REVIEW OF TRANSPORTATION'S ASSET MANAGEMENT SYSTEM AND MAINTENANCE FUNDING PRACTICES

JULY 2010

Auditor of Public Accounts
COMMONWEALTH OF VIRGINIA

AUDIT SUMMARY

Transportation's Asset Management System (AMS) is capable of providing an accurate, independent, consistent assessment of the states infrastructure maintenance needs. The system can provide a list of assets and their corresponding needed repair. Such valuable information is available not only to high-level decision makers but also to the districts who carry out the maintenance activity. Transportation should continue to use system information to determine maintenance funding levels and distribute those funds among the districts based on needs determined by AMS. Transportation management should establish maintenance priorities that guide the districts in their use of maintenance funds to ensure that the districts' planned maintenance activities move Transportation towards meeting its performance measures and targets.

Analysis of asset condition assessments provides an accurate picture of total funds needed to meet the Commonwealth's highway system maintenance needs every year. Transportation uses average cost data from its Transport system, a database of historical infrastructure construction and maintenance cost, to determine the cost of maintenance needed based on Transportation's established performance goals. Transportation presents this information to the General Assembly to support the request for maintenance funding. Transportation submits a final decision of maintenance funding for a given year and the allocation to each of Transportation's nine districts to the Commonwealth Transportation Board for approval.

Transportation uses AMS to capture condition assessment data for 100 percent of bridges, interstate and primary pavements, 25 percent of secondary pavements, and various other assets. Once Transportation loads condition assessment data into AMS, the system uses matrices and decision trees to analyze the data and determine the required maintenance activity; (1) Do Nothing, (2) Perform Corrective Maintenance, (3) Perform Preventive Maintenance or (4) Perform Restorative Maintenance.

Each district's Pavement and Bridge Engineers receive data from AMS. Each district plans and budgets its maintenance activities. Transportation does not reconcile the AMS proposed maintenance activity to actual maintenance activities performed. The data collection process begins again, as Transportation completes condition assessments on Virginia's roadways the next year.

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INTRODUCTION

The Department of Transportation (Transportation) builds, maintains, and operates the Commonwealth's roads, bridges, and tunnels. Virginia has one of the largest state-maintained highway systems in the United States, spending $3.3 billion annually. Transportation maintains over 57,000 miles of interstate, primary, and secondary roads and distributes state funds to help maintain over 10,000 miles of urban streets. Transportation not only maintains roads, but also maintains more than 12,600 bridges, four underwater tunnels, two mountain tunnels, one toll road, one toll bridge, four ferry services, and a number of rest areas and commuter parking lots.

In February 2002, Governor Warner requested that the Auditor of Public Accounts conduct an operational and performance review of Transportation. We issued a report entitled: "Special Review of the Cash Management and Capital Budgeting Practices" in July 2002. Among other areas, we reviewed maintenance funding practices. Specifically, we found that Transportation did not have a systematic way to identify its maintenance needs, and therefore could not reasonably determine or quantify its maintenance needs. We made the following recommendations:

2002 Recommendation: Transportation should implement an objective means of identifying and prioritizing maintenance needs, namely an asset management approach. Transportation should use an automated system to record data and should prioritize needs based on an objective set of criteria.

2002 Recommendation: Transportation should make the implementation of asset management a priority, with or without the automated systems fully in place to support it. Transportation should make continuous efforts towards this goal and ensure that all maintenance staff, including those from the area headquarters level and up, understand the changes that will come with asset management. Transportation should recognize that there is no way to appropriately fund the maintenance program without an asset management system to provide sound data and decision-making tools.

