Transportation Asset Management Case Studies

Presented by

U.S. Department
of Transportation

**Federal Highway
Administration**

BRIDGE MANAGEMENT
Practices in Idaho, Michigan and Virginia

Cover: *Perrine Bridge, courtesy of Idaho Transportation Department*

Note from the Director

The U.S. Department of Transportation (DOT) Office of Inspector General (OIG) recommended in January 2009 that the Federal Highway Administration (FHWA) evaluate the State Departments of Transportation's implementation and use of Bridge Management Systems (BMS) and provide technical assistance to them as needed.

With such factors as an aging national infrastructure and limited funds weighing heavily on transportation agencies, State DOTs are looking for innovative and proactive ways to manage and maintain their transportation assets and to maximize the performance of both their transportation systems and organizations. Transportation asset management is a strategic approach to managing transportation infrastructure assets and their performance. The goal of transportation asset management is to minimize the whole-life costs for managing and maintaining transportation assets.

A transportation asset management performance based approach can provide valuable information for planning, programming, and overall management of the transportation network. Information from management systems is essential in transportation decision-making and helps organizations establish realistic agency goals, setting investment levels across assets.

The FHWA Office of Asset Management, Pavements and Construction will continue to advance the concepts and initiatives of asset management through such tools as the new AASHTO Transportation Asset Management Guide, various webinars, peer-exchanges, training and workshops. We are combining our efforts to better manage our transportation assets.

In an effort to provide technical assistance to the bridge community, we have undertaken a number of activities to share information on best practices. We have developed publications that include case studies of best practices from State DOTs or other organizations on various topics including bridge management and culvert management. Recently, we conducted a review of Bridge Management practices in Idaho, Michigan, and Virginia with the goal to identify and promote best practices.

On behalf of the FHWA, we are pleased to present you the Bridge Management Systems Case Study of Idaho, Michigan, and Virginia. I believe the case study will be helpful as you work toward implementing and advancing bridge management systems in your agency

Butch Wlaschin
Director, Office of Asset Management, Pavement, and Construction

Note to the Reader

The Transportation Asset Management Case Study series is the result of a partnership between State departments of transportation and the FHWA Office of Asset Management. The FHWA provides the forum from which to share information, and the individual states provide the details of their experiences. For each case study report, the FHWA and a contractor interviewed State transportation staff, and the resulting material was approved by the State. As such, the reports rely on the agencies' own assessment of their experience. Readers should note that the reported results may or may not be reproducible in other organizations.

Contributors

Case studies were prepared by George Hearn using information provided by State DOTs and by the USDOT FHWA. Contributors include:

Idaho Transportation Department: Matt Farrar, Kathleen Slinger

Michigan Department of Transportation: David Juntunen, Amy Gill, Linda Reed, Robert Kelley, Richard Kathrens

Virginia Department of Transportation: Kendal Walus, Adam Matteo, Jeffery Milton, Prasad Nallapaneni

USDOT FHWA: Shyan-Yung Pan, Wade Casey, Sonny Jadun, Larry O'Donnell

Acronyms

AASHTO	American Association of State Highway Transportation Officials
BCFS	Bridge condition forecasting system
BMS	Bridge management system
BSIR	Bridge safety inspection report
CPM	Capital preventive maintenance
CSM	Capital scheduled maintenance
DBSIE	District bridge safety inspection engineer
DMV	Division of Motor Vehicles
DOT	Department of Transportation
ECR	Epoxy-coated rebar
FHWA	Federal Highway Administration
FO	Functionally obsolete
FY	Fiscal year
HBP	Highway bridge program
HMA	Hot-mix asphalt
ITD	Idaho Transportation Department
LHTAC	Local Highway Technical Assistance Council
MBIS	Michigan bridge inspection system
MBRS	Michigan bridge reporting system
MDOT	Michigan Department of Transportation
N/A	Not applicable
NBI	National Bridge Inventory
NBIS	National Bridge Inspection Standards
NCHRP	National Cooperative Highway Research Program
OIG	Office of Inspector General
QA	Quality assurance
QC	Quality control
S&B	Structure and Bridge Division
SD	Structurally deficient
SF	Square feet
STC	State Transportation Commission
STIP	Statewide transportation improvement program
TAMC	Transportation Asset Management Council
TAMS	*Idaho*: Transportation asset management system
	Virginia: Turnkey asset maintenance services
TMS	Transportation management system
US	United States
USDOT	United States Department of Transportation
VDOT	Virginia Department of Transportation

Executive Summary

Bridge management practices of departments of transportation (DOTs) in three US states, Idaho, Michigan and Virginia, are reported. These DOTs are examples of the success that is possible for asset management practices applied to bridges and culverts. Idaho, Michigan and Virginia employ bridge management practices that include four features:

- Measurement of performance of bridges and culverts with targets for performance.
- Work programs that respond to performance measurements and targets.
- Reporting to stakeholders on performance of bridges and culverts.
- Commitment within DOTS to preservation of existing assets.

Idaho, Michigan and Virginia measure the performance of bridges and culverts using National Bridge Inventory (NBI) general condition ratings. Idaho reports network-level performance as the percentage of structures in good condition. Michigan and Virginia report the percentage of structures in fair or good condition. The lowest NBI general condition rating for a structure determines its classification. These DOTs identify structures in fair condition as having all NBI condition ratings at 5 or higher (Table 1). Idaho TD reports percentages for deck area on structures. Virginia and Michigan report percentages for counts of structures. Virginia identifies its performance classifications as red, yellow and green, rather than poor, fair and good. Red structures are structurally deficient (SD). Yellow structures are functionally obsolete (FO). Green structures are neither deficient nor obsolete.

Table 1
Structure Condition & NBI General Condition Ratings

	Structure Condition		
	Good	**Fair**	**Poor or SD**
Idaho TD	≥ 6	5	≤ 4
Michigan DOT	≥ 7	5, 6	≤ 4
Virginia DOT	-	-	≤ 4

Transportation departments in Idaho, Michigan and Virginia employ preservation as a means of bridge management. Structures in fair or good condition that have adequate traffic capacity and adequate load rating are preserved more easily than they could be rebuilt or replaced. But needs at structures in poor condition may seem to be more urgent. Funding, always limited, can be exhausted in projects for structures in poor condition if priorities are evaluated among structures as a single population. The adaptation seen in practices in Idaho, Michigan and Virginia is a segmentation of structure populations, and a separation of work programs. Based on their general conditions, structures are identified as good, fair or poor, and so become candidates for maintenance to preserve good conditions, for repairs to avoid poor conditions, or for rehabilitations to remedy poor conditions. There are budgets directed to each work category, and projects are selected and prioritized within each work category. This allows structures in good and fair condition to receive needed maintenance and repair.

Each State's strategy for management of structures is quantified as the mix of funding directed to preventive maintenance at healthy structures, to repair of structures with defects, and to rehabilitation of structures with major defects. Idaho, Michigan and Virginia each identify three categories of work to keep bridges and culverts in service. The categories provide actions for 1) Cleaning and patching; 2) Deck overlays, painting, and repair or replacement of devices such as joints, and; 3) Rehabilitation including work such as deck replacements. The names of the work categories differ (Table 2). At Idaho TD, the work categories are *operation*, *preservation* and *restoration*. Michigan identifies *scheduled* maintenance, *preventive* maintenance and *rehabilitation*. Virginia has work categories for *preventive* maintenance, *restorative* maintenance and *rehabilitation*.

Table 2 Work Categories for Structures

Typical Actions	Work Category		
	Idaho TD	Michigan DOT	Virginia DOT
Clean, patch	Operation	Capital Scheduled Maintenance	Preventive Maintenance
Overlays, Joint repair/replacement	Preservation	Capital Preventive Maintenance	Restorative Maintenance
Rehabilitation, Deck replacement	Restoration	Rehabilitation	Rehabilitation

Strategies are adjusted in response to performance measures. Projects are selected to be consistent with strategies, to deliver programs that balance needs statewide, and to recognize the limited capacities in DOT district offices to develop and manage projects. Strategies are set by bridge management staff. Staff make use of outputs from BMS. Once strategies are set, decisions in selection and prioritization of projects begin with BMS data, usually as lists of structures needing work. Lists are reviewed and revised in consultations among DOT staff in district offices and the central office.

Transportation departments in Idaho, Michigan and Virginia use Federal highway bridge program (HBP) funds for preventive maintenance of bridges and culverts under agreements with the USDOT FHWA. Actions for preventive maintenance include repairs, deck overlays, joint replacements, and corrosion protection including painting (Table 3).

Table 3 HBP-Eligible Preventive Maintenance

Idaho TD	Michigan DOT	Virginia DOT
Repairs, Deck overlays, Joint replace, Deck Rehabilitation	Repairs, Deck overlays, Joint replace, Painting, Slope repair	Joint replace, Deck overlays, Painting/Coating, Cathodic protection, Electrochemical chloride extraction, Scour countermeasures, Retrofit fracture-critical members, Cleaning/washing structures

State maintenance crews perform cleaning, minor repairs, and clearing of embankments and channels. Virginia DOT's crews do some larger repairs on structures on secondary roads (Table 4).

Table 4
Work by State Maintenance Crews

Idaho TD	Michigan DOT	Virginia DOT
Clean, Painting, Sealing, Patching, Debris removal	Repairs, Patching, Spot painting, Brush cutting	Maintenance, repairs and rehabilitation of structures on secondary roads

Projects for replacements and improvements are included in statewide transportation improvement programs (STIPs). Virginia DOT has, in addition to STIP, a dedicated fund program to replace SD bridges on non-interstate routes.

Public accountability for management of bridges and culverts is provided by frequent reporting on bridge conditions. Internet dashboards at each of these transportation departments report network-level performance as percentages of structures meeting goals for general condition. Dashboards address many aspects of performance of transportation systems including measures of traffic safety, traffic operations, pavement conditions, structure conditions, financial management, program (construction) delivery, access to transportation services and user satisfaction (Table 5).

