair work	
62299 (Federal)	Other repair work	
73211	Mechanical replacement	Each
73216	Guardrail upgrade	Linear foot
63216 (Federal)	Guardrail upgrade	Linear foot
73241	Tile removal/replacement	Linear foot
63241 (Federal)	Tile removal/replacement	Linear foot
73260	Dolphin/buoy repair/replacement (ferry)	Each
73261	Cable replacement (ferry)	Linear foot
73305	Culvert and pipe extension	Linear foot
63305 (Federal)	Culvert and pipe extension	Linear foot
73306	Sleeve pipe and culvert	Linear foot
63306 (Federal)	Sleeve pipe and culvert	Linear foot
73308	Replace any pipe	Linear foot
63308 (Federal)	Replace any pipe	Linear foot
73310	Cut and fill wash-outs and slides	Cubic yard

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

63310 (Federal)	Cut and fill wash-outs and slides	Cubic yard
73320	Latex striping and line painting	Linear foot
63320 (Federal)	Latex striping and line painting	Linear foot
73321	Wet reflective markings/ messages	Linear foot
63321 (Federal)	Wet reflective markings/ messages	Linear foot
73322	Thermoplastic or epoxy striping or marking	Linear foot
63322 (Federal)	Thermoplastic or epoxy striping or marking	Linear foot
73323	B-6 striping or marking	Linear foot
63323 (Federal)	B-6 striping or marking	Linear foot
73324	Remove pavement marking	Linear foot
63324 (Federal)	Remove pavement marking	Linear foot
73325	Pavement marker work	Each
63325 (Federal)	Pavement marker work	Each
73326	Lens only replacement	Each
63326 (Federal)	Lens only replacement	Each
73330	Retrofit or replace large signs (> 20 ft2)	Each
63330 (Federal)	Retrofit or replace large signs (> 20 ft2)	Each
73331	Retrofit or replace regular signs (≤ 20 ft2)	Each
63331 (Federal)	Retrofit or replace regular signs (≤ 20 ft2)	Each
73340	Replace rumble strips	Linear foot
63340 (Federal)	Replace rumble strips	Linear foot
73345	Concrete pavement restoration	Lane mile
63345 (Federal)	Concrete pavement restoration	Lane mile
73350	Thick overlay (>1.5 inches)	Lane mile
63350 (Federal)	Thick overlay (>1.5 inches)	Lane mile
73355	Mill and thick overlay (> 1.5 inches)	Lane mile
63355 (Federal)	Mill and thick overlay (> 1.5 inches)	Lane mile
73360	Liner replacement	Linear foot
63360 (Federal)	Liner replacement	Linear foot
73361	Masonry/rock repair/replacement	Linear foot
73399	Other restorative/replacement work	
63399 (Federal)	Other restorative/replacement work	
74425	Crack and seat/break and seat	Lane mile
64425 (Federal)	Crack and seat/break and seat	Lane mile
74430	Full depth replacement	Lane mile
64430 (Federal)	Full depth replacement	Lane mile
74450	Bridge deck rehabilitation	Each
64450 (Federal)	Bridge deck rehabilitation	Each
74455	Bridge superstructure rehabilitation	Each

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

64455 (Federal)	Bridge superstructure rehabilitation	Each
74460	Bridge total structure rehabilitation	Each
64460 (Federal)	Bridge total structure rehabilitation	Each
74499	Other rehabilitation work	
64499 (Federal)	Other rehabilitation work	
Common (shared) work activities		
75140	Inspection/contract monitoring	Each
65140 (Federal)	Inspection/contract monitoring	Each
75200	Installation of new assets	Each
65200 (Federal)	Installation of new assets	Each
75300	Preliminary engineering/contract development	
65300 (Federal)	Preliminary engineering/contract development	
Operations activities		
76110	Traffic control	Each
76114	Tiger team support	Hour
76120	Traffic control for special events	Each
76200	Control room operations	Hour
66200 (Federal)	Control room operations	Hour
76205	Bridge and tunnel field operations	Hour
66205 (Federal)	bridge and tunnel field operations	Hour
76210	Safety service patrol	Hour
66210 (Federal)	Safety service patrol	Hour
76215	Central control system maintenance	Each
66215 (Federal)	Central control system maintenance	Each
76220	System field maintenance	Hour
66220 (Federal)	System field maintenance	Hour
76225	Project administration	Hour
66225 (Federal)	Project administration	Hour
76230	Direct expenses	Each
66230 (Federal)	Direct expenses	Each
76231	Utility bills	Each
66231 (Federal)	Utility bills	Each
76235	Building and equipment maintenance	Each
76640	Traffic engineering studies	Each
76699	Other operations activities	
Federal disaster codes		
60101	Debris removal – storm or emergency	Cubic yard
62000	Permanent repairs to road, facilities, and bridge systems	Each
66102	Protective measures – search and rescue	Each

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

66103	Protective measures – temporary and emergency repairs/facilities	Each
66104	Protective measures – demolition of unsafe structures	Each
66105	Protective measures – emergency transportation	Hour
66106	Protective measures – other assistance	Hour
66107	Mobilization/standby time/meals	Hour
66108	Administrative support	Hour
66109	Building damage	Each
66110	Protective measures – traffic control – storm/emergency	Each
66111	Supervisory/dispatching operations	Hour
66112	Federal Emergency Management Agency (FEMA) damage assessment	Each
66113	Federal Highway Administration (FHWA) inspection/bridge safety inspection	Each
66114	Tiger team support – storm/emergency	Hour
66115	Dept. of Emergency Management (DEM) assigned missions	Hour
66118	Snow plowing	Lane mile
66119	Chemical application	Lane mile

Table 12.9 *Virginia maintenance activity codes*[100] *(continued)*

CHAPTER 13

Washington

The scan team met with Washington State DOT (WSDOT) personnel from the bridge preservation office (BPO), regional operations, regional maintenance crews, and ferry operations.

WSDOT has programs for bridge maintenance and for bridge preservation (see Table 13.1); the distinctions are in scope and cost. DOT maintenance crews perform tasks of limited duration and cost. Larger projects and projects involving multiple bridges are performed by contract and funded under Washington's bridge preservation program.

Operate the system	Movable bridge operations, navigation light operations, over-height warning system operations
Repair the system (corrective maintenance)	Bridge repair list, replace caps and piles, repair concrete members, heat straightening, steel element replacements, patch decks, repair or replace expansion joints, restore tendons in prestressed beams, repair rails, scour repairs, sign bridge repairs, public damage reports, disaster maintenance (debris removal, scour work), call-ins on emergent repairs such as pot holes in deck (public, roadway maintenance, and state patrol)
Perform preventive maintenance	Inspections, special bridge PMs generated by the Maintenance Productivity Enhancement Tool (work-order driven), bridge cleaning (including joints, drains, and all surface areas), appurtenance servicing, replace light bulbs or LEDs on navigation lights, tighten joints, tighten timber decks
Unprogrammed work	Graffiti removal, homeless encampment cleanup, false alarms, jumpers, Homeland Security heightened-alert inspections, tours, constituent political requests, post-earthquake and flooding inspections

Table 13.1 *Washington maintenance definitions*[101]

The maintenance categories used by DOT regions and by the central BPO are:

- **Maintenance,** which incorporates routine tasks, such as smaller structural repairs, cleaning, sweeping, and spot-painting to extend the life of the structure as much as possible. Maintenance work is carried out by WSDOT's state workforce.
- **Preservation,** which focuses on larger jobs, such as reconstructing a bridge when it has reached the end of its designed lifespan, large-scale repainting of steel bridges, and larger-scale structural repairs. Preservation jobs are carried out by contractors.

[101] Keegan C, *Amplifying Questions,* Washington Department of Transportation, 2009

WSDOT's central office for maintenance and operations uses a maintenance accountability process (MAP) to measure maintenance effectiveness. MAP categories applied to bridge maintenance are listed in Table 13.2.

Category	Note
4A1 Bridge Deck Repair	Includes all work necessary to repair scaling, spalling, cracks, and exposed reinforcing steel on bridge decks. The work includes saw cutting and removal of broken asphalt or concrete from the damaged area and patching with an appropriate mix or compound, such as asphalt, epoxy, or concrete.
4A2 Structural Bridge Repair	Includes repairing piers or girders, replacing bearing pads, replacing damaged or deteriorated truss members, replacing or repairing expansion joints, repairing scour around piers, and removing debris build-up against piers, bulkheads, or pilings. This may also include tunnel interior maintenance, maintenance of nonstructural portions of the bridge (e.g., bridge rail, traffic gates, and navigation lights,).
4A3 Bridge Cleaning	Includes all work necessary to clean bridge surfaces, sidewalks, and drains to remove sand and debris build-up, provide proper drainage, and an aesthetically clean appearance. Work includes sweeping and washing decks and sidewalks, power-washing or sand-blasting rust, moss, bird guano, or dirt from surfaces, and cleaning plugged drains and grates so water flows through them freely. This activity also includes painting steel structures to prevent rusting and present an aesthetically pleasant appearance.
4B1 Movable and Floating Bridge Operation	Includes maintenance of all mechanical and electrical working parts so the bridges can be opened and closed when needed. The activity includes the work operation of opening and closing the bridge span. Also includes work to operate floating bridges, including pumping water out of pontoons and adjusting anchor cable tension.
4B3 Urban Tunnel Systems	Includes all work necessary to ensure that all the mechanical, electrical, and electronic equipment, such as exhaust fans, fire protection systems, carbon dioxide monitoring equipment, lighting, radio systems, and all other equipment, including the computer control system, is operational at all times.

Table 13.2 *Washington MAP measures related to bridges*[102]

Maintenance Goals

WSDOT's maintenance goal is to retain the highway system in a condition as near as possible to the condition of its initial construction or subsequent improvement[103].

Scheduled Maintenance

WSDOT applies some maintenance activities at scheduled intervals for movable bridges, floating bridges, and the Tacoma Narrows bridges.

[102] *Maintenance Accountability Process Manual,* Washington Department of Transportation, 2008, 85 pp

[103] *Maintenance Manual,* Washington Department of Transportation, Maintenance and Operations Division, M51 01, 2008, 180 pp

Ferry Terminal Maintenance

WSDOT operates transportation ferries, and bridge inspectors have a role in safety inspections of the ferry terminals and transfer spans. Maintenance includes terminal assets, such as hoist and counterweight cables, cathodic protection systems, generators, electrical systems, mechanical systems, and landing aids. Maintenance categories for ferry terminals are listed in Table 13.3.

Category	Note
Preventive maintenance	Routine, usually cyclic, maintenance preformed mostly by DOT crews
Corrective work	Needs identified during preventive maintenance, and performed either by DOT crews or by contractors
Facility work	All needs for terminal buildings, sewers, water service, or electrical service
Landing aids	Maintenance of wing walls and dolphins
Paving	Needs for paving, grading, striping, etc., for terminal ways, lots and access ways
Structural	Needs at trestles, transfer spans, overhead loading ramps, and associated mechanical systems
Painting – structural steel	Painting for steel trestles, transfer spans, and ramps
Vendors	Work done by established wants and agreements, usually under $10,000 per event
Bird removal	Nest removal, egg removal, bird trapping at terminals

Table 13.3 *Washington categories of ferry terminal maintenance*

Signature Bridges

WSDOT keeps operation and maintenance manuals for signature bridges. Manuals address maintenance and preservation needs. Work is captured (and sometimes programmed) by a work-order system called the Maintenance Productivity Enhancement Tool (MPET).

Documents

WSDOT documents related to bridge maintenance include the *Maintenance Manual*[104], the *Maintenance Accountability Process Manual*[105], and the *Transportation Structures Preservation Manual*[106]. WSDOT publishes a series of programmatic permit guidance memos for maintenance work that may require permits. WSDOT also publishes annual reports of ferry terminal maintenance[107].

[104] *Maintenance Manual,* Washington Department of Transportation, Maintenance and Operations Division, M51 01, 2008, 180 pp

[105] *Maintenance Accountability Process Manual,* Washington Department of Transportation, 2008, 85 pp

[106] *Transportation Structures Preservation Manual,* Washington Department of Transportation, 1998, 29 pp

[107] Castor T, *Ferry Terminal Facilities Annual Report,* Washington State Ferries, 2008, 74 pp

Bridge Maintenance Program

Washington's inventory of DOT structures is shown in Table 13.4.

State-owned highway bridges > 20 feet	2,995
Culverts > 20 feet	91
County- or locally owned highway bridges > 20 feet	18
State-owned highway bridges ≤ 20 feet	336
Pedestrian bridges	63
Railroad bridges	5
Tunnels and lids	39
Other (please specify): Passenger-only facility	3
Overhead sign structures	341
Buildings	1
Other (please specify): Landing aids, wing walls, dolphins	176

Table 13.4 *Washington structures*

Maintenance Execution

Bridge maintenance crews based in DOT regions perform most maintenance work. Crews make minor repairs, remove debris in channels, perform some joint replacements, and install scour countermeasures. WSDOT's Bridge Preservation Program delivers projects for most bridge painting, deck overlays, and large scour remediation needs. Joint replacements may be done by DOT crews or by contract.