In 2004, we performed a follow up on the 2002 report to determine Transportation's status in implementing the report's findings and issued a report entitled "Follow-Up of the Special Review of the Cash Management and Capital Budgeting Practices." We found that maintenance was still an area of concern at Transportation. The growing maintenance requirements and the limited ability to budget on a needs-based approach increases the risk of inappropriately applying funding. Transportation was implementing a needs-based budget approach for the fiscal year 2006 maintenance budget request. When Transportation fully implements the Asset Management System (AMS), Transportation should have the ability to implement this approach and develop a prioritized maintenance program. We made the following recommendation:

2004 Recommendation: Transportation should continue to make the implementation of asset management a priority. There is no way to appropriately fund maintenance needs without an asset management system that provides sound data and decision-making tools. Transportation should then perform analyses to identify its true maintenance needs on a statewide level.

The purpose of this report is to continue to follow Transportation's progress in the area of maintenance funding practices.

FINDINGS AND RECOMMENDATIONS

Transportation's AMS collects and analyzes infrastructure condition assessments to determine maintenance activities and the related funding needed to keep Virginia's roads and bridges at established performance standards. Key maintenance decision makers can rely on the relevant information in AMS to make sound maintenance plans.

However, Transportation does not rely exclusively on AMS to make final district allocation decisions. To an extent, this is reasonable; Transportation should consider many other factors. Currently, Transportation's allocation of maintenance funding is dependent on AMS information, the prior year allocation, and Transportation's ability to increase quantities of work contracted in a given district without significantly driving up market prices. We recommend Transportation continue with their plan to increase funding to districts in which the AMS determined need is held back in order to prevent a strain on the infrastructure maintenance industry in that area and decrease funding to districts in which the AMS determined need is exceeded in order to maintain standard funding. This will slowly adjust competition in such districts, resulting in better maintained roads at a reasonable price.

Transportation should increase and document its control over the maintenance activities at all nine districts. Each district makes their maintenance plans for the year with limited direction from the Central Office. The Central Office does review and approve the district's maintenance plan. However, there are essentially nine different ways of determining what maintenance the districts will actually complete. There is no reconciliation of the needs determined by AMS and the maintenance activity completed in the districts. Transportation will gain district accountability by establishing a standard procedure for maintenance planning and requiring each district to report progress during and at the end of each year.

INDUSTRY STANDARDS

Every state deals with the issue of transportation infrastructure maintenance. The American Association of State Highway and Transportation Officials (AASHTO) provides reports on industry standards that help states identify best practices in all areas of transportation. The summary of the following report provides guidance on the best practices of four states with infrastructure systems similar to the Commonwealth.

In January 2008, AASHTO published a report from the National Cooperative Highway Research Program (NCHRP) entitled "NCHRP Report 608 GASB 34-Methods for Condition Assessment and Preservation" that discussed methods of condition assessments, performance measures, and budgeting used by several state Departments of Transportation. Interviews with the states regarding their practices took place in March, April, and October of 2006. States included in the report were Florida, Ohio, Oregon, and Washington. The following best practices were common among the four states reviewed.

Methods of Condition Assessment included best practices such as:

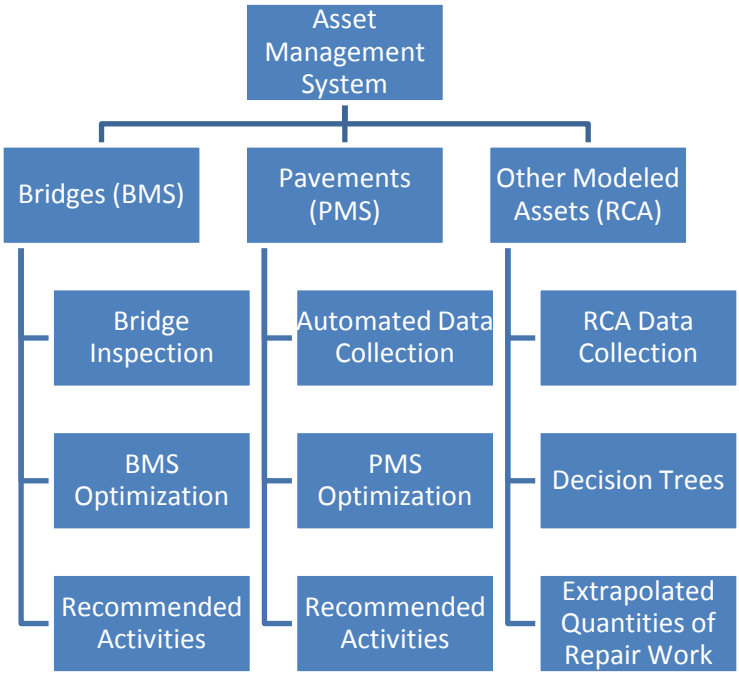
- Assessing 100 percent of pavement and bridge populations;
- Inspecting bridges using procedures that meet National Bridge Inspection Standards;
- Obtaining quality control over assessment data;
- Contracting complex bridge assessments to experienced firms; and
- Assessing pavement conditions electronically, (this practice leads the industry).