Table 5
Dashboard Performance Measures

Idaho TD	Virginia DOT	Michigan DOT
Bridge condition		
Pavement condition		
Safety		
Traffic operations		
Project delivery		Public transit
Project costs		Intermodal facilities
DOT administration		Risk/Vulnerability
DMV services	Airport pavements	

Idaho, Michigan and Virginia apply asset management principles to physical assets that include structures and pavements, and to operational and administrative aspects of department activities. These states implement data systems to support asset management, including comprehensive systems for management of multiple asset classes. Table 6 lists data systems for asset management developed by or for these DOTs.

The abilities among DOT staff have increased greatly since the earlier days of automated bridge management systems. DOT staff know what the program outcomes ought to be. Staff know that work candidates and projects must have adequate scope and be reasonably coordinated along routes and throughout a State. Staff abilities are evident in the ownership role taken by DOTs in BMS analysis and analytical software. Virginia DOT extends Pontis capabilities with a post-processor to make realistic work plans for bridges. Michigan DOT uses Markov deterioration models expressed in NBI condition ratings that offer recommendations for projects to add to existing work plans using unencumbered portions of budgets. Idaho has applied an analysis of improvements to performance that could be, and subsequently were, achieved by dedicated funding for preventive maintenance of structures.

Table 6 - Data Systems for Asset Management

Idaho TD	Michigan DOT	Virginia DOT
TAMS[1], including	Bridge Condition Forecasting System	Roadway Network System
Financial Planning	*TMS*[2], including	*Optimizer* for Pontis
Pavement Management	Bridge Reporting System	
Maintenance Management	Bridge Inspection System	
Fleet and Equipment System	Congestion Management	
Network Management	Intermodal Management	
WebCars (vehicle crash data)	Pavement Management	
	Public Transportation Management	
	Safety Management	

Asset management enjoys political support in Idaho, Michigan and Virginia. The focus on performance and reporting underscores the importance of asset management to these DOTs and their State governments. The transportation departments get direction on asset management goals and methods from advisory boards or councils. Michigan DOT has an internal transportation asset management program that interacts with a Transportation Asset Management Council (TAMC). TAMC, a part of Michigan State government, oversees asset management activities of all State and local agencies. Idaho TD has a bridge asset management unit and a separate transportation asset management unit. Both report to Idaho's State Transportation Board.

Asset management has mandates in State law. State law in Michigan and in Virginia defines terms in preservation, maintenance and asset management. Michigan law establishes the TAMC and creates its central role in statewide direction of asset management. Virginia law requires the use of asset management procedures, and periodic reporting on asset conditions and on the budgets and programs intended to maintain assets.

Asset management of structures has improved conditions of structures. Idaho has increased the percentage of structures in good condition from 67% in 2006 to 73% in 2010. Michigan increased its percentage of good and fair bridges from 79% in 1998 to 91.6% in 2011. Virginia increased its percentage of fair and good structures from 90.3% in 2000 to 92.3% in 2011.

[1] Transportation Asset Management System (TAMS)
[2] Transportation Management System (TMS)

Background

Bridge management has been an evolving area of practice among US State DOTs for more than twenty years. During that time, states have made steady progress in development of bridge management practices, in measurement of performance of bridges and culverts, and in capabilities of data systems. This progress is documented in case studies of bridge management experiences of California, Florida, and South Dakota published in 2007[3], and in case studies of bridge management practices of Idaho, Michigan and Virginia presented here.

Transportation departments in Idaho, Michigan and Virginia have bridge management practices that are similar in outline, but different in detail. Specific targets for performance measures differ. Specific activities identified as structure preservation or structure restoration differ. Levels of funding directed to preservation and to restoration differ. But each DOT has a program to preserve structures. Each DOT tracks structures in good or fair condition as a performance measure. Each DOT evaluates work strategies in terms of performance measures. And each DOT has made improvements in recent years in performance measures for structures.

IDAHO TRANSPORTATION DEPARTMENT

The Idaho Transportation Department's (ITD) practice for management of bridges and culverts is data-driven and expert-mediated. The practice is data-driven because project selection and prioritization begins with BMS data on structure conditions and work needs. It is expert-mediated because ITD staff in both central and district offices advance or delay specific work candidates based on knowledge of local needs together with global assessments of contributions to statewide mobility. In short, data on structure condition, age and service are examined to identify work candidates and to select appropriate actions. Projects indicated by data are reviewed jointly by ITD staff in the central office and in district offices to arrive at work programs.

ITD has funding dedicated to structure preservation and to structure restoration. These dedicated funds are part of ITD's focus on performance of structures and networks. Preservation and restoration, together, have allowed ITD to shift away from a worst-first approach to work programming.

ITD's management of structures responds to, and is guided by, performance measures. ITD's goal is to have 80% of State-owned bridges in fair or good condition[4].

Administration

ITD is guided by a seven-member Transportation Board appointed by the Governor of Idaho. The Board sets policy and general direction for ITD[5]. ITD has six divisions[6]. ITD's Highway Division is responsible

[3] http://www.fhwa.dot.gov/infrastructure/asstmgmt/bmcs7toc.cfm
[4] Using ITD's definitions of fair and good conditions. See Table 1.

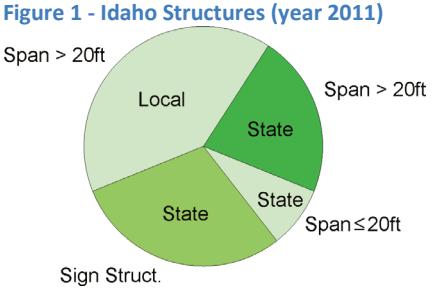
for State-owned roads and bridges. In ITD's Highway Division, the Bridge Section has a unit for Bridge Design and a unit for Bridge Asset Management. The Bridge Asset Management Unit keeps data on structure inventory and conditions, operates bridge management software, and performs structure inspections and load ratings. The Bridge Design Unit develops and programs projects in preservation and restoration of State-owned bridges and culverts.

Idaho has a Local Highway Technical Assistance Council[7] (LHTAC) that assists local agencies in construction and maintenance of local roads.

Inventory of Structures

There are nearly 4200 bridges and culverts in Idaho (Figure 1). Of these, 3681 meet the national bridge inspection standards (NBIS) definition of a bridge[8]; others are short spans[9]. There are 1800 State-owned bridges and culverts. ITD manages more than 1700 sign structures. ITD has one movable bridge; a border bridge shared with Washington State.

Figure 1 - Idaho Structures (year 2011)



Structures	Count
NBIS Structures	
State-owned, highway bridges > 20'	1300
County or locally owned highway bridges > 20'	2381
Non-NBIS Structures	
State-owned, highway bridges ≤ 20'	500
Ancillary Structures	
Overhead sign structures	1743

In 2011, ITD reported 52 SD bridges and 201 FO bridges in the State-owned inventory (Table 7). Bridges owned by local agencies include more than 295 SD bridges.

Table 7
ITD SD/FO Bridges[10]

System	Structurally Deficient	Functionally Obsolete
Interstate	16	129
US Route	15	19
State Highway	20	13
Other	1	40

[5] *Facts and Figures 2010* (2010) ITD, 48p.
[6] Administration, Aeronautics, Highways, Motor Vehicles, Transportation Planning, Public Transportation
[7] http://www.lhtac.org/
[8] Bridges and culverts on public roads with span greater than 20 ft.
[9] Bridges and culverts with spans between 10 ft. and 20 ft.
[10] Year 2011 counts from ITD Bridge Asset Management Unit.

Management of In-Service Structures

ITD manages in-service bridges and culverts with programs for operations maintenance, preservation and restoration (Table 8). Operations maintenance includes cleaning, channel clearing, minor repairs and some painting and coating activities[11]. Preservation includes repairs and replacements of components, some rehabilitation, and painting. Preservation also includes preventive maintenance activities such as crack sealing, seal coating, and thin overlays[12]. Some preventive maintenance activities are eligible for Federal HBP funds. Restoration includes rehabilitation and replacement. Rehabilitation projects can be preservation or restoration depending on extent and cost.

Table 8 ITD Work Programs & Activities

Program	Activities
Operations Maintenance	Clean structure, Clear drains Painting[13], Coating and sealant applications[13] Minor deck patching Railing repairs Debris removal, Stabilizing banks[13], Correcting erosion problems
Preservation	Structure improvements, Rehabilitation[13] Rail modification Deck protection systems, Crack Sealing, Seal Coating, Repairs[13], Overlays[13], Replacements Joint repairs[13] and replacements[13] Painting[13] Incidental repairs[13]
Restoration	Structure rehabilitation, Replacement Deck replacement Incidental repairs
Local bridge	Structure rehabilitation, Replacement Deck replacement Painting

Structure Management by Local Agencies

Local governments and agencies in 191 cities, 33 counties, 64 local highway districts, 5 metropolitan planning districts, and one transportation management area (metro-Boise)[14] manage highway structures. Idaho's LHTAC develops uniform standards for local highway maintenance, construction, operation and administration. LHTAC makes recommendations to the Idaho Transportation Board for the prioritization and use of Federal funds for local highway projects.

[11] *Maintenance Manual* (2011) ITD, http://itd.idaho.gov/manuals/Online_Manuals/Maintenance/index.htm
[12] *Idaho's Transportation Vision* (2004). Idaho Transportation Partners 84p.
[13] Federal-aid eligible preventive maintenance activity.
[14] *Statewide Transportation Improvement Program* (2011). ITD, 121p.

Work Programming

Operations maintenance to clear drains and make minor repairs is managed in ITD districts. Needs in operations maintenance are identified in road surveys by maintenance foreman, and collected from lists of needs that ITD's Bridge Asset Management Unit sends to districts four times each year. The bridge asset management unit compiles lists of work needs from reports of safety inspection.

Bridges and culverts are programmed for preservation or for restoration based on their condition and age. Guidelines are flexible. In general, structures having an NBI general condition rating at 5 or lower are restored. Structures in good condition are preserved. Structure age is important. Younger structures are preserved. Older structures are restored.

ITD's central Bridge Design Unit develops programs for structure preservation and restoration. The Unit collects lists of structures, their conditions and their needs from the BMS. The Unit examines structural deficiencies, scour-critical status, structure age, NBI general condition ratings and element-level condition reports. Knowledgeable input is sought and used. Bridge inspectors are asked to identify their top work candidates. As projects emerge, the Unit considers route, average daily traffic, and location to form balanced statewide programs. Project selections are reviewed and refined in face-to-face meetings with staff in each of ITD's six districts. District staff have a great influence in decisions on projects. The final, consensus list of projects goes forward to ITD's STIP.