DOT regions respond to work needs on WSDOT's Bridge Repair List, which is compiled twice a year by the DOT central office.

Regions and Crews

All WSDOT regions have bridge maintenance crews. Regions with large or special bridges have specialty crews for these bridges. The Northwest and Olympic regions have floating bridges and corresponding crews to maintain them. Each region has adaptations in crews, staff, and skills to match the needs of its bridge inventories.

Environmental Administration

WSDOT regions have environmental maintenance coordinators to assist with permits for bridge work. Maintenance crew supervisors in regions have responsibility for filing environmental reports and making requests for permits. Region environmental coordinators are available to assist crew supervisors.

Maintenance of Ferry Terminals

Work at Washington ferry terminals is executed both by DOT crews and by contract. Crews

are organized into eight shops: carpentry, electrical, insulation, machine, pipe, sheet metal, shore gang, and welding. Contracts are awarded as small contracts (i.e., under $35,000) and as job order contracts. Job order contracts are open-ended contracts that offer standard work items at prebid prices. The MPET system generates maintenance work orders.

Engineering Design

Engineering review and design are not required for minor repairs and in-kind replacements performed by DOT crews. WSDOT regions have few or no structural engineers. The WSDOT central BPO reviews bridge modifications.

Execution – Southwest Region

WSDOT's Southwest region has 522 bridges, 10 tunnels, 22 short spans, 53 culverts, 1 suspension bridge, and 316 sign bridges. The region's bridge crew is self-directed and spends about half of its time completing items on the bridge repair list prepared by Washington's central BPO. The rest of its time is spent on emergent maintenance needs.

The bridge crew supervisor retrieves bridge repair needs from Washington's Bridge Engineering Information System (BEISt, pronounced "beast") and prepares detailed work plans for the crew using a spreadsheet-based list of outstanding work.

Execution – Northwest Region

WSDOT's Northwest region has a region-wide maintenance crew, a deck crew, two crews for floating bridges, and two crews for movable bridges. The region has 1,300 structures, of which nine are movable bridges and three are floating bridges.

Crews for movable bridges and floating bridges execute work orders generated by Washington's MPET. One feature of MPET is automatic generation of work orders to perform cyclic maintenance activities at pre-established intervals. Movable and floating bridge crews are largely independent of the regional and deck bridge crews.

The Northwest's region-wide crew spends about 50% of its time on items from the bridge repair list. The crew supervisor prepares detailed work plans for the crew.

Execution – South Central Region

WSDOT's South Central region has a bridge maintenance crew with seven workers, a lead technician, and a supervisor. The crew supervisor prepares work plans and tracks crew accomplishments with a spreadsheet-based list.

Execution – Olympic Region

WSDOT's Olympic region has 616 highway bridges and 341 sign bridges. Highway bridges include one floating bridge, two suspension bridges, one cable-stayed bridge, and seven movable bridges.

Maintenance Staffing Levels, Training, and Longevity

Job titles and counts for some Washington maintenance crews are listed in Table 13.5.

Crew	Personnel	Job titles
Olympic Region		
Hood Canal floating bridge	9	1 Maintenance specialist 5 1 Bridge lead tech 2 Signal techs (electricians) 5 Bridge techs
Tacoma Narrows bridges	9	1 Maintenance specialist 5 1 Maintenance specialist 4 7 Maintenance specialists suspension bridge
Aberdeen crew	11	1 Maintenance specialist 5 1 Signal tech 3 Bridge maintenance techs 6 Bridge tenders
Olympic region crew	11	1 Maintenance specialist 5 2 Bridge maintenance lead techs 8 Bridge technicians
South Central Region		
Specialty bridge crew	8	1 Maintenance specialist 5 1 Maintenance lead tech 6 Maintenance mechanic
Southwest Region		
Region-wide crew	11	1 Supervisor 2 Maintenance lead techs 6 Bridge techs 2 Summer temps

Table 13.5 *Washington bridge maintenance crews*

Staff – Ferry Terminal Maintenance

Maintenance personnel for WSDOT's ferries are responsible for both maintenance work and capital projects. The ferry organization includes a terminal maintenance program manager, a terminal maintenance engineer, two facility engineers, and a terminal maintenance design engineer. These personnel are supported by inspectors, mechanical engineers, structural engineers, electrical engineers, and permit specialists. The workforce for crews is about 110 people and includes carpenters, electricians, machinists, pipefitters, welders, and shore gangs. Crews are formed, project by project, as needed.

DOT Crews – Training and Certification

Members of WSDOT maintenance crews usually have basic construction skills. Some workers are certified welders or have substantial experience as carpenters or equipment operators. WSDOT provides in-house training in the use of man-lifts and scaffolding assembly. All crew members must acquire a CDL within six months of their initial employment with WSDOT.

Maintenance Decisions

At WSDOT, bridge inspectors make recommendations for maintenance work. These recommendations are part of inspection reports and appear in Washington's BEISt database. The central bridge preservation office distributes lists of bridge repair needs to DOT regions. Crew supervisors in regions make detailed work plans for crews that combine items on the bridge repair list with other known needs at bridges within the regions.

Inspections

WSDOT's central BPO manages bridge safety inspections, and regional maintenance crews make annual bridge inspections. Both sets of inspections yield recommendations for maintenance work.

Safety inspection reports and photographs collected during inspections are available as electronic files through Washington's Structural Inspection (SI) application. Bridge inspectors' work recommendations are accessed using Washington's BEISt application and examined during QC review of inspection reports.

Work recommendations are assigned one of five priorities: urgent; priority 1, 2 or 3; or monitor. Urgent repairs must be completed as soon as possible. Priority 1 repairs must be completed within one year. Priorities 2 and 3 are assigned for routine maintenance. Work recommendations are communicated to regions by the bridge repair list and sometimes by direct communication of bridge inspectors with maintenance crew supervisors.

Washington's team for dive inspections is made up of professional engineers who are certified as master divers. Timber piles in water are inspected on a 30-month cycle. Steel and concrete substructures in water are inspected every 60 months. Some underwater inspections, such as anchor cables for floating bridges, are performed by consultants.

Identification of Maintenance Needs

WSDOT regions can access inspectors' work recommendations for bridges through the BEISt application, which is available on WSDOT's intranet. In addition, the central bridge office publishes a prioritized bridge repair list twice each year using information from BEISt.

WSDOT's central office controls the bridge repair list. Completed maintenance work is reported to the SI system. Bridge inspectors view work completion reports in preparation for safety inspections at bridges. Completed work items become inactive when crews report completed work and are closed after verification by bridge inspectors. Closed work items remain in BEISt as part of bridge work history.

Maintenance of Ferry Terminals

Maintenance needs at ferry terminals are identified by terminal supervisors, facility engineers, bridge inspectors, and state-force craftsmen. Needs are input to the MPET, where they are assigned priorities, undergo review and approval, and are committed for completion as work orders. For emergency needs, there is a 24-hour ferry operations center with an on-call

terminal engineering team.

Programming Process

Bridge maintenance crew supervisors use the bridge repair list to set up detailed plans for work. Crew supervisors seek engineering advice from the DOT central bridge office as needed for specific repairs. Crews and supervisors have substantial autonomy in the scheduling and execution of work in response to the list of needed repairs at bridges. Crew supervisors consider repair priority, potential impacts of seasonal weather on repair operations, and locations of work within a region to make efficient plans for travel and staging. Crew schedules are reviewed weekly.

Bridge repairs are programmed at the region level for work that can be completed by maintenance crews. Larger projects and all repairs with an estimated cost greater than $60,000 are performed by contract, usually under Washington's bridge preservation program.

Bridge Preservation – WSDOT's P2 Program

WSDOT's P2 program provides rehabilitation and replacement for bridges that have a sufficiency rating less than 50 and are either structurally deficient or functionally obsolete. The P2 program provides component and element replacements. Elements in condition state 4 are candidates for preservation projects (i.e., for element replacement). Projects for bridge painting are funded by Washington's P2 program. A DOT committee selects P2 projects. The state legislature approves, and may alter, P2 program plans.

Maintenance Programming Administration

DOT districts administer maintenance crew work. Contracts under $100,000 are administered in districts; larger contracts are administered by the DOT central office.

Performance Measures

Priority Indicators

The WSDOT central office publishes prioritized lists of bridge projects for each biennial programming period. Lists are published for work categories that include concrete deck repairs; miscellaneous repairs; steel painting projects; scour repair projects; and special repairs, such as repairs to joints, railings, and superstructure and substructure components.

Washington's program for bridge rehabilitation and replacement uses a priority formula based on average daily traffic, bridge sufficiency rating, and bridge load factor. The formula is used to rank qualifying bridges (i.e., bridges with a sufficiency rating below 50 that are structurally deficient or functionally obsolete).

$$\text{Priority} = \frac{ADT}{\text{Sufficiency Rating}} \times (\text{Load Factor}) \times \left(\frac{1}{100}\right)$$

Where

$$\text{Load Factor} = \frac{1}{\text{HSTruckRating}}$$

Performance Measures

WSDOT has performance measures for number of structurally deficient bridges, values of bridge structural ratings, scores from the maintenance accountability process, and network grades of good, fair, or poor. Network grades are determined by NBI condition ratings for superstructure and substructure; NBI 4 is poor, NBI 6 is good. Network grades are reported to the governor's office; the governor has a goal of less than 3% bridges in poor condition (based on deck area).

Maintenance Accountability Process

The MAP communicates to the governor, state legislature, Transportation Commission, and public the effectiveness of funds used for transportation maintenance. MAP addresses transportation asset and service aspects, such as bridges, traffic signals, winter operations, ferry operations, tunnels, slopes, pavements, basins, rails, pavement striping, sweeping, rest areas, signs, lights, highway patrols, mowing, graffiti, and litter.

MAP provides level-of-service (LOS) reports for maintenance program accomplishments. LOS grades are A, B, C, D, and F, and MAP reports grades for 32 areas of maintenance. LOS grades are published twice a year in WSDOT's *The Gray Notebook*[108].

Four MAP categories address bridge maintenance: movable bridge operation, structure repair, bridge deck repair, and bridge cleaning. MAP scores are based on simple measures of current conditions. MAP scores for:

- **Movable bridges** are based on the percentage of malfunctions in bridge openings.
- **Structure repair** are based on the percentage of priority 1 repairs that are completed on time.
- **Deck repair** are based on percentage of spalled deck area.
- **Bridge cleaning** are based on the percentage of deck area covered by debris.

The criteria, data sources, and thresholds for A grades in level of service are shown in Table 13.6.

[108] *The Gray Notebook,* Washington Department of Transportation, 34th ed., 2009, 146 pp

MAP category	Criteria	Data source	A level of service
4A1 – Bridge Deck	Percent area spalled	Bridge inspection reports	< 2.5% area
4A2 – Structural Bridge Repair	Percent of Priority 1 repairs completed	Bridge repair lists	> 90% completed
4A3 – Bridge Cleaning	Dirty bridge surfaces, graffiti, blocked drains	MAP field survey[110]	< 4 MAP score2 [111]
4B1 – Movable, Floating Bridge Operations	Percent delayed openings	Data from DOT regions	< 2% delays
4B3 – Urban Tunnel Systems Operations	Closures to flammable cargo	I-90 tunnel group	< 5 closures/year

Table 13.6 *Washington MAP performance measures*[109]

Optimization of Maintenance Programs

DOT regions arrange work schedules for crews to make best use of travel time and to avoid return trips to the same bridges and sites.

Outcomes of Maintenance

Maintenance Tracking

When work is executed, maintenance crews report completion dates to BEISt. Bridge safety inspectors verify completed maintenance work and re-examine open work recommendations. Safety inspectors can modify the scope or priority of open work. All work recommendations (pending, active, and verified [closed]) are preserved in BEISt.

Ferry Terminals

Maintenance work accomplishments at ferry terminals are tracked in the MPET system and appear in annual facility reports. Unmet needs remain in the MPET system with indications of their status and priority.

Maintenance Meetings

WSDOT holds annual meetings of maintenance personnel and participates in the biennial Pacific Northwest Bridge Maintenance Conference.

Maintenance Effectiveness – Ferry Terminals

The basic measure of service at ferry terminals is the number of missed (or lost) ferry trips. Trip reliability at terminals is an indicator of maintenance effectiveness.

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[109] *Maintenance Accountability Process Manual,* Washington Department of Transportation, 2008, 85 pp

[110] Field surveys are separate from bridge safety inspections.

[111] Scores are defined in Washington's *Maintenance Accountability Process Manual* (Washington Department of Transportation, 2008, 85p.) and are related to the number or percentage of defects.

Maintenance Accomplishments

Maintenance accomplishments are measured, in part, as improvement in the performance measures developed in the MAP, improvement to the percentage of deficient bridges, and the percentage of bridges in poor condition.

Ferry Terminals

Washington state ferries make annual reports on their facilities, noting the maintenance work completed. The report contains detailed lists of inspections and PM work completed at all facilities[112].

Maintenance Budget

WSDOT's bridge preservation budgets for the current and prior biennium are shown in Table 13.7.