We could not determine a standard performance measure target among the four states reviewed. Most of the states establish their own performance measures based on varying factors. In all four states, the condition targets directly affect the budget requests or vice versa. Budget constraints limit the targets but the desire to achieve the targets also influences the budget allocations. All four states prioritize maintenance activity within established performance measures above new construction activity.

ASSET MANAGEMENT SYSTEM

The 2006 Appropriation Act (HB5002), Item 444, A.4, A.5 and B.1-4, required Transportation to develop and submit Highway System Maintenance documents to the General Assembly. Over the past four years, Transportation's Asset Management Division has developed the Asset Management System (AMS) to accomplish this requirement. Transportation prepared an Asset Management Methodology and a Six-Year Maintenance and Operations Program for review by the General Assembly to increase the transparency, predictability, equity of funding, and stability of investment over time.

The Asset Management System has three modules, one for each type of infrastructure asset. Each module not only houses condition assessment data but also analyzes and makes recommendations for maintenance activity based on criteria specific to that asset type.



CONDITION ASSESSMENT

The section below provides an overview of the condition assessment process for each infrastructure asset type: bridges, pavements, and other modeled assets.

Transportation staff and contracted bridge inspectors perform bridge condition assessments. Transportation developed condition assessment standards based on the American Association of State Highway Transportation Officials condition standards. One bridge is one assessable unit. Inspectors assess at both the component and element level. Transportation assesses the condition of every bridge every two years. Inspectors collect condition data on tablets and then upload the data to the Bridge Management System (BMS) of AMS. Transportation's goal is to have no more than eight percent of bridges rated deficient. A bridge is deficient when the assessment shows a general condition rating of five or less.

Transportation assesses interstate, primary, and secondary road systems through a contracted company called Fugro-Roadware using hardware/software called WiseCrax. Transportation has developed its standards based on guidelines from the United States Army Corp of Engineers (USACE) since no national standard exists. Fugro-Roadware uses a vehicle to observe and measure distresses in the pavement. Transportation assesses 100 percent of interstate and primary road systems and 25 percent of secondary road systems every year. The assessable unit for pavements is a homogeneous pavement section measured in lane miles. Transportation enters condition assessment data in the Pavement Management System (PMS) as a batch upload from the WiseCrax access database. This process occurs at the Central Office. Transportation's goal is to have no more than 18 percent of interstate and primary pavements rated deficient. A road section is deficient when assessed at a combined critical index (CCI) of less than 60 percent.

Other modeled assets include but are not limited to cross pipes, signs, guardrail terminals, guardrails, paved and unpaved ditches, unpaved shoulders and pavement markings. Transportation developed standards for condition assessment of other modeled assets between the Maintenance Division and Traffic Engineering Division. The Random Condition Assessment Data Collection Manual provides criteria by which the inspection team uniformly evaluates maintenance assets and an illustrated guide to methods of rating the maintenance condition of Transportation's assets. All other asset condition assessments are by human evaluation. The assessable units for other assets vary with the type of asset. Transportation, through contract with Virginia Polytechnic Institute and State University (Virginia Tech), assessed all other modeled assets during the 2007 calendar year. Transportation does not plan to assess the condition of items identified as other assets in the future. Transportation currently is adjusting their contract with the Fugro-Roadware/WiseCrax to include an inventory and pictures of other assets along with the pavement assessment data. The contractor provides the data in an Access database, which Transportation uploads to the AMS-SCADSS database by Transportation's Information Technology Division. Transportation has not established performance measures or targets for other modeled assets.