SD bridges and culverts are programmed for replacement under ITD's bridge restoration program. Functional improvements are made when structures are replaced or rehabilitated; that is, functional defects are addressed when structures are programmed for work due to poor or deficient condition.

Projects for structures are added every year as the fifth year of a continuing STIP. The STIP delivers projects for preservation and restoration of pavements and structures, as well as projects for highway expansion and safety. Projects are added to the STIP after approval by the Idaho Transportation Board.

Bridges and culverts owned by local agencies are prioritized for restoration or replacement according to their NBI sufficiency ratings. LHTAC gets sufficiency ratings for structures from ITD, and coordinates with local bridge owners to develop work programs. Once prioritized, projects are programmed to the extent of available funding.

Performance Measures

ITD tracks performance measures that include traffic fatalities, on-time completion of projects, comparison of construction costs and estimates, conditions of pavements, and conditions of bridges[15]. ITD's strategic plan identifies performance measures and goals[16] (Table 9). ITD reports performance measures at an internet *Dashboard*[17] (Figure 2).

[15] *Annual Accountability Report* (2010) ITD, 24p.
[16] *2011 Strategic Plan* (2011). ITD, 2p.
[17] http://itd.idaho.gov/dashboard/default.htm

Table 9 - ITD Performance Measures and Goals

Asset	Performance Measure	Goal
Safety	Five-Year Annual Fatality Rate Per 100 Million Miles Traveled	1.38
Highways	Pavements in Good or Fair Condition	82%
	Bridges in Good Condition	80%
Services	Percentage of Current-Year Projects Developed on Time	100%
	Bid Amounts Between 90% and 110% of Construction Budgets	100%
User satisfaction	Completion Time for Title Requests	7 Days
	Internet Transactions Processed by DMV annually	225,000

Performance of bridges and culverts is measured as the percentage of network deck area on state-owned structures in good condition[18]. Currently (year 2011) structures in good condition make up 73% of state-owned deck area, fair structures make up 20% of deck area, and poor structures make up 7%. Structures in good condition have increased from 67% to 73% of network deck area in the last five years.

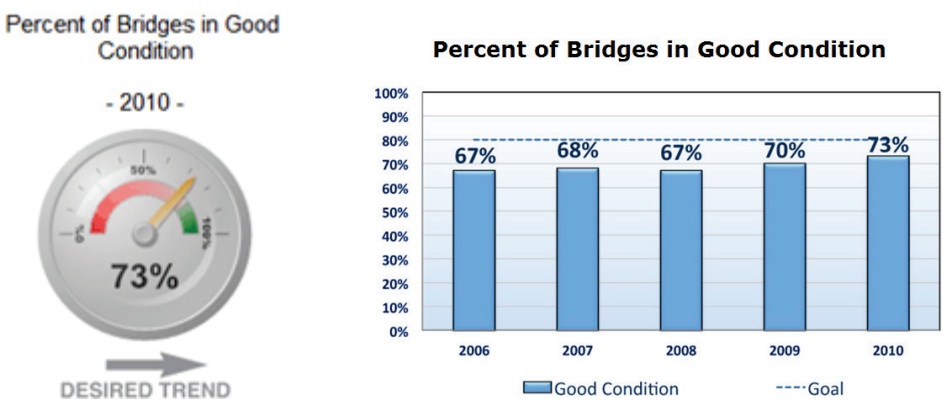


Figure 2 - ITD *Dashboard* (portion)

[18] see Table 1

Bridge Management - Data Systems

ITD uses AASHTOWare Pontis bridge management analytical software to store inventory data, condition data, and inspectors' recommendations for work on bridges and culverts[19]. The Pontis database includes data for both State-owned and locally-owned bridges (Figure 3).

District	Bridge Key	Route	Milepost	Features	Year Built	NBI Rating
1	10025	US 2	25.418	UPRR AND BNRR(DOVER BR)	1937	SD
1	10150	SH 3	117.623	I 90 EB-WB;ROSE LAKE IC	1962	FO
1	10175	SH 5	0.423	ST.MARIES RR	1937	SD
1	14240	SH 41	0.135	BURLINGTON NORTHERN RR	1936	SD
1	14255	SH 41	38.71	BURLINGTON NORTHERN RR	1966	SD
1	14665	SH 53	14.063	UNION PACIFIC RAILROAD	1936	FO
1	16745	I 90 EBL	2.067	S 8505;PLEASANT VIEW IC	1976	FO
1	16750	I 90 WBL	2.068	S 8505;PLEASANT VIEW IC	1976	FO
1	16785	I 90 EBL	7.116	SH 41;SH 41 IC	1971	FO
1	16790	I 90 WBL	7.117	SH 41;SH 41 IC	1971	FO

Figure 3 - ITD Bridge List (portion)

ITD is developing other data systems for management of transportation assets and operations[15]. These include a financial planning system, pavement management system, maintenance management system, fleet and equipment system, mobility (network) management system, and safety (WebCars) management system.

Systems for pavement management and maintenance management are integrated under a Transportation Asset Management System (TAMS); a data system developed for ITD[20]. The maintenance management system will generate and track work orders including work orders for needs at structures. Maintenance actions will be coded in a numbering series presented in ITD's maintenance manual[11]. TAMS may eventually integrate data from Pontis BMS.

BMS Analyses

In 2009 as part of a study of transportation funding, ITD analyzed the outcomes in structure conditions that would result from funding directed to structure preservation and restoration. In the analysis, structure conditions were related to structure age. Costs for preservation and restoration projects were expressed in terms of bridge deck area. Various budget levels were investigated. Greater or lesser budgets delivered preservation and restoration at greater or lesser aggregate quantity of bridge deck. In the analysis, costs for projects were costs to preserve or restore conditions, plus costs to remedy structural deficiencies and functional obsolescence. The analysis showed that funding directed to a mix of preservation and restoration projects would lead to better conditions among structures. One result of the study is ITD's current strategy for management of in-service bridges and culverts. ITD's strategy directs approximately 20% of funding to preservation and 80% of funding to restoration.

[19] *Management of Idaho's Bridges* (2009). ITD, Technical Report 18, 4p.
[20] *The Transporter* (2010) ITD, webpage, http://itd.idaho.gov/transporter/2010/121710_Trans/121710_TAMS.html

Bridge Management Staff

Management of in-service structures is performed by the ITD Bridge Design Unit and ITD Bridge Asset Management Unit. Both units report to the ITD Chief Engineer. The Bridge Design Unit identifies structures needing work and develops work programs. The Bridge Asset Management Unit is responsible for safety inspections and load ratings, and operates ITD's implementation of Pontis BMS. BMS analytical software is operated by a full-time database manager with part-time participation by the Bridge Inspection Engineer[21] and the State Bridge Engineer[22].

The Bridge Design Unit has a staff of twelve engineers (including three squad leaders) and six technicians. The Bridge Asset Management Unit has three engineers, four bridge inspectors, one bridge equipment specialist and one BMS database manager.

ITD has a Transportation Management Unit that operates TAMS software and oversees its continued development.

Bridge Inspection

ITD's Bridge Asset Management Unit is responsible for inspection of the entire population of 4200 State- and locally-owned highway structures[19]. Underwater inspections are performed at 232 bridges. Safety inspections collect both NBI general condition ratings and element-level condition reports. ITD has developed additional bridge elements, beyond the set of AASHTO[23] commonly recognized elements.[24] ITD's bridge elements include bridge wingwalls, bridge gusset plates, submerged abutments and submerged piers (Table 10).

Single-Point Urban Interchange, Idaho

Locally-owned bridges and culverts are inspected by consultants managed by ITD's Bridge Asset Management Unit. Inspectors' recommendations for work on structures are transmitted to bridge owners. ITD reports data on structure inventory, conditions and sufficiency ratings to LHTAC and to bridge owners for their use in prioritizing work.

Quality Review of Inspection Data

ITD's procedures for quality review and assurance include periodic field review of each ITD inspection team leader, and each consultant inspection team. The ITD Bridge Inspection Engineer makes field

[21] Head of ITD Bridge Asset Management Unit
[22] Head of ITD Bridge Design Unit
[23] American Association of State Highway Transportation Officials
[24] *AASHTO Guide For Commonly Recognized (CoRe) Structural Elements*. (1997). AASHTO, Washington, 60p.

reviews of ITD team leaders. ITD team leaders, located in ITD districts, make field reviews of consultant inspection teams. Office reviews are made of a sample of reports from inspections performed by ITD team leaders, and of all reports from inspections performed by consultants. Reports from inspection consultants are reviewed by ITD inspection team leaders and by the ITD database manager.

Table 10 ITD Additional Structure Elements and Flags[25]

No.	Name	Unit
	Structure Elements	
162	Unpainted Gusset Plate(s)	EA
163	Painted Gusset Plate(s)	EA
209	Reinforced Concrete Wingwall	EA
208	Timber Wingwall	EA
224	Painted Steel Submerged Pile	EA
218	Reinforced Concrete Submerged Abutment	LF
219	Reinforced Concrete Submerged Pier Wall	LF
	Smart Flags	
364	Steel Connection Distress	EA

Scour Monitoring

ITD uses *BridgeWatch*[26] for real-time monitoring of 250 scour-vulnerable bridges. *BridgeWatch* uses weather data and stream flow data to post alerts for individual bridges according to stream flow conditions specified by ITD.

Reporting

ITD publishes manuals for inspection, maintenance and evaluation of structures, and reports on transportation performance, capital programs, department administration and department goals and strategies.

ITD manuals related to bridge management include a bridge inspection coding guide[25], a maintenance manual[11], a bridge evaluation manual[27], and a manual for funding of local highway jurisdictions[28]. ITD publishes annual accountability reports[15], reports of projects and costs in the current STIP[29], reports on formation and inputs to the STIP[14], a strategic plan[16], a long-range plan[30], and ITD's *Vision*[12]. ITD publishes annual facts and figures reports5 that outline ITD organization, administration and funding.