Strategy	2007-09 ($MM)	2009-11 ($MM)
Hood Canal Bridge	$176.0	$11.1
Bridge replacement	$94.2	$148.2
Bridge repair	$12.4	$23.8
Bridge painting	$16.4	$28.7
Bridge deck rehabilitation	$21.3	$5.0
Movable bridge	$11.1	$0.0
Seismic retrofit	$29.9	$38.2
Scour	$1.8	$3.1
Miscellaneous structures	$1.5	$0.4
Total	**$364.6**	**$130.5**

Table 13.7 *Washington bridge preservation budget*[113]

The Washington legislature approves lump sum amounts for DOT maintenance. Allocations to asset classes and, for the bridge assets, allocations to maintenance, preservation, rehabilitation and replacements are decisions made in the DOT.

MAP – Budget

Budgets for relevant work areas in WSDOT's MAP are listed in Table 13.8.

[112] *Castor T, Ferry Terminal Facilities Annual Report,* Washington State Ferries, 2008, 74 pp

[113] *Wilson D, WSDOT Bridge Preservation Program*, Washington Department of Transportation, 2009, PowerPoint

MAP area	Biennial budget ($MM)	Activities
4B1 Movable and floating bridge operations	7.4	Mechanical and electrical maintenance, opening and closing of the bridge, pumping pontoons, and adjusting anchor cable tension
4A2 Structural bridge repair	9.2	Bridge cap repair, bridge column repair, debris removal, scour repair, expansion joint repair
4A1 Bridge deck maintenance	2	Repair cracks, broken or flaking concrete, exposed steel on bridge decks, and spalling/potholes
4A3 Bridge cleaning and painting	2.4	Cleaning of all bridge surfaces; removal of sand and debris buildup; maintaining proper drainage; power-washing or sandblasting to remove rust, moss, graffiti, bird guano, and dirt; spot-painting bridge structures

Table 13.8 *Washington budgets in MAP areas*

The annual budget for maintenance of ferry terminals is about $2 million for contract work, $400,000 for vendor work, and $3.5 million for state crew work.

Data Systems

Structural Inspection

WSDOT inspectors use SI to submit bridge inspection reports and bridge repair needs. Inspection data are sent to databases for bridge management and repair needs.

Bridge Engineering Information System

WSDOT's BEISt offers a variety of search-and-list views for bridge repair information. BEISt provides information on repair history, recommendations, work completed, and work verified. It also has links to photographs that illustrate repair needs and accomplishments.

Maintenance Productivity Enhancement Tool

WSDOT's MPET provides automated generation of work orders for maintenance tasks. Work orders for cyclic maintenance are generated from information on maintenance intervals and the last reported execution of work. Orders for repairs are based on reported conditions of elements. MPET captures costs of maintenance and repair work.

WSDOT's ferry maintenance program has been using MPET for 12 years. Ferry terminals, landing aids, hoists, and machines all have many maintenance tasks that must be completed at set intervals; emergent needs for repairs must also be addressed. WSDOT likens the MPET installation for ferries to a user's manual hooked up to an alarm clock. Over the 12 years ferry maintenance has been using MPET, more than 81,000 work orders have been generated.

BMS – BRIDGIT

WSDOT uses BRIDGIT[114], a BMS developed under the National Cooperative Highway Research Program. BRIDGIT uses element-level data on quantities and conditions, but with some notable differences from commonly recognized elements used in Pontis. In BRIDGIT, all elements have four condition states, described generally as good, minor repairs needed, defects do not affect load capacity, and defects do affect load capacity.

Element quantities are often reported in a single condition state. Element quantities are always reported in the poorest condition state if defects affect load capacity. For example, a defect of small spatial extent can reduce load capacity of an entire girder, so the entire girder is reported in poor condition.

Maintenance Accountability Process

MAP is a scoring system for WSDOT maintenance programs' accomplishments. MAP identifies actions to be taken in response to MAP level-of-service scores (see Table 13.9).

4A1 Bridge deck repair	
1936 Deck maintenance	Sq ft
4A2 Structural bridge repair	
1931 Structural bridge inspection	None
1932 Remove debris underneath bridge	None
1941 Nonstructural bridge maintenance	None
1942 Structural maintenance	None
1943 Scour repair	None
1952 Sign bridge repair, structural	Each
1953 Expansion joint maintenance	Linear foot
1999 Other bridge and structure maintenance as approved by superintendent	None
4A3 Bridge cleaning	
1922 Bridge, structure cleaning	None
1923 Surface/sidewalk cleaning and sweeping	None
1928 Clean and repair bridge drain	Each
1933 Painting – including sandblasting	None
4B1 Movable and floating bridge operations	
1915 Pump water from pontoon cells	None
1916 Anchor cable tensioning	None
1921 Routine inspection of movable/floating bridges	None
1955 Movable/floating bridge mechanism maintenance	None
1956 Movable/floating bridge electrical maintenance	None

[114] TNCHRP 12-28(02), http://144.171.11.40/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=303

1957 Movable/floating bridge hydraulic maintenance	None
1980 Movable bridge operation	None
4B3 Urban tunnel systems	
3211 Vent fan/mechanical system PM	Each
3212 Fire protection systems – electronics PM	Each
3213 Electrical system PM	Each
3214 Air plenum PM	None
3215 Carbon monoxide monitor PM	Each
3216 Fire protection systems – mechanical PM	Each
3217 Computer or electronics system PM	None
3231 Vent fan/mechanical system repair	Each
3232 Fire protection systems – electronics repair	Each
3233 Electrical system repair	Each
3234 Air plenum repair	None
3235 Carbon monoxide monitor repair	Each
3236 Tunnel washing – walls	100 linear foot
3237 Tunnel washing – illumination	None
3238 Fire protection systems – mechanical repair	Each
3280 Urban tunnel facilities work	None
3291 Computer or electronics system work	None
3299 Other urban tunnel maintenance as approved by superintendent	None

Table 13.9 *Washington MAP categories and operations*[109]

Financial Systems

Expenditures for maintenance work are collected from crew timesheets. Data are entered into the Transportation Reporting, Accounting, and Information System. Data are queried using the Financial Information Retrieval System.

Materials and Methods

Materials

WSDOT has developed a self-contained paint-removal device for suspender ropes. Ropes are squeezed, breaking old, brittle paint. Next, scribes in the device clean the grooves between surface wires.

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[115] *Maintenance Accountability Process Manual*, Washington Department of Transportation, 2008, 85 pp

[116] http://www.flex-crete.com/

[117] http://www.unitex-chemicals.com

[118] http://www.unitex-chemicals.com/

[119] http://www.albioneng.com/

[120] Zaharris A, *Amplifying Questions,* Washington Department of Transportation, 2009
WSDOT Bridge Maintenance, Washington Department of Transportation, 2009, PowerPoint

WSDOT uses deck repair materials that include FlexCrete[116], UreFast[117], and UniTex[118]. WSDOT uses battery-powered Albion[119] caulking guns to apply UreFast for repairs to deck joints.

WSDOT is performing a pilot study on the use of van-mounted video cameras to perform inspections of the top sides of bridge decks. The vans have multiple cameras to provide views ahead, on top, and elsewhere that are adequate for visual definition of deck conditions[120].

CHAPTER 14

Findings, Recommendations, and Implementation Plan

Findings

Bridge Maintenance

Maintenance work includes bridge cleaning and minor repairs that can be performed by DOT crews; major repairs, component treatments, and component replacements that may be performed by DOT crews or by contract; and rehabilitations of components or bridges, usually performed by contract. Maintenance actions and the associated maintenance categories identified by DOTs are shown in Table 14.1[121]. Some DOTs have separate maintenance programs for large bridges (see Table 14.2).

DOT Organization

DOT organization for bridge maintenance includes a central office that provides funding, policies, and priorities to DOT districts; district offices that identify candidates for work programs in minor repairs, major repairs, and rehabilitations; and field inspectors, supervisors, and crews that identify maintenance needs, develop detailed work plans, execute maintenance actions, and verify completed work.

DOT Inventory

DOT maintenance programs are responsible for most state-owned structural assets that carry or cross highways. These include NBI bridges and culverts[122]; short spans[123]; tunnels; earth-retaining structures; nonbridge assets, such as high mast lights and sign structures; and facilities, such as ferry terminals, rest areas, and welcome centers (see Table 14.3).

DOT Maintenance Crews

DOT maintenance crews are organized for bridge and culvert work; for structural work, including assets other than bridges and culverts; or for general maintenance with some assignments to bridge work (see Table 14.4). Many DOTs have special or dedicated maintenance crews for movable bridges, special bridges, or bridge painting.

DOT crew members have basic construction skills, and some crew members may be qualified as welders, equipment operators, or journeymen in construction trades. Many DOTs require that crew members hold a CDL. Most training for crews is by experience on the job. Ohio has a formal, multilevel training program that is tied to advancement of personnel through five

[121] Note that for ease of reading, this section's tables begin on page 158

[122] Bridges and culverts meeting the NBI definition

[123] Bridges and culverts with spans of 20 feet or less and not meeting the NBI definition

titles in the DOT's highway technician series (see Table 14.5).

Identification of Maintenance Needs

Maintenance needs are identified at the element level by bridge inspectors and maintenance crews (see Table 14.6). Many DOTs have standardized lists of maintenance actions that are used by inspectors; standard actions are available as drop-down lists on electronic forms for inspection reporting. Standard actions reported from inspections are available to districts to aid in formation of work plans and reporting of completed work. Inspectors identify maintenance needs, quantities, and priorities. Inspectors at some DOTs report whether maintenance work should be completed by a DOT crew or by a contractor.

DOT districts receive maintenance needs in annual summaries prepared by the DOT central office. Not all recommendations are acted on. High-priority needs and those that are suitable for maintenance crews are addressed. Some needs are sent to contract. Large needs, such as bridge replacement, enter administrative procedures for prioritizing and programming.

Priorities of Maintenance Needs

Inspectors identify the priorities of maintenance needs during safety inspections (see Table 14.7). Maintenance crews, too, report priorities for needs. DOTs have standard identification of and response to needs that affect bridge safety or performance.

Regional or central DOT staff review priorities for maintenance needs. In review, needs are directed to crew work, district-level contracts, or programming through the central DOT office.

Needs persist. A need for significant work that remains unmet can become a higher priority. In one DOT, bridges are placed on a distressed bridge list if they have significant needs that go unmet for more than one inspection cycle.

Performance Measures and Priority Indicators

DOTs employ both performance measures and priority indicators. Performance measures are network-level values that show the fitness of bridge networks and, over time, the achievements of bridge programs (see Table 14.8). Priority indicators are values for individual bridges that are used to determine the category of maintenance that is appropriate for a bridge and to rank competing candidates for work programming. Often, a single kind of measure, such as NBI condition rating, is a basis for both performance and priority. In a performance measure, the percentage of bridges at or beyond a stated NBI condition rating is tracked. In a priority indicator, NBI condition ratings contribute to ranking of work candidates.

Performance measures include percentages of bridges that are structurally deficient, functionally obsolete, or present risks such as seismic or scour vulnerability. Performance measures also include program success in timely response to maintenance needs, especially for high-priority needs. Washington's Maintenance Accountability Process is an example (see Table 14.9). Ohio and Oregon use Organization Performance Indicators that identify deficiencies in bridge paint, wearing surface, and floor condition and make a general appraisal.

Priority indicators include single measures, such as NBI condition ratings or status of a bridge as structurally deficient, and combined measures, such as Delaware's Bridge Deficiency Formula, that use multiple factors in bridge condition and inventory (see Table 14.10).

Maintenance Budget

Funding for maintenance work typically has three components (see Table 14.11): funding allocated to districts for work by maintenance crews, funding for small contracts that are administered in districts, and funding for larger contracts allocated to specific bridge projects through a process of candidate identification and ranking. Identification and ranking involves cooperative work by DOT central and regional offices.

Funding is obtained from both state and federal governments. Federal participation is available to projects that remedy bridges that are deficient, in poor condition, or present specific risks. Federal participation in bridge preventive maintenance is available to DOTs that have secured prior approval from FHWA.

Budgets are determined using historical funding shares, cost estimates for known maintenance needs, or proportions based on performance measures, bridge conditions, and bridge inventories in DOT districts.

Allocations to DOT districts are under district control. That is, districts make decisions on the application of funds to specific maintenance tasks. The use of funds within districts can differ from the basis for allocation used by the DOT central office. Some DOTs allow (and even encourage) districts to bank funds and accumulate funds over several years for large projects; districts can also borrow funds from other districts.

Maintenance Planning and Programming

Work planning and project programming follow processes that depend on the means of work execution (see Table 14.12). Work plans for DOT crews are developed in districts. Districts use lists of maintenance needs compiled from inspection reports, together with the districts' first-hand knowledge of their bridges, to form work plans for crews that suit both the crews' capabilities and the available funding. DOTs may set targets for work distribution to crews and to contracts. For example, Florida's goals are 20% DOT crews, 40% site contracts, and 40% asset maintenance contracts. Districts also plan for cyclic maintenance activities, such as bridge washing and deck sealing.

Districts in most DOTs are able to develop, award, and manage small contracts for maintenance work. These may be site contracts, contracts to provide specific services in support of crew work, or specific items under open-ended contracts.