Condition assessment standards are reasonably consistent across the state. Transportation ensures consistency through statewide procedures and extensive quality assurance reviews. For bridges, inspectors use tablets to complete the inspection with a downloaded form used statewide. For pavements, Transportation achieves consistency by intrusting assessment responsibilities to one contractor using one method. For other assets, Transportation developed a Data Collection Guide and provided training classes for contractors and Transportation personnel who would be involved in the Random Condition Assessment (RCA) process (Transportation personnel are only involved for quality assurance purposes).

For detailed information on the bridge, pavement, and other asset condition assessment processes, see Appendix A.

DETERMINING FINAL NEEDS

AMS uses Transportation developed decision trees to determine the constrained and unconstrained maintenance needs of the Commonwealth's bridges, pavements, and other assets. Decision trees are developed separately for each type of asset and then again for each element condition, pavement distresses, and other asset conditions. AMS applies the decision trees to the condition assessment data for bridge elements and homogeneous sections of pavement resulting in the recommended maintenance activity.

Bridges

In BMS, each bridge element has an individual decision tree with the cost affixed to each maintenance activity. Each element has as few as two or as many as five condition levels. Within each condition level a maintenance activity level is preselected according to the most cost effective choice, the system is set up to automatically select the most cost effective maintenance activity. Maintenance activities range from "do nothing" to "replace element"; activities in between vary depending on the element.

Pavements

In the Pavement Management System (PMS), AMS uses a two-phased process to determine maintenance. In the first phase, AMS applies condition or distress data to decision matrices to determine a road section's initial maintenance needs. In the second phase, AMS enhances the initial decision through the utilization of traffic levels, asset types, and maintenance history information. Both phases are automated processes; the system is set up to make the decisions based on assessment data.

System Functionality

PMS and BMS can, using a cost constraining scenario, produce a prioritized list of assets in need of maintenance. Essentially, programmers enter a dollar amount of available funds and the performance rating desired, and the system will generate a list of needs prioritized to maximize an area's performance. A discussion of performance targets and transforming maintenance activities to dollars follows in the section "Determining Cost to Meet Performance Goals" below.

AMS cannot build projects. It can identify elements on a bridge needing repair or homogenous portions of highway in need of maintenance. Transportation uses that information to build the project in the TransPort system.

For bridges and pavements, AMS does provide condition level by asset. Bridge condition assessments are available at any point in time during the year. Transportation constantly updates bridge data as inspectors complete assessments throughout the year. For pavements, interstate and primary, AMS determines the condition level once a year when Transportation records the Fugro-Roadware condition assessment. Fugro-Roadware assesses the secondary road system in full every four years (25 percent every year).

PMS and BMS have the capability to designate the maintenance or repairs necessary to achieve an established condition level at a designated budget amount using a "multi-constraint optimization" methodology to meet a specified performance target. However, Transportation does not use this functionality to decide what maintenance activities to perform in each of the districts and residencies once the Commonwealth Transportation Board or Transportation officials allocate the maintenance funds.

AMS' analytical procedure to determine maintenance needs based on condition assessments is reasonable. AMS does not build maintenance projects, since the TransPort system handles this function, but it does have the capability to provide accurate and detailed information to key decision makers at the Transportation Board and district level. The following sections, "Decisions at the General Assembly Level and at the Commonwealth Transportation Board Level" and "Decisions at the District Level" will further examine the use of the system in the decision making process.