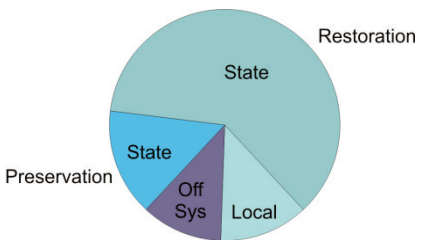
Budgets for In-Service Structures

ITD's six divisions6 have a combined annual budget of $539M (FY 2010). The highway division receives 87% of the total. Preservation and restoration of State-owned bridges and culverts are funded at about

[25] *Idaho Bridge Inspection Coding Guide* (2010) ITD, 185p.
[26] http://www.usengineeringsolutions.com/solutions/bridgewatch/
[27] *ITD Manual For Bridge Evaluation - Section 6: Load Rating* (2010) ITD, 44p.
[28] *Manual on Local Highway Jurisdictions Funding* (2003) LHTAC, 25p.
[29] *Capital Investment Program - All Districts - By Program* (2010) ITD Office of Transportation Investment, 97p.
[30] *Idaho On The Move* (2010). ITD, 48p.

$48M per year; 9% of ITD's total budget. Funding for local and off system structures is about $14.7M per year (Figure 4).

Funding for major work on local bridges and culverts is mostly Federal-aid funding. Allocation and use of Federal funds for local roads is controlled by the Idaho Transportation Board[28].



Program	5-Yr Funding $ Thousands
Preservation - ITD Bridges	46,910
Restoration - ITD Bridges	190,924
Local Bridges	38,815
Off System Bridges	35,026

Figure 4 Bridge Programs in ITD's 2011-2015 STIP

Bridge Management Achievements

ITD is improving the conditions of its bridges and culverts by funding programs for preservation and restoration, by using inventory and condition data to identify work candidates, and by engaging the inputs of bridge inspectors and ITD district personnel to assemble effective work programs.

ITD invested in work to develop deterioration models and cost models in Pontis, but has found that a staff-managed process to identify work candidates is effective.

Bridge Management Future

ITD's bridge management process has improved Idaho's efforts to reach performance goals. ITD notes that the AASHTOWare Pontis BMS is currently undergoing changes that affect element-level inspections and bridge deterioration modeling. ITD looks forward to incorporating these changes in its bridge management process in the future. Resources are limited though, both in availability of ITD staff and in funding to engage consultants to maintain models for deterioration and for costs. ITD uses Pontis to complement, rather than supplant, engineers' judgment in selection of work candidates and projects.

MICHIGAN DEPARTMENT OF TRANSPORTATION

The Michigan DOT executes programs for preventive maintenance, rehabilitation and replacement to manage in-service bridges and culverts, uses performance measures to direct work programs and to monitor progress in networks, applies deterioration models in programming and budgeting, and relies on deterioration models as meaningful predictors of structure conditions to be achieved, or incurred, by greater or lesser funding for programs.

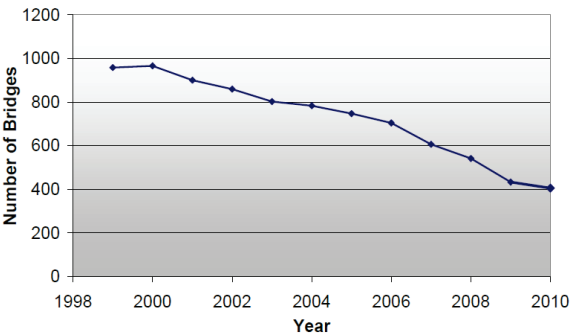
Michigan DOT's deterioration models are notable. Michigan DOT forms Markov chains for NBI condition ratings, and tracks each structure by its lowest condition rating. The resulting models employ relatively few transition probabilities. Calibration of models each year and for each DOT region is practical.

Bridge Inspection, Michigan DOT

Recent history of bridge programs at Michigan DOT is instructive. A strategic plan to improve deficient bridges and preserve good bridges was implemented more than a decade ago. Michigan DOT established funding allocations for preventive maintenance and rehabilitation of bridges in good and fair

condition, and for replacement of bridges in poor condition. Since adopting this strategy, conditions among Michigan DOT bridges have improved, and the number of SD bridges has been reduced by more than half (Figure 5).

Figure 5
Michigan SD Structures (State-owned)[31]



Administration

Michigan DOT is guided by a State Transportation Commission (STC) that is assisted by TAMC. STC sets policy for system preservation and development, and for long-term planning for all modes of transportation[32]. TAMC establishes methods and standards for asset management processes[33]. For bridge management, Michigan DOT's Bridge Operations Section interacts with bridge engineers in DOT regions to develop programs for work, to monitor conditions, and to evaluate the success of programs for bridges and culverts. The Section collects and digests data on structure conditions, computes performance measures, and reports these to the TAMC, to Michigan State government and to the public.

Strategic Plan for Trunkline Bridges

In 1998, Michigan DOT established a strategic plan[34] for bridges on trunkline[35] roads. The plan identified bridge condition as a performance measure, set goals for bridge condition, and established work categories for bridges. The strategic plan allowed Michigan DOT to transition from 'worst first' programming to a balance of preventive maintenance, rehabilitations and replacements.

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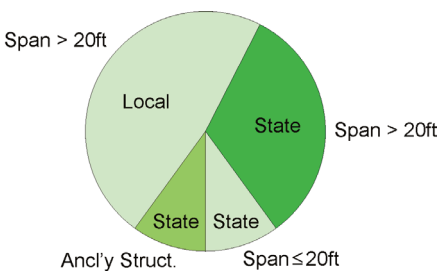
[31] *2011 System Performance Measures Report*. Michigan DOT, 80p.
[32] *About the State Transportation Commission* (2011) http://www.michigan.gov/mdot/0,1607,7-151-9623_31969_31970-29364--,00.html
[33] *Transportation Asset Management Council* (2011) http://tamc.mcgi.state.mi.us/MITRP/Council/Default_Council.aspx
[34] *Strategic Investment Plan for Trunkline Bridges* (1998). Michigan DOT, 30p.
[35] Trunkline roads include interstate routes, US routes and State routes.

The plan worked. More than 90% of freeway[36] bridges are in good or fair condition[37] today (year 2011) compared to 76% in 1998[38].

Inventory of Structures

Michigan DOT maintains 4400 state-owned bridges and culverts having over 49 million square feet (SF) of deck area. Nearly 1700 bridges are freeway bridges. Michigan DOT maintains about 40% of the bridges in the State, and about 75% of bridge deck area. Local agencies own and maintain 6400 bridges and culverts. Michigan DOT also manages short spans[39], pedestrian bridges, railroad bridges, high mast lights, and sign structures. Counts of structures are shown in Figure 6.



Structures	Count
NBIS Structures	
State-owned, highway bridges > 20'	4403
Toll authority owned highway bridges > 20'	3
County or locally owned highway bridges > 20'	6437
Other highway bridges > 20'	30
Non-NBIS Structures	
State-owned, highway bridges ≤ 20'	1060
Pedestrian bridges	173
Railroad bridges	127
Ancillary Structures	
High mast lights	350
Overhead sign structures	~1000

Figure 6 Michigan Structures[40]

Management of In-Service Structures

Michigan DOT applies programs for preventive maintenance, rehabilitation, and replacement in its management of in-service bridges and culverts[41] (Table 11). Preventive maintenance includes activities identified as Capital Scheduled Maintenance (CSM)[42] and activities identified as Capital Preventive Maintenance[43] (CPM). CSM keeps structures in good condition using activities such as structure wash-

[36] Bridges that carry or cross controlled-access roads.
[37] *Good* = NBI condition ratings 7 and higher; *Fair* = NBI condition ratings 5 and 6.
[38] *Transportation System Performance Measures* (2011). Michigan DOT, http://www.michigan.gov/documents/mdot/MDOT-Performance_Measures_Report_289930_7.pdf
[39] Bridges and culverts with span between 10 ft and 20 ft.
[40] Counts are from MDOT's response to questionnaire for BMS case study, 2011.
[41] *Typical Work Activities For Bridge Preservation Components* (2008) Michigan DOT 1p.
[42] *Bridge Capital Scheduled Maintenance Manual* (2010) Michigan DOT, 59p.
[43] *Project Scoping Manual* (2009) Michigan DOT, 462p.

ing, joint repairs, drain maintenance, crack sealing, and removal of debris and vegetation. CPM is applied to structures in fair condition. CPM activities include painting, joint replacements, deck overlays, pin/hanger replacements and scour countermeasures. Rehabilitation of in-service bridges includes deck overlays, and major repairs to superstructures or substructures. Michigan DOT's replacement program includes deck replacement, superstructure replacement and substructure replacement, as well as complete replacement of structures.

Table 11 - Michigan DOT Actions for In-Service Structures

Capital Scheduled Maintenance	**Capital Preventive Maintenance**
Superstructure washing	Pin & hanger replacement[44]
Vegetation control	Complete painting[44]
Drainage system cleaning / repair[44]	Zone painting[44]
Spot painting[44]	Joint replacemen[44]
Joint repair[44]	Epoxy overlay[44]
Concrete sealing[44]	Deck patching[44]
Minor concrete patching and repair[44]	Scour countermeasures[44]
Concrete crack sealing[44]	HMA overlay with waterproofing membrane[44]
Approach pavement relief joints[44]	HMA cap (no membrane)[44]
Slope paving repair[44]	Minor substructure repair[44]
Reseal construction joints	
Rehabilitation	
Concrete overlay – shallow	Extensive substructure repair
Concrete overlay – deep	Substructure repair
Superstructure repairs	Substructure replacement
Beam end repairs	Replace bridge rail
Diaphragm repair/replacement	Widen bridge
Bearing rehabilitation	
Replacement	
Deck replacement	Culvert replacement
Superstructure replacement	Structure replacement

Maintenance by Local Agencies

Local agencies in Michigan manage and inspect their own bridges and culverts. There are local road agencies in 83 counties and approximately 450 municipalities. Work programming for locally-owned structures is administered by the Michigan DOT Local Agency Program assisted by a Local Bridge Advisory Board and by seven Regional Bridge Councils. Michigan's TAMC publishes a guide to bridge asset management for local agencies[45] that includes relevant State law, an overview of NBIS, and sample

[44] Federal-aid eligible preventive maintenance activity.