DOT central and district offices jointly program larger projects. The central office identifies and ranks bridges that are eligible for work under preventive maintenance, rehabilitation, and replacement categories. The central office establishes the budget available to districts for these work categories. Districts respond with their selections among eligible bridges and prepare project scope and cost estimates. Joint review by the central office and district offices yields an

agreed-to work program. Districts prepare their proposed programs within the constraints of eligible bridges, available funding, and their DOT's priorities and initiatives.

Programs are assembled as multiyear plans (see Table 14.13). Major projects enter the program at a five- or six-year horizon, and detailed project development begins two years before the planned date for award. DOTs allocate funding for project development as projects enter the two-year window.

Contracting Mechanisms

Contracts for bridge maintenance work include site contracts, open-ended contracts, and asset management (see Table 14.14). Site contracts are construction contracts that deliver a set of repairs or treatments at bridges. Open-ended contracts offer a schedule of maintenance actions that district managers can direct to bridges. The contractor provides, in effect, additional maintenance crews. Asset management contracts place responsibility for both the identification of maintenance needs and the execution of work with the contractor. In asset management contracts, DOTs periodically inspect assets to verify that the level of service is adequate.

In bid processes, site contracts entail bidding on a fixed schedule of items with fixed quantities. Open-ended contracts entail bidding on a fixed schedule of actions with estimated quantities; quantities are estimated for the first years' work in a contract based on known maintenance needs. AM contracts entail bidding on a schedule of actions and estimated quantities intended to deliver a specified level of service.

Preventive Maintenance

DOTs apply preventive maintenance actions to preserve bridges in good or fair condition (see Table 14.15). Preventive maintenance actions range from routine cleaning to repairs of joints, from deck treatments to deck and superstructure replacements. Some improvements are included, such as retrofits with cathodic protection systems. Virginia includes a set of cyclic actions in preventive maintenance (see Table 14.16).

One Florida district performs preventive maintenance tasks such as clearing drains and repairing spalls at adaptable intervals. With each visit to a bridge, crews perform the intended maintenance and report the extent of work needed. The interval to the next work visit is adjusted, based on the work quantities just completed, to limit the accumulation of new defects.

DOTs report that preventive maintenance work is improving network conditions. Michigan reports that on interstate routes, 88% of bridges are now in good or fair condition, up from 76% at the start of the state's strategic plan. Among Michigan's state bridges, 89% are in good or fair condition, up from 79% previously. More importantly, some of the state's regions have already met the goals of 95% interstate and 85% state-owned bridges in good or fair condition.

Federal Funds for Preventive Maintenance

Among state DOTs included in the scan, Delaware, Michigan, New York, and Virginia

have agreements with FHWA to use federal HBP funds for specific preventive maintenance activities. Other DOTs in the scan have not applied for the use of federal HBP funds for preventive maintenance, or have applied but have not yet received approval.

Maintenance Tracking and Accomplishments

The maintenance needs noted by bridge inspectors and entered into data systems are tracked using those same data systems (see Table 14.17). Districts perform and report work in response to the lists of maintenance needs compiled by central DOT offices. At some DOTs, safety inspectors verify work reports in the following inspection cycle.

Maintenance needs accumulate for some bridges until these needs are resolved in projects for bridge rehabilitation or replacement.

Effectiveness of Maintenance

For DOT central offices, effectiveness of maintenance is expressed in performance measures. The success of maintenance is seen as improvement in performance measures and in the persistence of good performance once it is achieved. For DOT districts, effectiveness is the timely and reliable execution of appropriate maintenance actions. Effectiveness is a part of selecting, scheduling, and completing maintenance work and applying appropriate maintenance methods and products (see Table 14.18).

Effectiveness is improved by communication among maintenance personnel. Several DOTs have regular meetings or conferences that bring together different regions or states to share information and experiences from their bridge maintenance programs.

Data Systems

DOTs use data systems for reporting inspections, compiling maintenance needs, tracking work completion, assessing network conditions, prioritizing bridge work candidates, and performing cost evaluation and analysis (see Table 14.19). Often, there is a separate software application for each use. Links between software applications are developed as data shells or Web portals that present a single data view by drawing on multiple systems. DOTs deploy different portals for different users. Bridge inspectors see a portal adapted to detailed reporting of conditions. Maintenance supervisors see a portal adapted to lists of bridges and work needs. Project programmers see a portal adapted to bridge candidates, priorities, and costs. DOT managers see a portal adapted to network performance measures and budgets in various work categories.

DOT practices differ in the application of standard entries for data items. DOTs in this scan require bridge inspectors to identify needed maintenance work. Some DOTs restrict inspector recommendations to selections from lists of standard actions, which are used directly in crew work planning, project development, and reports of work completion.

Materials and Methods

DOTs that have maintenance crews are able to field test new materials and techniques. Working with DOT materials engineers, maintenance crews assist in approving products for qualified materials lists (see Table 14.20).

Category	Note
California	
Maintenance	Minor repairs
Preservation	Joint repair and replacement, deck treatments and overlays
SHOPPs	State Highway Operation and Protection Program – rehabilitations and replacements
Delaware	
Crews	Clear vegetation and debris; repair erosion and erosion control measures; repair deck, slab, and approach slab spalls; repair ac overlay; clean scuppers and drains; clean/clear weep holes; clean/flush bearings/bearing seats; apply protective coating (for concrete); seal joints in slope paving and at abutment or wing wall
Contract maintenance	Larger repairs, items in open-ended maintenance contracts
STIP	Rehabilitations and replacements
Florida	
Periodic	Movable rebuild, deck major repair, superstructure or substructure major repair, paint system replacement, deck joint replacement, deck/slab overlay, scour countermeasures, fender repair replacement
Routine	Maintenance and reapair of deck joints, decks, railings, superstructures, channels, electrical systems, mechanical systems, movable structural systems
Michigan	
Routine	Minor repairs by DOT crews following recommendations from inspections
Capital scheduled maintenance	Superstructure washing, vegetation control, drainage system cleaning/repair, spot painting, joint repair/replacement, concrete sealing, minor concrete patching and repair, concrete crack sealing, approach pavement relief joints, slope paving repair
Capital preventive maintenance	Joint replacement, pin and hanger replacement, complete painting, zone painting, epoxy overlays, deck patching, scour countermeasures, HMA overlay with waterproofing membrane, HMA cap (no membrane)
Rehabilitation	Concrete overlay, shallow concrete overlay, superstructure repair, extensive substructure repair, substructure replacement
Replacement	Deck replacement, superstructure replacement, structure replacement
New York	
Cyclical maintenance:	Washing, lubricating bearings, and sealing concrete surfaces
Minor repairs:	Spall repair, minor joint repair, bolt tightening
Corrective maintenance, major repairs	Cap beam/pier column repair, wing wall replacement, structural concrete repairs, steel beam repairs
Major bridge rehabilitation, replacement, and construction	Complete design review process

Table 14.1 *Maintenance categories*

Ohio	
Maintenance	Repairs of all bridge elements, including abutments, wing walls, and headwalls, but excluding approach fill and approach slab
Major maintenance	Painting, repairs, and emergency patching of bridge decks to restore the bridge's structural integrity
Routine maintenance	Clearing debris, sweeping, snow, removing ice, patching minor wearing surface, cleaning bridge drainage systems, marking decks for traffic control, making minor and emergency repairs to railing and appurtenances, making emergency patches of decks, maintaining traffic signal and lighting systems
Cyclic maintenance	Bridge cleaning
Preventive maintenance	Sealing concrete surfaces
Scheduled maintenance	Expansion joint replacement, deck replacements and overlays , painting structural steel, paving flow lines and replacing headwalls on culverts
Reactive maintenance	Deck patching, corrective repair from accidents and weather
Oregon	
Maintenance	Cutting back brush; drift removal; channel clearing for fish restoration; patching concrete caps or sills; patching concrete superstructure members; spot painting steel superstructure members; concrete deck patching; patching curbs, rails, and felloe guards; patching concrete piling or posts; painting steel pilings or posts; sealing or patching approach roadways; cleaning or replacing deck joints; cleaning or painting bearings and seats; cleaning catch basins and other drainage; patching and cleaning bridge protective screening
Repair	Repair/replace timber caps/sills, steel caps/sills, concrete caps/sills, concrete superstructure members, steel superstructure members, timber superstructure members, concrete deck, wood deck, curbs, rails, felloe guards, timber pilings/posts, concrete pilings/posts, steel pilings/posts, bracing, and metal decking; fill in or repave approach roadways; repair/replace deck joint; diving, sounding, other structure repair; repair/replace bearings and seats, rivets, catch basins, rip rap or bioremediation, slope paving, other drainage, fender systems, and fish restoration structures; painting; transient camp cleanup; drawbridge operations; graffiti removal; other structure maintenance
Major maintenance	Replacing deteriorated timber elements; repairing/replacing joints, jacking end panels, and deck overlays; deck sealing; strengthening; washing steel bridges; heat-straightening bent steel; spot painting; cleaning bearings
Virginia	
Preventive maintenance	Cleaning, deck sealing, joint repairs, thin deck overlay
Restoration	Rigid deck overlay, superstructure repair, substructure repair, fatigue retrofit, scour repair
Rehabilitation	Superstructure replacement, deck replacement, culvert rehabilitation
Washington	
Preservation	Bridge replacement, repairs to pier columns, movable bridge machinery, steel painting, deck overlays, deck replacement, seismic strengthening, and scour protection

Table 14.1 *Maintenance categories (continued)*

Maintenance (Similar to preservation, but with lesser scope, cost or complexity)	Brush and drift removal, concrete caps and sills, concrete superstructure members, steel superstructure members, concrete deck, curbs, rails, felloe guards, concrete pilings or posts, steel pilings or posts, approach roadway, deck joints, bearings and seats, catch basins, fish restoration, bridge protective screening
Repair/replace	Timber caps/sills, steel caps/sills, concrete caps/sills, concrete superstructure members, steel superstructure members, timber superstructure members, concrete deck, wood deck, curbs, rails, felloe guards, timber pilings/posts, concrete piling/posts, steel piling/posts, bracing, metal decking, deck joints, bearings and seats, rivets, catch basins, rip rap or bioremediation, slope paving, drainage, fender systems, approach roadway work, diving, sounding, fish restoration, structure painting, transient camp cleanup, graffiti removal
Other	Anchor cables for floating bridges Ferry slips: pile replacement, pile repair, pile cap repair or replacement
Wisconsin	
Cyclic	Deck washing, deck sealing
Maintenance	Brush, spalls, joints, bearings, rails, beams
Major/repair replace	Decks, girders, caps

Table 14.1 *Maintenance categories (continued)*

Program	Note
Michigan	
Big Bridge Program	Deck area 100,000 ft2 or greater Post-tensioned segmental concrete Movable bridges
Ohio	
Major bridge program	More than 1000 feet in length Single bridge with deck area 81,000 ft2 or greater Twin bridges with deck area 135,000 ft2 or greater Spans the Ohio River Movable bridge Continuous/cantilever truss bridge Suspension bridge Cantilever truss span > 300 feet Arch, deck, and through-truss span > 250 feet Concrete deck arch span > 130 feet Continuous steel girder span > 150 feet Cable stay span > 300 feet

Table 14.2 *Maintenance of large bridges*

DOT	Assets
California	Bridges, small structures, tunnels, earth-retaining structures, pedestrian bridges, railroad bridges, overhead signs, local bridges
Delaware	Bridges, small bridges, pipes, sign structures
Florida	Bridges, small bridges, sign structures, high mast lights
Michigan	Bridges, small bridges, pedestrian bridges, railroad bridges
New York	Bridges, small bridges, overhead sign structures, high mast lights
Ohio	Bridges, small bridges, railroad bridges, overhead structures
Oregon	Bridges, small bridges, overhead sign structures, tunnels
Virginia	Bridges, small bridges, culverts, pedestrian bridges, tunnels, ferry slips, rest areas, welcome centers, commuter parking lots, overhead sign structures, high mast lights, signal mast arm structures
Washington	Bridges, small bridges, large culverts, overhead sign structures, retaining and noise walls, ferry terminals, transfer spas, hoists, walls, and dolphins
Wisconsin	Bridges, small structures, tunnels, retaining walls, noise barriers, high mast lights, sign structures, ferry

Table 14.3 *Assets to maintain*

Crew	Note
California	
General maintenance	District-based
Painting	12 crews: six regional, six statewide
Delaware	
Structures crew	Actions: Bridge repair and maintenance, building maintenance, movable bridge maintenance, pipe (culvert) replacement, sign structure maintenance, concrete sealing, parapet painting, graffiti cleaning
Florida	
Bridge crew	Some, but not all, districts have bridge crews
Michigan	
Bridge crew	All seven districts have bridge crews
New York	
	Staff of 550 for bridge maintenance crews
Oregon	
General maintenance	14 crews for 15 maintenance districts; crews perform patching, deck sealing, joint replacement, epoxy injection, pile replacement, spot painting, and welding
Dedicated crews	Four crews for the DOT's movable bridges
Virginia	
Small bridge	For bridges with length less than 60 feet: bridge replacement, superstructure replacement, box culvert construction, timber deck replacement, bridge widening, railing replacement, and other work
General maintenance	Crews in five of nine DOT construction districts, and in most of the 42 construction residencies
Washington	
Dedicated crews	Crews for movable bridges. Crews for floating bridges Region-wide bridge crews, all six WSDOT regions
Wisconsin	
1 central bridge crew	Specialized heat straightening, truss repairs, welding, and other tasks