DETERMINING COST TO MEET PERFORMANCE GOALS

Transportation translates the AMS identified maintenance needs into dollars based on the previous year's contracted amount for a similar maintenance activity.

BMS generates the estimated bridge preservation needs for the bridge and large culvert assets. The system contains an optimization model, which considers the cost of performing different types of repairs on elements in different condition states and determines whether it is more cost-effective to pursue a particular type of repair now or to wait until further deterioration occurs. Transportation applies the results to the structures in the inventory to determine what action Transportation should take now, or within a year of a multi-year planning period, along with an estimate of their costs. The results also include benefits and costs of taking each action, which Transportation can use to set priorities for use of limited resources.

For pavements, AMS identifies maintenance needs from the assessment data analysis, then Transportation uses TransPort, its Project Management System, to determine the cost of a recommended maintenance activity. Transportation calculates a 12-month average cost using TransPort historical cost data and applies this to the AMS identified maintenance activity, which can be corrective, preventive, restorative, or reconstructive.

For other modeled assets, each repair type has an associated resource requirement and unit cost. Transportation bases unit cost on the most recent 12-month period bid prices from Transportation's financial system, FMSII. Transportation extrapolates asset counts, conditions, repair assignments, and the associated costs to the remaining network based on directional miles sampled by district and system. In addition, AMS uses deterioration rates and district cost adjustment factors to determine amount of work the district should perform and the associated cost.

The processes described above provide Transportation with a total dollar need to repair all of the Commonwealth's bridges, interstate, primary and secondary roads, and other assets. Funding and staffing restrictions prevent Transportation from performing all needed maintenance work in one year. Therefore, Transportation establishes performance goals. Transportation constrains AMS maintenance cost estimates to meet only these established performance goals.

Transportation sets their performance goals, based on current and historical conditions, available funds, available resources, material costs, and performance measures and targets of other progressive states such as Florida, Maryland, Texas, Wisconsin, and California. Transportation staff present the performance goals to the Commonwealth Transportation Board for review and approval every biennium. It is also important to note that the performance goals apply individually to each lane mile and each bridge. There is no weighted average across all assets; for example, a bridge in good condition cannot cancel out a bridge in bad condition.

Prior to 2007, the performance target for bridges was to have no more than 40 percent of structures with a General Condition Rating (GCR) less than six. Transportation based this target on performance at that time and available funds. In 2007, Transportation tightened their bridge performance measures because of a bridge collapse in Minnesota. Transportation's current performance target is no more than eight percent of bridges deemed structurally deficient.

Transportation defines structural deficiency as a bridge component having a General Condition Rating of less than five or a structural condition or waterway adequacy appraisal rating of less than three. As of June 2009, Transportation was performing at 8.6 percent of bridges classified as structurally deficient and has a goal of reaching eight percent by the year 2012.

Transportation established performance measures and targets for pavements in 2004. Transportation's current performance target is to have no more than 18 percent of interstate road system pavements rated deficient and no more than 18 percent of primary road system pavements rated deficient. Transportation considers a lane mile deficient when the Combined Critical Index (CCI) is less than 60 percent. As of June 2009, Transportation was performing at 20 percent of interstate road systems rated deficient and 24.6 percent of primary road systems rated deficient. Transportation has a goal of reaching their performance targets by June of 2011 and 2013, respectively.

Transportation has not established performance measures or targets for secondary road systems or other modeled assets.

DECISIONS AT THE GENERAL ASSEMBLY AND COMMONWEATH TRANSPORTATION BOARD LEVEL

During the budget development process, the Commonwealth Transportation Board (CTB), in cooperation with Transportation staff, determines the amount of funding needed for highway maintenance, and then it is subject to the General Assembly's review and approval. The CTB is required to ensure that Transportation maintains roads at an established level before funding any other new construction projects.