[45] *Asset Management Guide for Local Agency Bridges in Michigan* (2011) TAMC, 78p.

asset management plans for structures. Asset management plans identify maintenance and preservation activities, relate condition data to selection of activities, provide intervals for scheduled maintenance, and list likely service life of repairs.

Work Programming

Michigan DOT follows a collaborative process to develop work programs for bridges and culverts. DOT regions propose new projects in response to an annual call for projects from the central Bridge Operations Section. The annual call begins in September each year with instructions transmitted from DOT central office to DOT regions. Instructions to regions include proposed strategies. Strategies, set by the central Bridge Operations Section, are expressed as the mix of funding directed to preventive maintenance, rehabilitation, and replacement. DOT regions respond with projects, costs and expected outcomes. The Bridge Operations Section analyzes regions' selections and their contributions to goals for network performance.

Selection Criteria

Conditions of structures determine assignments to programs. Structures in good condition are assigned for preventive maintenance, structures in fair condition are assigned for rehabilitation, and structures in poor condition are assigned for replacement.

Michigan DOT publishes decision matrices for preventive maintenance, rehabilitation, and replacement of bridge decks.[46,47] Decision matrices identify repair options in response to deck conditions, and the expected duration (life) achieved by each repair. A portion of the decision matrix for decks with uncoated reinforcing steel is shown in Table 12.

Deck Repair, Michigan DOT

Big Bridges

Michigan DOT has thirty-one *Big Bridges.* These include movable bridges, unique bridges and bridges with deck area in excess of 100,000 SF. The central Bridge Operations Section manages safety inspections, work planning, and work programming for big bridges. Michigan DOT develops 50-year plans for each big bridge showing the anticipated years and costs of projects for preventive maintenance and rehabilitation.

Scour Vulnerability

Michigan DOT prioritizes projects for scour-vulnerable structures using assessment methods developed for NCHRP[48]. The NCHRP report, intended to help DOTs recognize and mitigate hazards in general, presents six steps to vulnerability assessment and response: 1) Identify critical assets; 2) Assess vulner-

[46] *Bridge Deck Preservation Matrix – Decks With Epoxy Coated Rebar (ECR)* (2011) Michigan DOT 2p.
[47] *Bridge Deck Preservation Matrix – Decks With Uncoated "Black"* Rebar (2011) Michigan DOT 2p.
[48] *A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection* (2002). NCHRP 20-07/Task 151B, 42p.

abilities; 3) Assess consequences; 4) Identify countermeasures; 5) Estimate costs of countermeasures, and; 6) Review operational security. Michigan DOT identifies scour-vulnerable structures and then combines the risk of scour-related failure at structures with the impacts on mobility resulting from loss of structures. Structures that possess both greater potential for failure and greater importance to networks are the higher priorities for scour remediation.

Table 12 - Bridge Deck Preservation - Decks with Uncoated Reinforcing Steel

Deck Condition State				Repair Options	Repair Life, Years
Top Surface		Bottom Surface			
BSIR[49] #58a	Defect Area	BSIR #58b	Defect Area		
≥ 5	N/A	N/A	N/A	Seal Cracks/Healer Sealer	1 to 4
	≤ 5%	> 5	≤ 2%	Epoxy Overlay	10 to 15
	≤ 10%	≥ 4	≤ 25%	Deck Patch	3 to 10
4 or 5	10% to 25%	5 or 6	≤ 10%	Deep Concrete Overlay	25 to 30
		4	10% to 25%	Shallow Concrete Overlay	20 to 25
				HMA Overlay + membrane	8 to 10
		2 or 3	> 25%	HMA Cap	2 to 4
< 3	>25%	> 5	< 2%	Deep Concrete Overlay	20 to 25
		4 or 5	2% to 25%	Shallow Concrete Overlay	10
				HMA Overlay + membrane	5 to 7
		2 or 3	>25%	HMA Cap	1 to 3
				Replace Deck use Epoxy Coated Rebar	60+

Performance Measures

Michigan DOT tracks performance of pavements, bridges, intermodal assets, public transportation, safety, and airport runways. Performance of bridges and culverts is measured using NBI general condition ratings. Michigan DOT's goal is to have at least 85% of non-freeway structures and at least 95% of freeway structures with no NBI general condition ratings less than 5 (Figure 7).

[49] BSIR = Bridge Safety Inspection Report

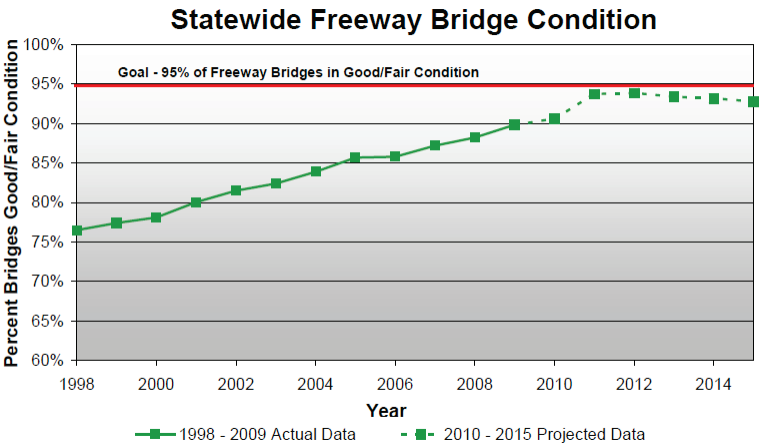


Figure 7 - Michigan DOT Freeway Bridge Condition[50]

Bridge Management - Data Systems

For management of bridges and culverts, Michigan DOT uses data systems that include AASHTOWare Pontis BMS, and two applications developed by Michigan DOT: a *Transportation Management System* (TMS) that holds inventory and condition data for most transportation assets, and a *Bridge Condition Forecasting System* (BCFS) (Figure 8) that models deterioration and evaluates the outcomes of proposed bridge programs.

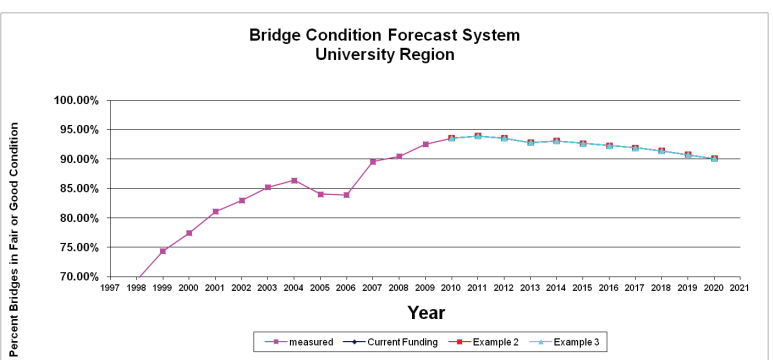


Figure 8 - Michigan DOT BCFS

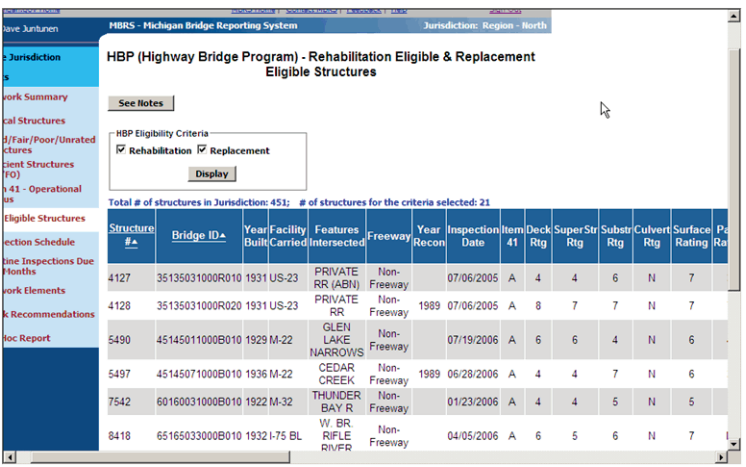
[50] *2010 Annual Report Dashboard* (2011). TAMC, http://tamc.mcgi.state.mi.us/MITRP/Data/PaserDashboard.aspx

TMS is a central database with web-accessible portals adapted to management areas that include structures, pavements, congestion, safety, public transportation, intermodal transportation, and airport runways. For bridges and culverts, portals in TMS include:

Michigan Bridge Reporting System (MBRS) - Access to structure inventory and condition data; access to lists of critical structures, SD bridges, and Federal-aid eligible structures; access to work programmed for structures (Figure 9).

Michigan Bridge Inspection System (MBIS) – Portal to assign, track and report safety inspections for bridges and culverts.

Figure 9
Michigan Bridge Reporting System



Bridge Condition Forecasting System

Michigan DOT has developed BCFS, an application to forecast network-level conditions of bridges from current conditions, budgets, deterioration transition probabilities, and improvement probabilities.

BCFS operates with NBI general condition ratings. Deterioration models and improvement probabilities are expressed in the 9-0 NBI scale. BCFS operates on an input population of structures expressed as counts of structures at each NBI condition rating. BCFS can analyze structures statewide, or within one DOT region. BCFS employs three work programs: Preventive maintenance, rehabilitation, and replacement. Each program is represented as a single generic action. In consequence, BCFS operates with three average costs only. Work programs are expressed as budget amounts. BCFS applies as many projects in each program as the program's budget allows.

BCFS uses lists of programmed work to compute unencumbered budgets and to avoid duplication of work. Future conditions are the combination of improved conditions at structures included in work

programs and continued deterioration at other structures. Forecasts of future condition include anticipated effects of programmed work and BCFS-generated projects.

Pontis BMS

Michigan DOT uses Pontis BMS to generate lists of potential work candidates and activities. Agency rules for Pontis have been developed and refined through repeated use to achieve outputs from Pontis that are consistent with Michigan DOT policy for programs. Pontis' lists of potential projects are transmitted to DOT regions for their use in development of work programs.

Michigan DOT uses Pontis to forecast the number of years until structures reach poor condition; that is, have at least one NBI general condition rating of 4 or lower. The analysis uses Pontis' deterioration models together with the NBI translator.