Figure 14.4 *Maintenance crews*

Grade	Title	Note
HT 1	Highway technician 1	General highway maintenance
HT 2	Highway technician 2	Basic construction inspection
HT 3	Highway technician 3	Lead worker
HT 4	Highway technician 4	Construction contract inspection
HT 5	Highway technician 5	Monitor field operations

Table 14.5 *Crew titles (Ohio)*

DOT	Staff	Note
California	Bridge inspectors	From standard action matrix
Delaware	Bridge inspectors	From standard action list of work suitable for crews
Florida	Bridge inspectors	Inspectors' recommendations are reviewed by DOT committee
Michigan	Bridge inspectors	From standard action list
	Maintenance crews	Needs identified during normal work at bridges
New York	Regional bridge maintenance engineer	From review of bridge inspection reports, bridge inventory, bridge history, and input from crew foremen
Ohio	Bridge inspectors	From standard action list
	County supervisors	Bi-weekly inspection
	Bridge operations and maintenance	Lists of maintenance needs compiled annually. Crew work goes to county supervisors. Contract work goes to state DOT programming
Oregon	Maintenance crews	Annual inspections
	Regional bridge inspectors	Needs are sent to district maintenance supervisors by telephone, email or in-person
	Bridge preservation team	Lists of maintenance needs compiled annually by bridge engineering section and sent to district maintenance supervisors. Smaller needs are sent to district maintenance supervisor. Larger needs are sent to the state DOT's bridge program team.
Virginia	Bridge inspectors	Recommend standard actions; federal-eligible actions are identified in coding
Washington	Bridge inspectors	Needs identified in plain language, not standard list
	Bridge preservation office	Compiles list of maintenance needs collected from inspectors, crews, and other input
Wisconsin	Bridge inspectors	From standardized maintenance actions or improvements
	County crews	Needs identified during site visits

Table 14.6 *Identification of maintenance needs*

DOT	Priority	Note
California	Time to repair	Recommendations range from 6 months to 10 years. Drop-down list.
Florida	Feasible action review committee (FARC)	Committee in district reviews and prioritizes needs reported by bridge inspectors. 1 – Emergency, repair in 60 days 2 – Urgent, 180 days 3 – Routine, 365 days 4 – Informational, Monitor.
Michigan	Priority	High, medium or low
New York	Red structural flag	Imminent failure of critical primary structural component; resolve within 42 days
	Yellow structural flag	Potentially hazardous condition; resolve within two years
	Safety flag	Clear and present danger to vehicle or pedestrian traffic, but not structural failure
	Prompt interim action	Red or safety-flag condition needs immediate attention; resolve within 24 hours
Ohio	Priority	1 – Immediate 2 – Schedule 3 – Preventive
Oregon	Priority	Critical (NBI 3) Urgent (NBI 4) Routine (program this work) Monitor (do not program at this time).
Virginia	Priority	Order of recommendations on inspector's report indicates priority: critical repairs, priority repairs, repairs
Washington	Priority	Urgent – Respond as soon as possible 1 – Respond within 1 year 2 – Regular work schedule 3 – No limit M – Monitor
Wisconsin	Priority	Critical Routine Cyclic

Table 14.7 *Priorities of work needs*

DOT	Measure	Note
California	Measure:	Percentage of elements in condition states 1 or 2
	Goal:	85% or greater
	Measure:	Percentage of bridges needing major maintenance
	Goal:	< 10%
	Measure:	Distressed bridges (bridges at risk or needing replacement)
	Goal:	< 5%
	Measure:	Count of SD and FO bridges
	Measure:	Count of bridges with Health Index < 80
Delaware	Measure:	Percentage of structurally deficient bridges
Florida	Measure:	NBI structural evaluation
	Goal:	90% of the bridges rated 6 or higher
	Measure:	Timely completion of maintenance work orders
	Goal:	90% for all work; 100% for priority 1 and priority 2 work
	Measure:	Programming for structurally deficient or weight-restricted bridges
	Goal:	Program within 6 years of identification
	Measure:	Programming for bridge replacements (not SD)
	Goal:	Program within 9 years of identification
Michigan	Measure:	NBI structural evaluation
	Goal:	95% of freeway bridges (either carrying or crossing freeways) in good of fair condition (NBI 5 or higher) 85% of other bridges in good or fair condition
New York	Measure:	NYS condition rating – weighted average of 13 structural bridge component inspection ratings
	Investment Strategy:	Number of interstate bridges rated < 4.5 Number of NHS bridges rated < 4.0
Ohio	Measure:	Network average values of operational performance indices (OPI); see Ohio "Performance Measures and Priority Indicators on page Error! Bookmark not defined.
Oregon	Measure:	Number of on-system bridges that are structurally deficient
Virginia	Measure:	Percentage of structurally deficient bridges
	Goal:	Less than 8% structurally deficient bridges
Washington	Measure:	MAP – Maintenance Accountability Process; level-of-service grades
	Measure:	NBI structural evaluation
	Goal:	Less than 8 % structurally deficient bridges

Table 14.8 *Performance measures*

MAP measure		Basis
4A1	Bridge deck repair	Percentage area that is spalled
4A2	Structural bridge repair	Inspection interval, debris removal, bridge rail, traffic gates, navigation lights, etc.
4A3	Bridge cleaning	Cleaning of the structure and bridge drains, and painting
4B1	Movable and floating bridge operation	Inspection interval, preventive maintenance and emergent maintenance of mechanical, electrical, and hydraulic components
4B3	Urban tunnel systems	Preventive maintenance and emergent maintenance of electrical, air and fire suppression systems

Figure 14.9 *Maintenance accountability process (Washington)*

DOT	Priority Indicator
California	Painting: Paint index is a form of health index. Painting is programmed for paint index < 65 (of 100)
	Multi-objective optimization: Combined application of Pontis analysis and utility functions, described in NCHRP project 12-67
Delaware	Bridge deficiency formula includes: health index, benefit cost ratio, structural deficiency, scour critical, load capacity, functional class, detour length, AADT, AADTT, functional obsolescence, fracture critical status, historical significance
New York	Component indices
	NYS condition rating: a weighted average for 13 structural bridge component condition ratings
Ohio	Organizational performance indices for structure general appraisals (GAs), wearing surface (WS), floor condition (FC), and paint condition (PC)
Florida	NBI condition ratings; structural deficiency
Michigan	**NBI condition ratings** Replace — NBI 4 or lower Rehabilitation — NBI 4 and 5 Preventive maintenance — NBI 5 and 6
Oregon	**State-owned bridges: NBI condition ratings** Critical — NBI 3 or lower Urgent — NBI 4
	Local-owned bridges: Technical ranking formula that includes bridge sufficiency rating, load deficiency, detour length, use by emergency vehicles, functional class, and construction material
Virginia	Ranking by factors that include NBI condition ratings, sufficiency rating, ADT, detour length, structural deficiency, fracture critical, fatigue prone, and load posting
Washington	NBI condition ratings; structural deficiency
Wisconsin	Rate score (state DOT score that includes many variables like: ADT, type, feature, facility etc.); NBI condition ratings; structural deficiency, paint condition element state

Table 14.10 *Priority indicators*

DOT	Category	Note	
California	Contract maintenance	$94 million current fiscal year	
	Crew maintenance	$9 million current fiscal year	
	Bridge preservation	$94 million current fiscal year	
	SHOPP	$300 million current fiscal year	
Delaware	Contract maintenance	$1.5 million per year	
Florida	Routine	Annual allocation to districts; state funds only	
	Periodic and rehabilitation	Allocation to districts by bridge condition and inventory. Repairs are state funds only. Rehabilitations include federal participation	
Michigan	Routine maintenance	$2 million per year for state DOT crews	
	Preventive maintenance	22%	Allocations to districts based on deck areas of bridges with priority needs; annual bridge preservation program funding is $185 million; $16 million is reserved for the Big Bridge Program, $3 million for special needs, and $3 million for bridge emerging technology
	Bridge rehabilitation	30%	
	Bridge replacement	48%	
	Big Bridge Program	Separate allocation that equals about 10% of MR&R funding	
New York (FY 07–08)	Bridge improvements	New bridges, replacements, and rehabilitations; by contact: $450 million for 296 bridges	
	Preventive maintenance	By crews and contract: $142 million for 5812 bridges	
	Local bridges	$257 million for 53 bridges	
	Crews	$6 million for crew tools and materials	
Ohio	Maintenance	Allocation to districts based on current inventory in square feet of bridges that are deficient in general appraisal, floor condition, wearing surface, or paint condition	
Oregon	Major bridge maintenance (MBM)	MBM funds are part of Oregon's STIP; MBM funds are $15 million in 2012–2013, 16% of STIP funding	
	Crews	$7.8 million in 2009–2011	
Virginia	Maintenance	$160 million statewide for all bridge work short of bridge replacement	
	Preventive maintenance	15%	Funding allocations used in Pontis analysis and in Project Optimizer for 11-year plan
	Painting	10%	
	Restoration	25%	
	Rehabilitation	50%	
Washington	Crews	$25.5 million current biennial funding	
	Bridge preservation	$250 million current biennial funding	

Table 14.11 *Maintenance budget categories*

DOT	Category	Office	Note
California	Work recommendations	Central	Peer-review meeting to select maintenance actions
	Preservation and SHOPPS	Central	Structures maintenance and investigations
		District	District maintenance staff
Delaware	Contract maintenance	Central	Bridge maintenance and operations
		District	Supervisor for maintenance; staff to manage contracts
Florida	Major repairs	District	District structures maintenance engineer
		Central	Bridge operations, DOT financial management
	Routine maintenance	District	District structures maintenance engineer directs work to crews or to standing contract
Michigan	Crew work	Regional	Bridge manager
		Subregional	Transportation service center
	Maintenance projects	District	Region bridge staff
		Central	Structure maintenance section
	Capital maintenance	Regional	Region bridge staff
		Central	Bridge operations office advertises call for projects to DOT regions.
	Long-range plan	Central	Developed by DOT with approval by state transportation commission; commissioners selected by governor
New York	Maintenance projects	Regional	Regional bridge maintenance engineer
		Central	Bridge maintenance program engineer
	Large projects	Regional	Regional program and planning engineer, regional structures management team
		Central	Capital maintenance
Ohio	Maintenance work plan	County	County supervisor develops county work plan
		Regional	Region manager reviews and combines into region plan
		Central	DOT's program management committee reviews and combines into a statewide plan
Oregon	Maintenance projects	District	District supervisors
		Regional	Sets district allocations and assists in scheduling and permits
	Major bridge maintenance	Central	Bridge program team
Virginia	Bridge replacement	District	District bridge engineer
		Central	Structure and bridge division

Table 14.12 *Coordination of bridge programming*

DOT	Category	Office	Note
Washington	Crew work	Regional	Regional crew supervisor; work plan developed from BEISt repair list
	Bridge preservation	Central	Bridge preservation office; may be altered by state legislature.
		Regional	Region maintenance engineer
Wisconsin	Crew work	Regional	County forces
	Bridge maintenance	Central, Regional	Structures development section application and regional bridge maintenance engineers

Table 14.12 *Coordination of bridge programming (continued)*

DOT	Note
California	5-year plan, updated every 2 years
Michigan	Replacement projects: 4 to 5 years Rehabilitation projects: 3 to 4 years Preventive maintenance: 1 to 2 years
Ohio	Multiyear work plan at district level
Virginia	6-year improvement plan

Table 14.13 *Planning*

DOT	Contract	Note
Delaware	Open-end	3-year duration, standard maintenance actions and costs, maximum contract amount
Florida	AM	Maintenance action executed when requested by DOT
	Site	Bridge rehabilitation, bridge replacement
Michigan	Site	Capital scheduled maintenance, capital preventive maintenance
New York	Site	Larger maintenance projects
	Job order	An open-ended contract type using a construction task catalog of fixed prices; suited to replacement-in-kind maintenance needs
	Hybrid	Contracts that provide bid items, quantities, and engineering design plans for one among a set of similar projects; schedule of bid prices are applied to additional, similar projects as quantities and engineering design become available
Oregon	Site	Small contracts are administered within districts; larger projects go to DOT's central procurement.
Virginia	Open-end	District-wide contracts have 3-year duration and are renewed each year; contracts funded at $2 million annually. Contracts have 95 bid items for both ordinary and preventive maintenance and a mix of federal-eligible and ineligible actions
	Site	Districts procure and administer small and large maintenance projects
	AM	Turnkey asset management contracts are used for operations and minor repairs along interstate routes
	Design	Consultant design services are available to DOT districts through three open-ended regional contracts
Washington	Job order	An open-ended contract type used for maintenance actions at ferry terminals
Wisconsin	Site	Large contracts let through central office