The Highway Maintenance and Operating (HMO) Fund covers Transportation's maintenance expenditures. Conversely, Transportation Trust Fund (TTF) allocations primarily support road construction. The Code of Virginia prioritizes the maintenance of the existing state highway infrastructure over other activities, including construction, by requiring the full funding of highway maintenance before the funding of construction. It does not establish specific guidelines relating to the condition of the highway system or any funding. In the event that there are not sufficient funds in the HMO fund, Transportation uses TTF funds to supplement maintenance activity. The Board must allocate reasonable and necessary funding for maintenance of roads within the interstate, primary, and secondary systems, city and town maintenance payments, and counties that have withdrawn or elect to withdraw from the secondary system. For fiscal years 2008 and 2009, Transportation spent $1.2 billion and $1.3 billion on highway maintenance, respectively.

AMS produces a fiscal year targeted need, the dollar amount necessary to meet the Commonwealth's established performance measures. The CTB determines, out of all Transportation funding, how much is available for maintenance activities. Transportation then allocates the available funding to the nine districts.

To allocate the funding available for maintenance, Transportation uses the AMS targeted need. Transportation determines each district's percentage of the targeted need and applies that percentage to the maintenance funding available to determine each district's portion.

Then based on management set criteria, Transportation adjusts the maintenance funding for each district. These criteria can change from year to year. For example, management may decide that there should be no decrease in the amount of funding each district receives over the prior year. However, if a district is receiving more than their proportionate share of maintenance funding, they will use it to perform lower priority needs in their district, while other districts cannot perform higher priority needs.

In contrast, if the system identifies a large increase in need for a particular district, Transportation may reduce that need to prevent changes in quantities of work that the industry in that district cannot support. If Transportation were to allocate an additional $50 million to a district where the industry cannot handle the sudden increase in demand for maintenance supplies and services, prices could increase drastically. Not only Transportation but also other businesses would experience a sharp increase in construction and maintenance costs in that area. However, if a district is receiving less than their proportionate share of maintenance funding, they will be able to perform only the highest priority needs, while other districts are able to perform needs much lower on their priority list.

Management is objectively looking at the AMS data and not allowing a computer system to determine district funding in a vacuum. However, if the system is identifying a consistent increase or decrease in need in a district, Transportation should have a plan in place to adjust funding between districts gradually over time, so that districts can perform higher priority maintenance needs consistently across the state. In districts where funding increases, a gradual change will encourage progression of the industry so that it can meet the maintenance needs of the district. In addition, if a district consistently receives more funding than needed due to the minimum funding levels, that district could use maintenance funds unnecessarily. Transportation should have a plan to reduce funding for that district gradually so that maintenance funding can go where it will accomplish the most good.

Recognizing the need to gradually adjust funding to align with need, Transportation's Six Year Plan, over the past three years, progressively distributes funding in a way that better represents AMS identified needs. In the beginning, Transportation determined maintenance funding based on total needs and each district's or region's total share of needs determined by AMS. For fiscal year 2009, maintenance funding used performance targeted needs. This allowed Transportation to funnel dollars to critical maintenance projects, that once completed would bring Transportation closer to meeting their established performance goals. Transportation implemented an even more detailed approach for fiscal year 2010 by breaking out needs by investment in core highway assets (pavement, bridge, traffic and safety assets, technology assets) and services (drainage maintenance, vegetation control, snow and ice control, incident response, traffic operations center and tunnel operations).

Transportation's goal is to direct maintenance dollars to a greater extent toward maintenance investments on core highway assets. Transportation's ability to focus the districts on key assets

increased. For fiscal year 2011, Transportation used a similar approach. In addition to identifying investment and service needs, services are broken out into five service areas and then into individual service groups to further delineate the services Transportation provides. Transportation is progressively using AMS information to target maintenance funds to the assets that need the most attention and is providing the districts with more direction on how to use the funds.

Recommendation:

Transportation management should continue their practice of gradually increasing or decreasing funding to districts to match each districts funding to the AMS identified need.