Bridge Management Staff

Bridge management is the responsibility of Michigan DOT's Bridge Operations Section, a part of the DOT Construction Field Services Division. The Section performs activities in management, inspection, and load rating. The Section provides technical guidance for bridge fabrication, erection, assembly, construction quality assurance, fracture critical members, and mechanical and electrical systems for movable bridges.

The Bridge Operations Section develops policies on preventive maintenance, rehabilitation and replacement work, provides guidance to regions in annual calls for projects, sets budgets for work programs, and analyzes the impacts of work programs on conditions of structures. The Section maintains structure data and data applications. This entails annual updates to cost workbooks and annual calibration of deterioration models in BCFS. Bridge management activities are performed by three to four staff in the DOT central office, and one or two staff in each of seven regional offices. Bridge management activities are led by the State Bridge Operations Engineer.

Data Collection

Michigan DOT inspects all State-owned bridges and culverts having span of 10 feet or greater[51]. Michigan DOT collects both NBI general condition ratings and element-level condition reports. Michigan DOT's data record for structure inventory and appraisal includes NBIS data items plus additional items[52]. Additional data items identify railing type and paint type, and provide additional information on load posting, and on pins and hangers.

Michigan DOT has developed additional bridge elements and smart flags, beyond the set of AASHTO commonly recognized elements[24]. Additional elements provide for a range of concrete reinforcing materials and types of joints. Additional smart flags indicate conditions of decks, false decking, concrete coatings, hard contact at ends of beams, and anchors in concrete for sign or utility attachments to structures.

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[51] *Pontis Bridge Inspection Manual* (2009) Michigan DOT, 101p.

[52] *Michigan Structure Inventory and Appraisal Coding Guide* (2009) Michigan DOT, 125p.

Michigan DOT collects a subset of inventory data for structures that do not carry roadways. These data include structure type, length, location and the agency having maintenance responsibility.

Quality Control. Quality Assurance.

Michigan DOT conducts independent review of 10% of safety inspection reports for quality control (QC). Reviews are performed by peer team leaders, and include field verification of reports. Reviews are logged by report, inspector, and reviewer.

Michigan DOT conducts quality assurance (QA) review of DOT regions every eight years; typically reviewing one region per year. Central office inspection activities undergo QA review, too, at 8-year interval. QA reviews examine inspection reports, load ratings, structure inventory and appraisal data, and element-level data. Michigan DOT manages QA reviews of bridge programs of local agencies. Most QA reviews of local agencies are performed by consultants to Michigan DOT.

Reporting.

Michigan DOT issues publications related to bridge management data systems and data coding[51,52], maintenance activities[42,43,46,47], costs of activities[53,54], planning[34,55,56,57], and performance[50,58,59,60].

Michigan DOT reports annually on conditions and performance measures for transportation assets[38]. TAMC prepares a similar, but separate, annual report on performance[60]. The DOT report is posted at an interactive website[61]. Data from TAMC's report is posted as an internet dashboard (Figure 10)[62].

Michigan DOT publishes average unit costs for activities in preventive maintenance[53], and in structure rehabilitation and replacement[54]. Costs are prepared by the Bridge Operations Section as Excel workbooks, and are available to DOT regions for project development.

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[53] *Capital Scheduled Maintenance Bridge Project Cost Estimate* (2010) Michigan DOT, Excel workbook.
[54] *Bridge Repair Cost Estimate* (2010) Michigan DOT, http://www.michigan.gov/documents/BridgeRepairCostEstimate_112227_7.xls
[55] *MI Transportation Plan Moving Michigan Forward – 2005-2030 State Long-Range Transportation Plan* (2007). Michigan DOT, 32p.
[56] *State Long-Range Transportation Plan, 2005-2030, Highway/Bridge Technical Report* (2006) Michigan DOT, 120p.
[57] *2011-2015 Five-Yea Transportation Program* (2011) Michigan DOT, 70p.
[58] *Driven by Excellence A Report on Transportation Performance Measurement at MDOT* (2010) Michigan DOT, 28p.
[59] *Highway Bridge Report - Listed By County* (2011) Michigan DOT, 142p.
[60] *Michigan's Roads and Bridges 2010 Annual Report* (2010). TAMC, 41p.
[61] http://www.michigan.gov/documents/mdot/MDOT-Performance_Measures_Report_289930_7.pdf
[62] http://tamc.mcgi.state.mi.us/MITRP/Data/PaserDashboard.aspx

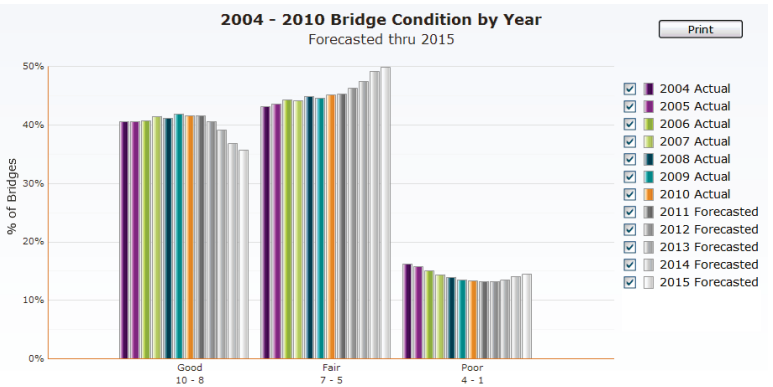
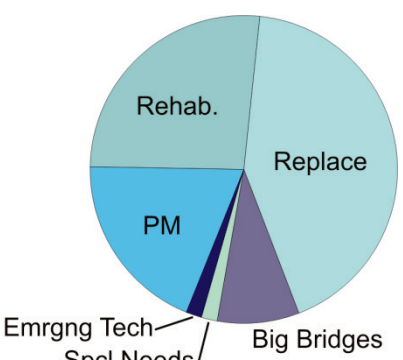


Figure 10 - Michigan TAMC Dashboard

Budgets for Bridge Programs

Michigan DOT's annual baseline budget for in-service bridges and culverts[63] is $185 million combined State and Federal funds. Average allocations are shown in Figure 11. Funding for preventive maintenance, rehabilitation, and replacement is 88% of the program for in-service structures. The relative funding levels of 23% for preventive maintenance, 31% for rehabilitation, and 46% for replacement are the current DOT strategy. The allocation shown for *Big Bridges* is an average annual amount; it can vary significantly year to year. *Special Needs* are essential repairs at structures in poor condition. *Emerging Technologies* are project-level trials of new methods and materials.



Bridge Program	Allocation Million $
Big Bridges	16.0
Special Needs	3.0
Emerging Technologies	3.0
Preventive Maintenance	35.9
Rehabilitation	48.9
Replacement	78.2

Figure 11 Michigan DOT Budgets for In-Service Structures

[63] Structures with span 10 ft and greater.

In the current year (FY 2011), budget allocations provide projects for 198 bridges and culverts[64]. These include preventive maintenance projects for 84 structures, rehabilitation of 62 structures, and replacement of 52 structures.

Michigan State government has determined that current funding for preservation of transportation assets is not adequate. In 2009, a task force studied transportation funding outlooks and alternatives[65]. Among its findings, the task force noted that declines in revenues from motor fuels taxes and increases in material and construction costs is moving Michigan from under-investing in transportation assets to dis-investing. The task force predicted that without new funding sources, poor conditions along State trunkline routes could increase from the current level of 10% of pavements and structures to 35% by the year 2015.

Improving Management of Structures

Michigan DOT identifies steps to improve management of highway structures. These include expanded use of Federal HBP funds for preventive maintenance of locally-owned structures, the use of Federal HBP funds for highway structures affected by comprehensive projects along road corridors, and the consideration of relative benefits of structure preservation and structure functional improvements. Coordination of work on structures within larger road projects can offer cost savings. The preservation of structures that are functionally obsolete can sometimes be a useful alternative to replacement or to taking no action at all.

Improving Data Systems

Michigan DOT identifies several areas of development for bridge management software. These include a database of transition probabilities for bridge elements, offering both national and regional values; a software utility to link contract pay items to costs of actions in BMS; greater capabilities in BMS to estimate costs of individual projects, and make comparisons among project alternatives, and; inclusion of structure vulnerability and criticality in automated programming of work. Michigan DOT's current practice in prioritizing scour-vulnerable structures provides a model for this approach.

Impediments

Michigan DOT could expand its use of data systems for management of structures. Michigan DOT is limited at present by lack of staff and of funding for information technology and particularly for development of web-based applications.

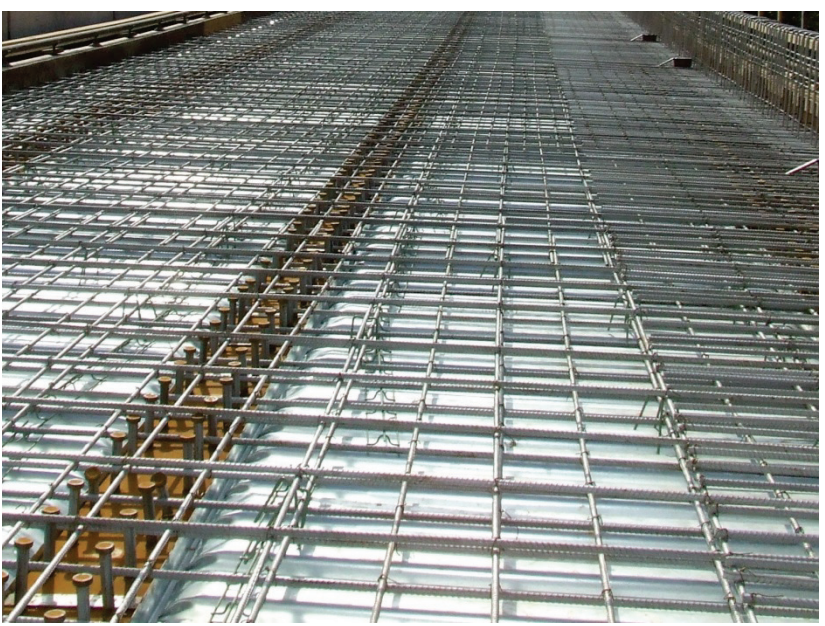
[64] These are 178 highway bridges, 7 culverts, and 13 pedestrian bridges.