Table 14.14 *Bridge maintenance contracting*

DOT	Preventive maintenance
California	■ Crack sealing, deck overlays, replace joint seals, painting ■ Request for federal HBP funds is in review
Delaware	■ Deck repairs, treatments and overlays, painting, cleaning, pile jackets, scour countermeasures, bearing replacement, and seismic retrofits ■ Uses federal HBP funds
Florida	■ Bridge deck cleaning, cathode protection systems; movable bridges: lubrication, adjustment, and general upkeep of mechanical and electrical systems ■ Does not use federal HBP funds
Michigan	■ Deck overlays, joint replacement, and painting ■ Uses federal HBP funds
New York	■ Remove brush; maintain stream channels; maintain bank protection and walls; clean substructure; seal substructure; lubricate bearings; repair bearings; clean superstructure and deck; repair joints; remove wearing surface; place wearing surface; place membrane; seal deck, curb, sidewalk, and fascia; fill cracks and joints; clean drainage system; spot painting; paint bridges; maintain electrical and mechanical equipment ■ Uses federal HBP funds
Ohio	■ Deck patching; overhead loose material removal; scour corrections; resetting bearings; deck repair and replacement; abutment repair; concrete sealing; replacement of deck edges; box culvert installation; approach slab repair and replacement; drainage repair, including scupper extensions, pile encasements, bridge and deck cleaning, resetting/repair bearing devices, scour protection/channel alignment ■ Does not use federal HBP funds
Oregon	■ Washing steel bridges, spot painting, and deck sealing ■ Does not use federal HBP funds
Virginia	■ Seal/replace leaking joints, deck overlays, painting spot and zone, cathodic protection systems, electrochemical chloride extraction, scour countermeasures, removal of large debris, fatigue retrofit, concrete deck repairs during overlay, substructure repairs during cathodic protection or electrochemical chloride extraction , sealants for concrete by coating or membrane, bridge cleaning or washing ■ Uses federal HBP funds
Washington	■ Bridge cleaning, drain clean/repair, painting ■ Federal HBP funds used for preservation, not preventive maintenance
Wisconsin	■ Washing bridge decks, sealing bridge decks, spot painting ■ Does not use federal HBP funds

Table 14.15 *Preventive maintenance actions*

Action	Interval
Wash bridge, sweep bridge	1-year
Wash bearing seats	2-year
Timber bridges – tighten bolts, apply preservative	2-year
Bearings – clean and lubricate	4-year
Culvert – clean	5-year
Joints – replace pourable seal	6-year
Joints – replace compression seal	10-year
Paint ends of steel beams	10-year
Deck – thin epoxy overlay	15-year

Table 14.16 *Preventive maintenance intervals (Virginia)*

DOT	Tracking
California	■ Completion reports from state crews ■ Completion reports for contracts
Delaware	■ Crews report completion to Maximo, a maintenance management system ■ Completion reports are later copied to Pontis' inspection comment field
Florida	■ Crew report completion to online maintenance management system ■ Priority 1 and 2 repairs are verified by special inspection ■ Other repairs are verified at next regular inspection
Michigan	■ Crew work completion is reported to Maintenance Activity Reporting System ■ Contract work completion is reported annually to district inspection team
New York	■ Crew work completion is reported to MAMIS, a maintenance management system ■ Annual reports is sent from MAMIS to regional bridge maintenance engineer and transferred to bridge inspection database
Ohio	■ Completion reported to Transportation Management System (TMS)
Oregon	■ Crew supervisors report work completion to Pontis ■ Regional bridge inspectors verify work at next regular inspection
Washington	■ Work completion reported to BEISt and verified at next regular inspection
Wisconsin	■ Recently developed county bridge item work order tracking addition to Highway structure Information System

Table 14.17 *Maintenance tracking*

DOT	Activity	Note
California	Meetings	Biennial Pacific Northwest Bridge Maintenance Conference, a multistate conference for bridge maintenance personnel
Florida	Meetings	Five or six teleconferences annually among DOT central office and districts to exchange information on maintenance materials and methods
	Quality assurance	Districts' maintenance programs undergo annual review; a sample of work orders is reviewed for appropriate recommendation, appropriate priority, and timely completion
Michigan	Meetings	Annual 1-1/2 day bridge maintenance conference attended by DOT regional crews, bridge inspectors/engineers, and county personnel, as well as material and equipment suppliers
		Monthly meetings of region bridge teams, including bridge inspectors, bridge programmers, maintenance supervisors, and transportation service center representative
	Monitoring	Bridge deterioration rates
New York	Meetings	Several meetings each year of the regional structures management team: the regional structures engineer, the regional bridge management engineer, and the regional bridge maintenance engineer
		Statewide quarterly meetings of regional bridge maintenance engineers and their staff, along with liaisons for the structures and technical services divisions
	Publications	Bimonthly *Bridge Maintenance Newsletter*
Oregon	Meetings	Biennial Pacific Northwest Bridge Maintenance Conference, a multistate conference for bridge maintenance personnel
		Statewide DOT maintenance conference, held biennially to alternate with the Biennial Pacific Northwest Bridge Maintenance Conference
	Quality Assurance	State DOT uses bridge design engineers as part of teams for quality assurance review of districts; this involvement helps inform design practice
Washington	Meetings	Biennial Pacific Northwest Bridge Maintenance Conference, a multistate conference for bridge maintenance personnel
Wisconsin	Meetings	Annual Regional Maintenance meeting with central office personal

Table 14.18 *Maintenance effectiveness*

DOT	System	Note
California	SMART	Structure Maintenance Automated Report Transmittal – inspection and work reporting
	BIRIS	Bridge Inspection Records Information System – presentation of bridge reports and photos
	LP 2000	Data for local government bridge programs
	Pontis	AASHTOWare BMS
	IMMS	Integrated Maintenance Management System – crew reporting
	TSN	Traffic information system – provides ADT and other roadway data
Delaware	MAXIMO	Maintenance management system
	Pontis	AASHTOWare BMS
Michigan	Oracle	Central database for bridges, roads, and other transportation assets
	TMS	Transportation Management System – suite of portals to Oracle database adapted to various DOT users
	MARS	Maintenance Activity Reporting System – system to report maintenance costs and track work completion
	MBIS	Michigan Bridge Inspection System – inspection reporting
	MBRS	Michigan Bridge Reporting System – general access to bridge data; used for bridge lists (SD, FO, etc.) and in development of 5-year plans
	Possible Projects	Automated scoping and cost estimating for bridge projects; forecasts network conditions resulting from projects
	BCFS	Bridge Condition Forecasting System – used in programming; applies Markov chains to NBI condition ratings
New York	MAMIS	Work reporting system – crew reporting
	Bridge Program Worksheet	Microsoft Access – used in capital programming; includes risk for bridges
	Needs Assessment Tool	Microsoft Access – used in capital programming; provides forecasts for 5-, 12-, and 2-year planning horizons
	Bridge Needs Assessment Model	Bridge condition curves calibrated to each bridge construction material and each DOT region; curves respond to corrective and preventive maintenance programs; used in capital programming
Ohio	BMS	Contains bridge inventory and appraisal data
	Ellis	Tracks project development
	TMS	Tracks bridge inspection and maintenance crew work
	BMRI	Bridge Management Remote Inspection – inspection reporting
Oregon	Pontis	Bridge inventory and condition data; not used for programming; work candidate section is used to identify and track maintenance needs
	MMS	Funding and tracking of work of maintenance crews

Table 14.19 *Data systems*

DOT	System	Note
Virginia	Site Manager	Work accomplishment for all maintenance contracts
	Pontis	For inventory and condition data
	CrossWalk	Relates Pontis actions to maintenance subprograms
	Optimizer	Post-processor for Pontis to generate 11-year maintenance work analysis
Washington	Bridgit	BMS developed in NCHRP project 12-28
	TRAINS	Transportation Reporting, Accounting and Information System – labor reporting system
	BEISt	Bridge Engineering Information System – database of repair needs and completion reports
	SI	Bridge structural inspection reporting
	MPET	Maintenance Performance Enhancement Tool – work order tracking and automated generation of work orders for cyclic work
	BRL	Bridge Repair List
Wisconsin	HSI	Highway Structure Information System

Table 14.19 *Data systems (continued)*

DOT	Component	Note
California	Deck	High molecular weight methacrylate for crack sealing; spread on surface and broadcast with sand for skid resistance
	Deck	Polyester concrete overlay; in use since 1985; placed 9.1 million ft2 in the past 10 years
	Painting	QuikDeck[124] and SafeSpan[125] used for painting platforms; containment is watertight, allows for humidity control during painting
Florida	CFRP	Use of carbon fiber reinforced plastic repairs for past 15 years
	Bridge	Controlled load testing to provide bridge load ratings and allow overloads
	Cathodic protection	Extensive use of both sacrificial and impressed-current cathodic protection for bridges and bridge components exposed to salt water
Michigan	Repair materials	Central construction testing lab uses maintenance crews to test and evaluate new materials
Virginia	Deck	Very-early rapid-set latex concrete carries traffic 3 hours after placement
	Deck	Trial decks with corrosion-resistant reinforcing steels, comparing stainless steel, stainless clad, and MMFX reinforcing bars
Washington	Suspender ropes	Self-contained device for paint removal by flexing steel ropes to shatter old, brittle paint
	Deck	Inspection by van-mounted video cameras for decks in good condition

Table 14.20 *Maintenance materials*

Recommendations

Key Recommendations

The scan team's key recommendations for bridge management decision-making are as follows:

1. Adopt element-level bridge inspection programs and establish standard condition states, quantities, and recommended actions (i.e., maintenance, preservation, rehabilitation, and replacement) to match the operational characteristics of the agency's maintenance and/or preservation program.
2. Establish national performance measures for all highway bridges for comparisons among bridge owners and owner-specific performance measures that can be used to allocate funding levels for a full range of actions (i.e., maintenance, preservation, rehabilitation, and replacement) to optimize highway bridge conditions.

[124] http://www.safway.com/Products/QuikDeck.asp
[125] http://www.safespan.com

3. Use owner-specific performance measures to set overall funding levels for maintenance and preservation programs.
4. Determine bridge needs and a proposed multiyear treatment program based on owner-specific objectives and use the proposed program to develop a needs-based funding allocation, using all types of funding within the state's prerogative for each of the recommended action types (i.e., maintenance, preservation, rehabilitation, and replacement).
5. Establish standards for preventive maintenance programs that are funded at levels set by analysis of performance measures. Programs must include the preservation needs of "cusp" bridges to keep them from becoming deficient bridges. In other words, do the right activity at the right time, keeping good bridges in good condition and moving away from "worst first." Experience in scan states has shown that preventive and minor maintenance must be a significant portion of bridge programs that optimize bridge conditions within limited budgets.
6. Develop work programs for maintenance and preservation at the lowest level of management or supervision when those positions are staffed by supervisors with extensive field maintenance knowledge and experience. Avoid blind use of work programs from BMSs and work programs dictated by goals to maximize performance measures (although both BMSs and performance measures provide useful information to maintenance crews).

Scan Team Overall Recommendations

Based on the findings, the scan team also identified a larger set of overall recommendations in addition to its key recommendations. These overall recommendations, which have been categorized into various bridge management areas, draw upon and expand the key recommendations to highlight effective bridge management practices that have broader program applicability. The team's overall recommendations are as follows:

Assessments

Element-level inventory and inspection

- Identify and store work recommendations (set to match agency practices) and costs in a corporate database
- Continuously capture accomplishments and unmet needs
- Create a feedback loop for validation to avoid re-reporting of resolved needs

Performance Measures

- Establish performance measures
- Include all bridges, not just structurally deficient bridges and functionally obsolete bridges

- Ensure that the measures are suitable for establishing relative funding levels for crew or contract maintenance, capital program rehabilitation, and capital program replacement
- Ensure that the measures are suitable for national comparison

Funding/Resources

For all highway bridges, develop needs-based funding formulas that recognize the value of maintenance and repair at the appropriate time to improve bridge conditions and extend service life.

Decision Tools

- Integrate project and network objectives, especially for program-level decision-making in asset management, to achieve single-asset optimization
- Use forecasting and modeling
- Ensure that the tools are capable of evaluating maintenance scenarios that are consistent with agency maintenance practices

Programming

- Use priority indicators that integrate urgency, vulnerability, delays, costs, and other related factors
- Coordinate work plans through local, district, and headquarters levels to include local knowledge, with day-to-day work schedules set at the lowest local level

Delivery Mechanisms

- Use a wide range of alternative design/contracting options for various types of maintenance and repairs, including state crews, contracted planned maintenance, on-call contracted as-needed repairs, and state specialty crews for specific repairs, such as spot painting, heat straightening, and corrosion mitigation
- Continue efforts in performance-management type contracts
- Develop standardized item-based contracting for specific on-call projects

Best Practice Recommendations

The best practices for bridge management included the following:

- **Bridge Maintenance**—Maintenance work includes bridge cleaning and minor repairs that can be performed by DOT crews; major repairs, component treatments, and component replacements that can be performed by DOT crews or by contract; and rehabilitation of components or bridges, usually performed by contract.
- **DOT Organization**—DOT organization for bridge maintenance includes a central office

that provides funding, policies, and priorities to DOT districts, and district offices that identify candidates for work programs.