[65] *Transportation Solutions A Report on Michigan's Transportation Needs and Funding Alternatives* (2009). Michigan Transportation Funding Task Force, 84p.

VIRGINIA DEPARTMENT OF TRANSPORTATION

The Virginia Department of Transportation (VDOT) maintains State-owned bridges and culverts, and monitors the conditions of all structures on public roads in the State. VDOT's role in structure maintenance includes direct work by State crews and contractors, oversight of autonomous asset maintenance contractors, QA reviews of local government bridge construction programs, and guidance to local government bridge owners. Most maintenance of State-owned structures is performed by contractors. All operations maintenance on interstate routes is delivered by asset maintenance contactors. In some Virginia counties, maintenance of secondary roads is managed by county governments using State-provided funds.

State law[66,67] requires the use of asset management processes, and periodic reporting on conditions of transportation assets. Managed assets include pavements, pavement markings, bridges, culverts, signs, guardrails, ditches, shoulders and cross pipes.



Deck Replacement, Corrosion-Resistant Reinforcing Steel, Virginia DOT

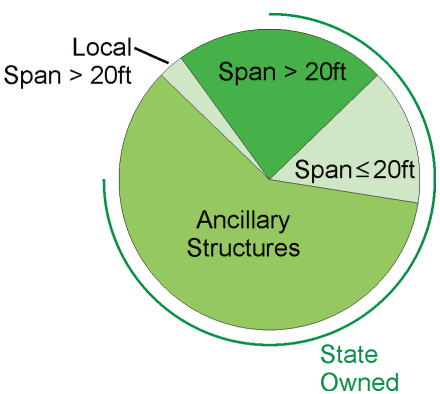
For bridges and culverts, VDOT has work programs that deliver projects for rehabilitation, restoration and preventive maintenance together with service maintenance (deck washing, for example). VDOT

[66] Virginia General Assembly, Appropriation Act Item 444 A. (Special Session I, 2006)
[67] *Code of Virginia* (2007). § 33.1-13.02.

implements six-year improvement plans that deliver projects for structures, and has a dedicated-fund program to replace deficient structures on non-interstate routes.

Inventory of Structures

VDOT has responsibilities for nearly 13000 bridges and 8000 culverts[68] (Figure 12). Ninety-three percent of these structures are owned by the Commonwealth of Virginia. Thirty-nine percent of structures are on interstate and primary road systems. About 8% of bridges and culverts statewide are SD. VDOT manages six tunnels, and more than 10000 sign structures, signal structures and high mast lights.



Structures	Count
NBIS Structures	
State-owned, highway bridges and culverts > 20’	11,807
Toll authority owned, highway bridges > 20’	73
County, or locally owned, highway bridges > 20’	1,240
Other highway bridges > 20’	124
Non-NBIS Structures	
State-owned, highway bridges ≤ 20’	2,694
County, or locally owned, highway bridges ≤ 20’	11
Other highway bridges ≤ 20’	17
Pipes, smaller culverts ≤ 20’	4,942
Pedestrian bridges	15
Ancillary Structures	
High mast lights	672
Overhead sign structures	1,362
Traffic signal structures	8,653
Tunnels	6
Luminaires	17,656
Sign structures (Cantilever, Bridge Mounted, or Butterfly)	2,201
Camera poles	420

Figure 12 Virginia Structures

[68] Includes short spans and structures not owned by the Commonwealth of Virginia

Management of In-Service Structures

VDOT lists standard activities[69] for work on in-service bridges and culverts (Table 13). Standard activities identify structure component (*Bridge, Deck, Superstructure, Substructure*, and *Culvert*) and work category (*Preventive Maintenance, Restorative Maintenance, Rehabilitation, Replacement*, and *Inspection/Engineering*). Preventive maintenance includes cleaning/clearing of structures and channels, zone coating, and minor repairs. Restorative maintenance includes most repairs to structures. Rehabilitation includes major repairs and replacements of decks or superstructures. Replacement is complete replacement of structures. Inspection/engineering includes safety inspections, load ratings and maintenance administration.

Bridge Replacement, Virginia DOT

VDOT has planned-preventive maintenance activities that are performed at set intervals to stay ahead of potential deterioration (Table 14). Planned-preventive maintenance activities are eligible for the Federal HBP funds under an agreement between VDOT and the FHWA.

VDOT has goals for its structure inventory: 1) Reduce the number of SD structures, 2) Restore structures that may become deficient, 3) Improve structure capacity as required for system growth, 4) Preserve structures that are in good condition[70], and 5) Furnish new structures that are more resistant to deterioration than existing structures. In new construction, VDOT is eliminating deck joints, and using protective systems and corrosion-resistant materials.

[69] *Recording and Tracking Bridge Maintenance Work* (2010) IIM-S&B-85.1, VDOT, 5p.

[70] Structures with all NBI general condition ratings ≥ 6

Table 13 – VDOT Maintenance Activities[69]

Category	Activities
Preventive Maintenance[71]	Deck cleaning, Sealing, Thin-bonded overlay Remove/replace joint seals, Repair/patch joint walls Superstructure cleaning, Paint beam ends Clean/lubricate bearings Substructure cleaning, Culvert cleaning Stream bank stabilization, Debris/vegetation removal
Restorative Maintenance	Asphalt overlay/membrane, Rigid overlay, Latex/silica fume overlay, Deck patching Repairs to rails, parapets, curbs, safety walks Apply wood preservatives, Repair/replace timber deck boards, Tighten/replace deck fasteners, Reconstruct joints, Close joints, Install/repair relief joints Bearing align, repair or replace Paint, overcoat, recoat, and zone coat Superstructure repairs Substructure repairs, Settlement repair Culvert repairs, Repair damaged headwalls/endwalls Fill scour holes, Rip-rap, Other scour countermeasures
Rehabilitation	Replace bridge deck or superstructure Replace/major repair of substructure Extend culvert, Sleeve installation, Flowline restoration
Replacement	Replace bridge or culvert
Inspection & Engineering	Safety inspection, Load rating analysis, Work scheduling, Planning/budgeting, Work oversight, Develop plans, specifications and/or contract documents for rehabilitation or replacement

Maintenance Delivery

VDOT uses State crews, project-level contracts, 'as-needed' contracts and asset maintenance contracts to maintain bridges and culverts. District-wide, as-needed maintenance contracts are set-up with bid items for commonly-needed work at structures. *Turnkey Asset Maintenance Services* (TAMS) contracts provide minor maintenance and incident management on interstate highways. VDOT makes great use of contract maintenance. In FY 2008, $891 million of $1.20 billion (74%) of highway maintenance expenditures were paid to the private sector[72].

Maintenance by Local Agencies

Some cities and towns in Virginia manage structures and other transportation assets on their road systems. Funding for local maintenance include local governments funds and street maintenance pay-

[71] Federal-aid eligible preventive maintenance activities.

[72] *Annual Report on Initiatives for Outsourcing, Privatization and Downsizing within VDOT* (2008) VDOT, 22p.

ments from VDOT. Safety inspections of locally-owned structures are executed by local governments and reported to VDOT. VDOT performs QA reviews of local government bridge programs.

Table 14
VDOT
Planned-Preventive Maintenance[73]

Action	Interval (years)
Bridge Management Services	
Bridge deck washing (concrete)	1
Bridge deck sweeping	1
Seats and beam-ends washing	2
Cutting and removing vegetation	2
Routine maintenance of timber structures	2
Removing debris from culverts	5
Preventive Maintenance	
Cleaning and lubricating bearing devices	4
Scheduled replacement of pourable joints	6
Scheduled replacement of compression seal joints	10
Scheduled beam ends painting	10
Installation of thin epoxy concrete overlay	15

Virginia has transferred ('devolved') maintenance responsibilities for secondary roads to some county governments[74]. Maintenance by counties is supported by State funding. Counties that maintain assets on secondary roads report the conditions of assets to VDOT.

Work Programming

VDOT examines structure conditions, status, and estimated costs to select work candidates and identify appropriate actions. When funding is available, in-service structures are replaced if they are SD and if their NBI sufficiency rating is 50 or less, or if rehabilitation costs exceed 65% of replacement costs. Structures are eligible for rehabilitation if their NBI sufficiency rating is 80 or less, and at least one NBI general condition rating is below 6. Structures are eligible for restorative maintenance if at least one NBI general condition rating is below 6 and limited repairs are needed. Preventive maintenance is usually applied to structures that have no NBI general condition ratings below 6.

Functional obsolescence and weight restrictions at structures are addressed in projects for replacement or rehabilitation. Functional obsolescence and weight restrictions, by themselves, usually do not make structures candidates for work unless improvement of structures would have a significant effect on commerce.

Most of the projects in VDOT's structure maintenance program involve rehabilitation, restorative maintenance and preventive maintenance. A dedicated-fund program replaces SD structures that are

[73] *Bridge Preservation* (2011) VDOT, ppt, Structure and Bridge Annual Leadership Training, 76 slides.
[74] *Code of Virginia* (2004). § 33.1-23.5:1.

not on interstate routes. Some projects for replacement or rehabilitation are delivered as part of Virginia's Six-Year Improvement Plans[75].

Jointless Bridge - Virginia DOT

Bridge Risk

VDOT identifies risk in terms of the number of structures that may become SD if not repaired. At-risk structures have at least one NBI general condition rating equal to 5, but no condition ratings below 5. These structures are candidates for restorative maintenance (Table 13). In 2011, VDOT had 1720 SD structures and 4720 structures at risk.

Review, Improvement of Bridge Programs

VDOT forms topical index committees to develop and update specifications, standards, details, and design aids. There are six main committees (Table 15); each is chaired by an engineer from VDOT's Structure and Bridge Division (S&B). More than forty sub-committees deal with specific sub-topics.

Table 15
VDOT Topical Index Committees

Design of Structures
Concrete Design
Steel Design
Geotechnical Design
Miscellaneous Design (sign structures, culverts, other structures)
Inspection & Bridge Management

Efforts to improve bridge programs include regular meetings of S&B engineers to review practices and policies. There are monthly meetings of leadership within the central S&B group, monthly meetings of S&B staff in each DOT district[76], quarterly meetings between the State Structure and Bridge Engineer and District Bridge Engineers, and annual meetings of central S&B staff with S&B staff in all districts.