- **DOT Inventory**—DOT maintenance programs are responsible for most state-owned structural assets that carry or cross highways. These include National Bridge Inventory (NBI) bridges and culverts; short spans; tunnels; earth-retaining structures; nonbridge assets, such as high mast lights and sign structures; and facilities, such as ferry terminals, rest areas, and welcome centers (see Table 14.3).
- **DOT Maintenance Crews**—DOT maintenance crews are organized for bridge and culvert work; for structural work, including assets other than bridges and culverts; or for general maintenance with some assignments to bridge work (see Table 14.4). Many DOTs have special or dedicated maintenance crews for movable bridges, special bridges, or bridge painting.
- **Maintenance Need Identification**—Bridge inspectors and maintenance crews identify maintenance needs at the element level (see Table 14.6). Many DOTs have standardized maintenance action lists that are used by inspectors.
- **Maintenance Need Prioritization**—Inspectors identify maintenance need priorities during safety inspections (see Table 14.7). Maintenance crews, too, will report maintenance need priorities. DOTs have standard identification and response to needs that affect bridge safety or performance. Regional or central DOT staff review priorities for maintenance needs.
- **Performance Measures and Priority Indicators**—DOTs employ both performance measures and priority indicators. Performance measures are network-level values that show the fitness of bridge networks and, over time, the achievements of bridge programs (see Table 14.8). Priority indicators for individual bridges are values that are used to determine the category of maintenance appropriate for a bridge and to rank competing candidates for work programming.
- **Maintenance Budget**—Funding for maintenance work typically has three components (see Table 14.11): funding allocated to districts for work by maintenance crews, funding for small contracts that are administered in districts, and funding for larger contracts that are allocated to specific bridge projects through a process of candidate identification and ranking.
- **Maintenance Planning and Programming**—Work planning and project programming follow processes that depend on the means of work execution (see Table 14.12). Work plans for DOT crews are developed in districts. Districts use lists of maintenance needs compiled from inspection reports and the districts' first-hand knowledge of their bridges to form work plans that suit both the work crews' capabilities and the available funding. Districts in most DOTs are able to develop, award, and manage small contracts for maintenance work. These may be site contracts, contracts to provide specific services in support of crew

work, or specific items under open-ended contracts. DOT central and district offices jointly program larger projects. Programs are assembled as multiyear plans. Major projects enter the program at a five- or six-year horizon, and detailed project development begins two years before the planned date for award. DOTs allocate funding for project development as projects enter the two-year window.

- **Contracting Mechanisms**—Contracts for bridge maintenance work include site contracts, open-ended contracts, and asset management contracts (see Table 14.14). Site contracts are construction contracts that deliver a set of repairs or treatments at bridges. Open-ended contracts offer a schedule of maintenance actions that district managers can direct to bridges. The contractor provides, in effect, additional maintenance crews. Asset management (AM) contracts place responsibility for both the identification of maintenance needs and the execution of work with the contractor. In AM contracts, DOTs make periodic inspections of assets to verify that the level of service is adequate.
- **Preventive Maintenance**—DOTs apply preventive maintenance actions to preserve bridges in good or fair condition. Among state DOTs included in the scan, Delaware, Michigan, New York, and Virginia have agreements with the Federal Highway Administration (FHWA) to use federal Highway Bridge Program (HBP) funds for specific preventive maintenance activities. Other DOTs in the scan either have not applied for the use of these funds or have applied but have not yet received approval.
- **Maintenance Tracking and Accomplishments**—The maintenance needs noted by bridge inspectors and entered into data systems are tracked using those same data systems.
- **Maintenance Effectiveness**—For DOT central offices, the effectiveness of maintenance is expressed in performance measures. The success of maintenance is seen as improvement in performance measures and as the persistence of good performance once it is achieved.
- **Data Systems**—DOTs use data systems for reporting inspections, compiling maintenance needs, tracking the completion of work, assessing network conditions, prioritizing bridge work candidates, and performing cost evaluations and analyses.
- **Materials and Methods**—DOTs that have maintenance crews are able to field test new materials and techniques. Maintenance crews, working with DOT materials engineers, assist in approving products for addition to qualified materials lists (see Table 14.20).

Implementation Plan

1. Investigate and recommend an FHWA demo project titled *Best Practices in Bridge Management Technologies and Computer Applications.*
2. Create a repository of home-grown repair techniques for skills training (i.e., TSP2 or TCC Web page).

3. Recommend that FHWA issue national approval guidelines for acceptable systematic process for bridge preventive maintenance activities.
4. Present recommendations to the Pontis Task Force for changes to the software:
    a. Option to include all needs in any project identified for a specific bridge
    b. Link recommended actions to corresponding core elements when applicable
    c. Include inspector-recommended actions in prioritized needs
5. Recommend an NCHRP synthesis study on methods of cost-effective maintenance contracting.
6. Recommend changes to the NHI Bridge Maintenance and Bridge Rehabilitation courses to include findings from the scan. Encourage cross-training of maintenance and inspection technicians.
7. Recommend changes to the NHI two-week Bridge Inspection Course on making repair recommendations.
8. Prepare draft PowerPoint presentation on the scan's summary and findings and present it at July SCOBS and SCOM general meetings.
9. Publish applications/spreadsheets/programs for identification, prioritization, and monitoring maintenance recommendations.
10. Include links to recommended applications in final scan report.
11. Publish a paper that describes examples of determining optimum level of maintenance and justifies adequate expenditures. Publish successful state federal-aid preventive maintenance programs in preventative maintenance based on improved overall system performance.
12. Recommend an NCHRP Synthesis on optimal performance measures for bridge preventive maintenance, including use of simple red-yellow-green indicators.
13. Prepare *Public Roads (Road and Bridges, Bridge Design and Engineering*, and the *New York Bridge Maintenance* newsletter) article on a summary of the scan and its findings.
14. Present a summary of the scan and its findings to various bridge conferences (e.g., IBC, NBC, NWBMC, IABSE, and TRB).
15. Recommend an NCHRP Synthesis on best practices for identification, prioritization, and monitoring of bridge management techniques, decision-making, and actions.
16. Prepare a communication plan (i.e., via Web sites, FHWA, webinars, articles, TRB, and AASHTO committees and task forces) to increase exchange of information on identification, prioritization, and monitoring of bridge management techniques, decisions, and actions, including support for exchanging information between TSP2 regional groups.

17. Recommend FHWA increase emphasis on requirements for maintenance of federal-aid projects, including preventive maintenance to achieve planned service life.
18. Encourage dissemination and use of the new *NCHRP Report on Deck Overlays and Preservation Methods*.
19. Recommend that the FHWA Office of Asset Management host a webinar to describe a summary of the scan and its findings and have three states highlight their best practices.
20. Recommend a special set-aside of NCHRP funding dedicated to bridge maintenance and preservation issues, based on the TSP Roadmap and TSP2 Strategic Plan.

APPENDIX A:

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APPENDIX B:

Scan Team Biographical Sketches

Peter Weykamp (AASHTO Co-Chair) is the bridge maintenance program engineer for the New York State Department of Transportation (NYSDOT). His primary duties include development of network level maintenance strategies, operations management, product evaluation, and technical supervision. He has been with NYSDOT for 25 years, holding positions in structural design, research, and construction. He has been in his current position since 1997. Weykamp chairs the Bridge Task Force on the AASHTO Subcommittee on Maintenance, is a member of the TRB AHD-30 Structures Maintenance Committee, is currently a panel member for several NCHRP projects related to bridge maintenance/preservation, and recently co-chaired a European scan tour on *Bridge Evaluation/Quality Assurance*. Weykamp holds bachelor of science degrees in biology and civil engineering and a master of science degree in public administration.

Tod Kimball (FHWA C0-Chair) is the design and structures engineer for the Vermont Division of the Federal Highway Administration (FHWA). In this role, he manages the Division's Federal-Aid Bridge Program and serves as the principal staff specialist for structural matters. Prior to joining the Vermont Division, Kimball served as the assistant structures engineer for the FHWA Pennsylvania Division, a structural engineer with the Bridge Inspection and Management Program of FHWA's Federal Lands Highway office in Virginia, and a bridge design engineer and regional bridge inspection engineer for the Georgia Department of Transportation in Atlanta. Kimball has experience in bridge inspection, management, design, and construction. He currently serves as the FHWA liaison for the Northeast Bridge Preservation Partnership, which functions under the AASHTO Transportation System Preservation Technical Services Program (TSP-2), and recently participated in a European Scan tour on *Bridge Evaluation Quality Assurance*. Kimball holds a master of science degree and a bachelor of science degree in civil engineering from the University of Maine, and a bachelor of science degree in mathematics from Gordon College, Massachusetts. He is a licensed professional engineer.

Arthur W. D'Andrea is the assistant bridge design engineer for the Louisiana Department of Transportation and Development. D'Andrea is in charge of bridge design, bridge rating, and permit evaluation teams. He has experience with many types of bridge rehabilitation projects, including Mississippi River Bridge truss strengthening, lift spans such as Danziger, and emergency project replacements using conventional and specialized devices such as SPMTs. D'Andrea has more than 30 years' experience in structural engineering. He is a member of AASHTO Technical Committee T-18 (Bridge Management, Evaluation, and Rehabilitation). He received his bachelor of science degree in civil engineering from Louisiana State University and is a licensed professional engineer in Louisiana.

Scot Becker is the state bridge engineer and Bureau of Structures Development chief for the Wisconsin Department of Transportation in Madison. He is responsible for developing and issuing statewide policy and procedures for all structure features used in transportation programs. His responsibilities include bridge management and policy decision support for structures in Wisconsin. He also has a responsible role in research and implementation

of innovative technology in the structures field in Wisconsin. Becker has served with the Wisconsin DOT for more than 15 years and has more than 19 years of experience in structural engineering for state highway administrations and private engineering firms. He is a graduate of the University of Wisconsin-Madison and holds both bachelor and masters of science degrees in civil engineering. He is a licensed professional engineer in Wisconsin and serves on several technical committees of the AASHTO Subcommittee on Bridges.

Bruce Johnson is the state bridge engineer for the Oregon DOT in Salem. Johnson currently directs the Bridge Engineering Section of ODOT, including bridge design standards; bridge inspection and load rating; bridge major maintenance; and preservation of movable, historic, and coastal bridges. The Bridge Section's current research emphasis includes seismic prioritization, self-curing concrete, optimization of impressed current cathodic protection, and shear cracking of reinforced concrete girders. Prior to joining the ODOT in 2004, Johnson served for 29 years in various bridge engineering positions with FHWA in Oregon, Iowa, Indiana, Colorado, Kansas, and Nevada. He is a graduate of Cal Poly University and holds a masters degree in structural engineering from Iowa State University. He is a licensed professional structural engineer in California and Oregon and serves on several technical committees of the Precast Concrete Institute and the Transportation Research Board.

Keith Ramsey is the director of the Field Operations Section in the Bridge Division of the Texas Department of Transportation (TxDOT), and oversees division support of bridge construction and maintenance, inspection, and geotechnical operations. The Field Operations Section acts as an in-house consultant to TxDOT on bridge-related issues to help minimize construction costs and maximize maintenance dollars. Ramsey began his career with TxDOT in the Bridge Division as a bridge design engineer. In 1995 he accepted the position of assistant state bridge inspection engineer within the Bridge Division, and in 1999 he became the state bridge inspection engineer, responsible for overseeing the inspection program for the country's largest bridge inventory. He graduated in 1984 from the University of Texas at Austin with a bachelor of science degree in civil engineering. Ramsey is a licensed professional engineer.

George Hearn (Subject Matter Expert) is an associate professor of civil engineering at the University of Colorado at Boulder. Hearn has nearly 30 years' experience in bridge inspection, design, rehabilitation, and management. He has served as principal investigator for bridge-related projects sponsored by the National Science Foundation, the National Academies, the FHWA, and the State of Colorado. He is the author of *NCHRP Synthesis 375 Bridge Inspection Practices* [126] (2007); the principal investigator for NCHRP Project 14-15, *Developing a National Database System for Maintenance Actions on Highway Bridges* (in progress); and the principal investigator in evaluation of bridge preservation costs for Colorado

[126] http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_375.pdf

DOT (in progress). He evaluated bridge deck durability for Colorado DOT [127] (2007), designed modular reaction walls for CU's earthquake simulation laboratory, wrote the international scan trip report *Bridge Preservation and Maintenance in Europe and South Africa*[128] (2005), developed a conceptual plan for a Colorado DOT system for maintenance management of retaining walls and sound barriers[129] (2003), evaluated the effects of nondivisible loads on fatigue life of steel bridges for Colorado DOT (2001), established procedures for the use of NDE test data in element-level condition reports for FHWA (2000), studied the reliability of field testing methods applied to highway bridges for the National Science Foundation (1998), developed methods for segmental inspections as a refinement to element-level condition reports for Colorado DOT (1997), and created the NBI translator for element-level condition data for FHWA (1994 and 1997 revision). Hearn is a licensed professional engineer.

[127] http://www.dot.state.co.us/publications/PDFFiles/bridgedecklife.pdf
[128] http://international.fhwa.dot.gov/pubs/pl05002/pl05002.pdf
[129] http://www.dot.state.co.us/publications/PDFFiles/retainingwallmgt.pdf

APPENDIX C:

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APPENDIX D:

Amplifying Questions

1. Respondent

1.1 Tell us about yourself and please provide your contact information (your name, state, organization, title, phone, fax, and e-mail).

2. Definitions

2.1 In your agency, what types of work are considered bridge maintenance?

2.2 Is preventive maintenance (PM) performed? If yes, what types of work are considered preventive maintenance[130]?

2.3 Do you have formal definitions of bridge maintenance and/or preservation? Where are these definitions stated? Are there state statutes that establish or affect your definitions of bridge maintenance and preservation?

2.4 Maintenance Categories – *We seek information on what categories you identify as bridge maintenance and what kinds of work are included in each category. Categories used at various DOTs include cyclic maintenance, preventive maintenance, scheduled maintenance, reactive maintenance, demand maintenance, minor maintenance, and major maintenance.*

2.4.1 Please name and describe your categories of bridge maintenance.

3. Documents

3.1 What manuals, guides, or other documents does your agency publish for bridge maintenance? Can we get copies of these documents?

4. Bridge Maintenance Program at Your Agency

4.1 How many bridges meeting the NBIS bridge definition are your maintenance responsibility?

State-owned highway bridges > 20 feet	
Toll-authority owned highway bridges > 20 feet	
County- or locally owned highway bridges > 20 feet	
Other highway bridges > 20 feet	

Table D.1 *NBIS bridges*

[130] PM is an activity performed on the structure or its elements to delay or curb the onset of deterioration. Source: AASHTO Guidelines for BMS, 1993

4.2 How many bridges not meeting the NBIS bridge definition are your maintenance responsibility?

State-owned highway bridges ≤ 20' feet	
Toll authority owned highway bridges ≤ 20 feet	
County- or locally owned highway bridges ≤ 20 feet	
Other highway bridges ≤ 20 feet	
Pipes, smaller culverts ≤ 20 feet	
Pedestrian bridges	
Railroad bridges	
Other (please specify)	

Table D.2 *Non-NBIS bridges*

4.3 What and how many other (ancillary) structures are your maintenance responsibility?

High mast lights	
Overhead sign structures	
Traffic lights	
Earth-retaining structures (i.e., retaining walls)	
Tunnels	
Other (please specify)	

Table D.3 *Other structures*

4.4 Are other agencies responsible for maintenance of any of the structures in Table D.1, Table D.2, and Table D.3?

4.4.1 If yes, please list those agencies and describe the extent of their maintenance responsibilities.

4.5 If a new structure contains a complex or unusual structural detail, does the engineer provide a complete owner's or user's manual for your maintenance personnel to use?

4.6 Has your agency established a guideline that clearly specifies what maintenance work must be reviewed or approved by a licensed professional engineer? If so, can we obtain a copy of the guideline?

5. Maintenance Execution

5.1 How does your agency execute the program for bridge maintenance? Please describe your agency's use of DOT crews, of contracts for individual maintenance projects, and of asset maintenance contracts (contracts for continuing maintenance).

5.2 Are there special crews for bridge maintenance?

6. Maintenance Goals

6.1 What are the goals within your bridge maintenance program? Is there a formal statement of program goals?

6.2 What are the maintenance goals of your DOT? Is there a formal statement of DOT goals? How do program goals correspond to DOT goals?

7. Maintenance Staffing Levels, Training, and Longevity

7.1 What is the number of personnel in your bridge maintenance program? Are these full-time personnel? What job titles/grades are used? What is the number of personnel in each job title?

7.2 What training requirements does your agency have for personnel in bridge maintenance? Please list requirements by job title/grade.

7.2.1 Does your agency require certification for some maintenance personnel such as: certified welder, certified concrete finisher, certified equipment operator, certified steel fabricator, or certified carpenter? If so, do you also require continuing education in these areas?

7.3 How many years has your bridge maintenance engineer been in that position?

7.4 Does your agency have a succession plan for personnel in the bridge maintenance program, especially for personnel managing the program? If yes, please describe the plan.

8. Maintenance Decisions

In this section, we seek information on how your agency identifies, prioritizes, programs, and tracks bridge maintenance work.

8.1 Identification of Maintenance Needs

8.1.1 How are bridge maintenance needs identified? Who (what personnel) identifies maintenance needs? Please describe the various roles of bridge inspectors, maintenance crews, bridge engineers, and maintenance engineers.

8.1.2 How are maintenance needs communicated among various staff at your agency, including bridge inspectors, maintenance crews, and design engineers?

8.1.3 How do you establish relative urgency of bridge maintenance needs (apart from emergency maintenance)?

8.1.4 What are your procedures for identification of emergency maintenance needs?

8.2 Maintenance Programming Process

To program maintenance is to select, schedule, and fund maintenance work.

8.2.1 Please describe your process to program bridge maintenance work. Please describe the process for each category of maintenance (crew work versus contract work, minor repairs versus major work, urgent versus routine, preventive versus corrective, etc.).

8.2.2 Please describe how processes for bridge maintenance programming differ for: Magnitude (cost) of maintenance; Urgency of maintenance; Complexity of maintenance; Traffic impacts of maintenance.

8.2.3 Please describe the various roles of bridge inspectors, maintenance crews, bridge engineers and maintenance engineer in maintenance programming decisions.

8.3 Maintenance Programming Administration

8.3.1 Are bridge maintenance programming decisions made at your DOT central office or in district/regional offices? Please describe the roles of the central office and district offices in maintenance programming decisions. Are maintenance teams involved in decisions in bridge maintenance programming?

8.3.2 Does your agency differentiate between highway maintenance districts and bridge maintenance districts?

8.3.3 What is the size of an average bridge maintenance crew and how is it organized as: Manager, Assistant Manager, equipment operator, carpenter, welder, concrete finisher, fabricator, laborer, traffic control, etc.

8.4 Priority Indicators, Indicators of Maintenance Need

8.4.1 What indicators, such as bridge health index, NBI sufficiency rating, or similar measures are tracked in your bridge maintenance program? Are these indicators used to prioritize bridge maintenance work?

8.4.2 Have you developed your own indicators for bridge maintenance priorities? Please describe your indicators.

8.5 Programming Scope

8.5.1 Does your agency develop annual bridge maintenance or preservation plans for each bridge? If yes, do the plans identify the maintenance needed to achieve bridge design life?

8.5.2 Are individualized maintenance and preservation plans developed for signature bridges?

8.5.3 Does maintenance programming operate at a bridge level (that is, select a bridge and perform all needed maintenance) or at a program level (that is, identify a need and perform maintenance at all instances on all bridges)?

8.6 Optimization of Maintenance Programs

8.6.1 How does your programming process seek optimal bridge maintenance programs?

8.6.2 Does your agency evaluate risk[131] at a maintenance program level? If yes, how do you evaluate risk?

9. Outcomes of Maintenance

9.1 Maintenance Tracking

9.1.1 How do you track completion of bridge maintenance needs? How do you keep track of maintenance needs that are not met? Do you estimate the funding required for unmet needs?

9.1.2 Do you estimate increased (future) costs resulting from deferred maintenance? Does this estimate affect future budget or programming decisions?

9.1.3 Is completed maintenance work reported to your bridge inspection program? How does completed maintenance change condition ratings for bridges or elements?

9.1.4 How does your agency track maintenance-related changes to a bridge's design?

Maintenance backlog is the set of unmet, but serious, needs for maintenance.

9.1.5 Does your agency have any backlog of bridge maintenance needs? If yes, what is the magnitude, in dollars, of the backlog of maintenance needs?

9.1.6 How do you keep track of unmet, serious needs (the maintenance backlog)?

9.1.7 How do you keep track of other, less serious, unmet maintenance needs?

9.2 Effectiveness of Maintenance

[131] Risk is a future event that may or may not occur and has a direct impact on the program to the program's benefit or detriment. Events are the things that happen sometime in the future that will trigger your opportunity or threat. A risk is a threat if the effect is a detriment to your ability to deliver the federal-aid highway program. A risk is an opportunity if it offers a benefit to your ability to deliver the federal-aid highway program. Source: FHWA 2007 Guidance document

9.2.1 How do you evaluate the effectiveness of bridge maintenance activities?

9.2.2 How do you share knowledge and experience gained in bridge maintenance?

9.2.3 How does bridge maintenance experience inform and improve design practice?

9.2.4 How do you measure the effectiveness of cyclic maintenance?

9.2.5 Has your agency developed a Bridge Maintenance Quality Control / Quality Assurance Program? What criteria are employed, such as timeliness, cost effectiveness, use of resources, etc.? What documentation is available for this QC/QA program?

9.3 Accomplishments in Network

9.3.1 What indicators (such as level-of-service grade, average index of bridge health, average rating of bridge sufficiency, etc.) do you use to measure outcomes of your bridge maintenance program?

9.3.2 Do you evaluate the benefits or gains achieved through your bridge maintenance program? How do you evaluate benefits or gains?

9.3.3 How are measures of effectiveness or gain presented to executive staff at your agency?

9.4 Documents Related to Programming

9.4.1 How does your agency document its bridge maintenance programming processes? How are agency policies and processes communicated to staff in your central office, district offices, and field units?

9.4.2 For bridge maintenance programming, do you have process maps, process flow charts, or similar documents? Can we obtain copies of these?

9.4.3 For maintenance programming, do you have standard operating procedures (SOPs) or something similar to SOPs? Can we obtain copies of these documents?

9.4.4 If there are no documents, flowcharts, or standard operating procedures, how does your agency communicate your programming procedures to staff in central office and beyond (i.e., region, district, and field units)?

10. Maintenance Budgets and Costs

10.1 Please describe your budgeting processes for bridge maintenance.

10.2 What is the agency's annual bridge maintenance and preservation budget?

10.3 What percentage of your total budget is spent on bridge preservation and maintenance activities? What is the ideal percentage that should be spent on these types of activities?

10.4 Are there multiple budgets for maintenance (that is, a budget for maintenance by DOT crews, a budget for contractor projects, etc.)? If yes, please describe each budget category and give its annual amount.

10.5 Do you compile and publish average costs for specific maintenance actions? Can we obtain a copy?

11. Bridge Preservation

11.1 Does your agency consider bridge maintenance and bridge preservation as: a single program, overlapping programs, or entirely separate programs? Please explain your response.

11.2 Does your agency establish a statewide or region-wide policy for bridge preservation[132] (also called maintenance, repair, and rehabilitation [MR&R] policy)? If yes, what is this policy and how is it documented? Can we obtain copies of these documents?

11.3 How does your agency identify, prioritize, select, and track bridge preservation projects?

11.3.1 Does your agency have an approved systematic process for bridge preservation?

11.3.2 What kinds of preservation activities are included within that process?

11.3.3 Can we obtain copies of documents that present your preservation process and activities?

11.4 What is the agency's annual bridge preservation budget?

11.5 Does your agency maintain separate estimates of bridge maintenance costs and preservation costs? Can we obtain copies?

[132] Bridge preservation consists of actions to deter or correct deterioration of a bridge to extend its useful (service) life; it does not entail structural or operational improvement of an existing bridge beyond its originally designed strength or capacity. Source: Draft AASHTO definition

11.6 Realistically, what percent of HBP funds or other available funds should be spent on preservation type activities? ____% What percent is actually spent? ____%

11.7 Has your agency requested to use HBP (previously called HBRRP) funds for system preservation? If yes, what amount of HBP funds are budgeted for this activity? _____ If no, what are the issues preventing HBP fund use?

11.8 How do you balance projects for bridge improvements and projects for bridge preservation?

12. Data Systems

12.1 Does your agency use one or more of the following data systems: maintenance management system, work reporting system, or bridge management system?

12.2 Please describe how these data system are used to: identify bridge maintenance needs, program bridge maintenance work, track maintenance accomplishments, track maintenance costs, and evaluate outcomes of maintenance programs.

12.3 Who (what branch, division, or personnel group) in your agency uses each data system?

12.4 How, and to what extent, do these data systems interact?

12.5 What documentation is available for each data system? Can we obtain copies of these documents?

12.6 Are your data systems used or accessed outside of your agency, perhaps by local governments or other bridge owners? Please describe such use or access.

13. Materials and Methods

13.1 What aspects of your bridge maintenance program are notable for their effectiveness, efficiency, or simplicity? Aspects might include a method or material in fieldwork, a process for selecting or executing a maintenance action, or a practice in monitoring or evaluating performance.

13.1.1 For each notable aspect, please outline its history; that is, its origins, development, and implementation.

13.2 How do your maintenance methods or materials contribute to or enhance mobility?

13.3 Has your agency developed design specifications to meet the maintenance or preservation needs of in-service bridges?

13.4 Has your agency developed material specifications to meet the maintenance or preservation needs of in-service bridges?

13.5 Has your agency developed contracting mechanism to meet the maintenance or preservation needs of in-service bridges?