Performance Measures

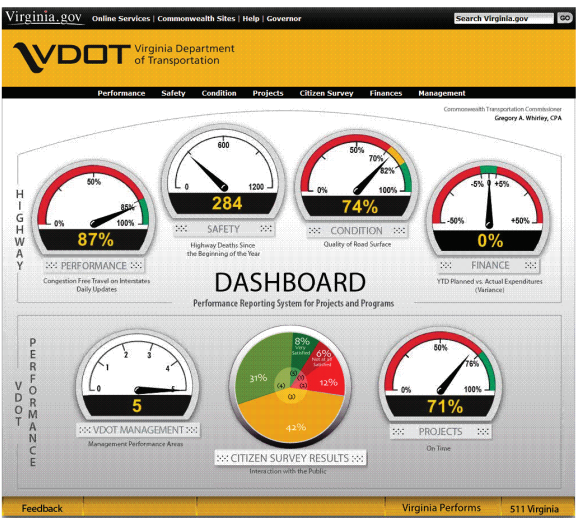
VDOT's annual reports[77] present performance measures for structures that include counts of: 1) SD structures; 2) FO structures; 3) Deficient structures (the sum of SD and FO structures); 4) SD structures restored or deteriorated; 5) Weight-posted structures; and values of 6) Bridge health index; and 7) Structure age. Performance measures for other transportation assets include pavement condition,

[75] *VDOT Six-Year Improvement Program*, http://syip.virginiadot.org/Pages/allProjects.aspx
[76] VDOT has nine districts: Bristol, Salem, Lynchburg, Richmond, Hampton Roads, Fredericksburg, Culpeper, Staunton, and Northern Virginia
[77] *State Of The Structures And Bridges Report* (2011). VDOT, 72p.

pavement ride quality, and need for repairs of ditches, shoulders, cross pipes, signs and pavement markings[78].

Two measures, SD structures and FO structures, are reported at VDOT's internet *Dashboard*[79] (Figure 13). The *Dashboard* also shows measures of pavement conditions, traffic safety, traffic congestion, DOT expenditures compared to budgets, DOT administrative performance, inputs from citizens, and on-time delivery of projects.

Figure 13
VDOT *Dashboard*



VDOT applies level-of-service grades to service maintenance of transportation assets. For bridges, level-of-service is related to deck ride quality, and response time to restore ride quality[80].

VDOT has goals to limit the percentages of SD bridges and culverts (Table 16). Goals vary by road system. The statewide goal is structural deficiency at not more than 8% of bridges and culverts.

[78] *Biennial Report on the Condition and Performance of Surface Infrastructure in the Commonwealth of Virginia. HB 2838/SB 1128* (2007). VDOT, 33p.
[79] http://dashboard.virginiadot.org/Default.aspx
[80] *Biennial Report on the Condition of and Investment Needed to Maintain and Operate the Existing Surface Transportation Infrastructure for FY 2011 and FY* 2012 (2009). VDOT, 87p.

Table 16
VDOT
Performance Measures
and Goals[77]

SD Structures		
System	**2011 Value**	**Goal**
Statewide	8.2%	≤ 8%
Interstate Roads	3.4%	≤ 3%
Primary Roads	5.7%	≤ 6%
Secondary Roads	10.4%	≤ 11%
Locally-maintained roads	8.7%	≤ 8%

Bridge Management - Data Systems

VDOT uses Pontis BMS analytical software in bridge inspection, inspection QC, identification of work candidates, statewide budgeting for in-service structures, allocation of budgets to DOT districts, reporting on structure conditions, computation of investment needs for structures, and for maintaining all bridge and culvert inventory data.

VDOT is developing a bridge programming tool, called the *Optimizer*, that uses Pontis outputs to form coherent work plans for structures. The *Optimizer* will provide realistic scoping for bridge projects, and will propose projects that conform to VDOT criteria for bridge programs.

Bridge Management Staff

VDOT has four full-time staff members in its central S&B division who use bridge management software on a regular basis. The Assistant State Structure and Bridge Engineer for maintenance works with three other engineers on statewide maintenance planning and bridge management. These engineers, a BMS team, review element-level condition data from safety inspections, and investigate unusual or unexpected condition reports. The BMS team assists in selection of structures for repair, rehabilitation and replacement. The BMS team reviews plans for maintenance and repair of structures, and manages the distribution of VDOT's dedicated bridge fund. The BMS team reviews completed maintenance work on structures. The BMS team is supplemented by individuals in district bridge offices.

The BMS team prepares policy memos for bridge and culvert maintenance and rehabilitation[81]. The BMS team identifies best practices in bridge and culvert maintenance and rehabilitation, and evaluates the performance of new materials and systems for bridges and culverts.

Data Collection

In safety inspections, VDOT collects both NBI general condition ratings and element-level condition data[82]. VDOT defines ten additional structure elements and eleven additional smart flags, beyond the set of AASHTO commonly recognized elements[24]. Additional elements include types of sidewalk, steel girders supporting timber deck, slopes, wingwalls, and slabs under fill. Additional smart flags address

[81] *Instructional and Informational Memoranda of the Structures and Bridge Division* are posted at http://www.virginiadot.org/business/bridge-ii-memoranda-index.asp
[82] *Element Data Collection Manual* (2007). VDOT, 92p.

utilities on structures, drains, lighting, pavements over culverts, debris in channels, and deck replacement needs.

Quality Control, Quality Assurance

District Bridge Safety Inspection Engineers (DBSIE) review all inspection reports for structures in DOT districts. DBSIEs perform QC review of inspection teams each quarter. VDOT central office performs annual QA reviews of the inspection programs of all DOT districts.

Districts offices perform QA reviews of local agency bridge programs. QA for local agencies includes office review of bridge and culvert inspection folders, and field verification of a sample of inspection reports.

Reporting

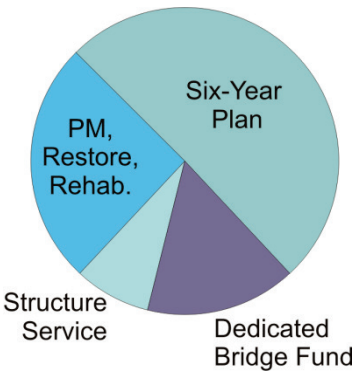
VDOT makes annual reports of conditions of transportation assets[77] and biennial reports of investments needed to maintain and improve assets[78]. Reports on asset conditions include current values, trends and goals for performance measures. Biennial reports on investments identify the maintenance and improvement needs for nine asset classes (Table 17). Biennial reports include estimated costs for needed maintenance and improvement of assets during the next biennium, current values of performance measures, and, in some reports, the total funding needed to remedy all deficiencies and defects.

Table 17
VDOT Reporting on Transportation Assets

Pavements	Pavement markings	Cross pipes
Bridges/culverts	Guardrails	Ditches
Tunnels	Signs	Shoulders

Budgets for Bridge Programs

Annual funding for bridges and culverts is $510M (FY 2011), with about 50% going to projects in six-year plans, 16% to the dedicated bridge fund, 26% to preventive maintenance, restorative maintenance and rehabilitation, and 8% to service maintenance (Figure 14). Virginia's 2012-2017 six-year plan provides $258M per year (average) for projects for bridges and culverts. The dedicated bridge fund provides about $80M per year. Maintenance funding is about $172M per year. Dedicated bridge funds and maintenance funds are allocated by the DOT central office to the DOT districts on the basis of total needs, historical levels of expenditures, and available funds. Maintenance funds are applied to investments in structures ($131M) and service for structures ($41M). Investments include activities in preventive and restorative maintenance, and rehabilitations. Service for structures include deck washing, bridge inspection and bridge load rating.



Program		Annual Budget $ Millions
Six-Year Plan, Bridge and culvert projects		258
Dedicated Bridge Fund (structure replacement, non-interstate roads)		80
Maintenance	Prevention, Restoration, Re-habilitation	131
	Service for Structures	41

Figure 14 Annual Budgets for In-Service Structures (year 2011)

VDOT identifies funding needs for several levels of performance for structures. Funding of $4.67B would replace all SD bridges and culverts. Funding of $850M would reduce the number of SD bridges and culverts to meet current goals for performance (Table 16). Funding of $344M would provide all restorative maintenance needs in the next biennium. Funding of $99.1M would provide all preventive maintenance activities during the next biennium.

Bridge Management Achievements

VDOT's management of bridges and culverts is part of a department-wide commitment to asset management of transportation infrastructure. VDOT makes programmatic use of performance measures, and reports performance measures to Virginia government and citizens. VDOT uses, and enhances, BMS analytical software to identify work candidates and actions for candidates. VDOT pursues simultaneous programs for planned-preventive maintenance, for restoration and rehabilitation, and for replacement. Simultaneous, but separate, programs and funding ensure that preventive maintenance and restoration go forward, even though there are pending needs for replacement of deficient structures.

VDOT identifies two avenues for further improvement of management of bridges and culverts. One is funding. Policy at the Federal level to recognize and reward states' success in structure preservation would support current practices and prompt State DOTs to increase preservation efforts. The other is BMS analytical software. A better, user-friendly interface for BMS analytical software is needed. Better project-level analysis and tracking are needed. An update to the NBI translator is overdue, both to correct its existing limitations, and to accommodate newly defined national bridge elements[83].

[83] *AASHTO Bridge Element Inspection Manual* (2011) AASHTO, 172p.

FURTHER INFORMATION:

USDOT Federal Highway Administration	Shyan-Yung Pan Office of Asset Management 202-366-1567, Shyan.Pan@dot.gov
Idaho Transportation Department	Matthew M. Farrar Bridge Engineer 208-334-8538, Matt.Farrar@itd.idaho.gov Kathleen Slinger Bridge Asset Management Engineer 280-334-8407, Kathleen.Slinger@itd.idaho.gov
Michigan Department of Transportation	David Juntunen Bridge Operations Engineer 517-322-5688, juntunend@michigan.gov
Virginia Department of Transportation	Kendal R. Walus State Structure and Bridge Engineer 804-786-4575, Kendal.Wlaus@vdot.virginia.gov

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