DECISIONS AT THE DISTRICT LEVEL

The district maintenance budgeting process is the process each district uses to decide which maintenance activities to perform with the funding they receive. Our understanding of the district maintenance budgeting process described below came from interviews with Richmond District managers and could vary between districts. There is no standardized or documented process for preparing the maintenance budget at the district level.

Central office provides instructions to each district regarding the percentage of maintenance dollars to use for pavements and bridge repair, designating the rest for service maintenance and administration. Once the district decides which maintenance activities to perform for the year, they submit a maintenance plan to central office for review and acceptance. The rest of the decision making process discussed below may vary by district.

Once a district receives its budget for the year, the district splits it into two categories; Service and Investment based on the percentages designated by central office. The Service budget covers routine maintenance such as patching, mowing, trash pickup, snow removal, and rest areas. The Investment budget covers maintenance activities that provide lasting value to the district's pavement and bridge infrastructure.

The district prepares an asset maintenance schedule based on needs identified by AMS. The first priority is to stop further deterioration. Then the district uses the data to determine which lane sections are in the very worst condition and then adds as many as possible to the maintenance schedule for the year. The district uses the same process for the bridge maintenance schedule. The district first attempts to prevent deterioration by performing tasks such as painting and fixing joints and then selects the bridges in the worst condition for needed remediation. However, Transportation management does not require the districts to use the information from AMS to make these maintenance decisions, they do not set the maintenance priorities, nor do they require the districts to update AMS for the maintenance activities performed.

The districts do not reconcile actual maintenance projects completed during the year with the need determined in AMS at the beginning of the process. Each year the assessment process starts over and, conceptually, the new needs assessed should reflect completion of those maintenance

activities. The district maintains the schedule of projects created at the beginning of the year, based on AMS identified needs, throughout the year noting the status or completion of the projects. At the end of the year, they have a good idea of the progress they have made in addressing the needs identified by AMS.

Recommendation:

Transportation management needs to ensure that the districts' use of maintenance funds supports Transportation's efforts to meet its established performance measures and targets. Management can accomplish this by establishing maintenance priorities that guide the districts in their use of the funds while allowing for district nuances. In addition, when management approves each district's maintenance plan, they should consider the impact the planned activities have on the performance measures and targets and only approve those plans that move Transportation towards reaching its goals.

CONCLUSION

The Transportation Asset Management System is capable of providing an accurate, independent, consistent assessment of the Commonwealth's highway infrastructure maintenance needs. The system can provide a list of assets and their corresponding needed repair. This information is available, not only to high-level decision makers, but also to the districts who carry out the maintenance activity. Transportation should improve how they use the Asset Management System information to determine maintenance funding levels and distribute those funds among the districts based on needs determined by AMS. Transportation should also improve how the districts use the system information to determine maintenance activity for the year.

Commonwealth of Virginia

Walter J. Kucharski, Auditor

Auditor of Public Accounts
P.O. Box 1295
Richmond, Virginia 23218

July 13, 2010

The Honorable Robert F. McDonnell
Governor of Virginia

The Honorable Charles J. Colgan
Chairman, Joint Legislative Audit
and Review Commission

We have audited the Department of Transportation's Asset Management System and maintenance funding practices and are pleased to submit our report entitled **Review of Transportation's Asset Management System and Maintenance Funding Practices**. We conducted this performance audit in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Audit Objectives

1. To determine best practices for Highway Infrastructure condition assessment, funding, and allocation;

2. To gain an understanding and determine the reasonableness of Transportation's Asset Management System (AMS);

3. To gain an understanding of how needs identified by AMS are translated into dollars and determine reasonableness;

4. To determine Transportation's Performance Measures related to Highway System Maintenance;

5. To determine how the information produced by the Asset Management System is used by key decision makers (General Assembly) to allocate highway maintenance funds;

6. To determine how Transportation's end decision maker (district) determines how to use maintenance funding; and

7. To determine, based on all information gathered, whether the Asset Management System is providing the necessary information for all funding decisions.

Audit Scope and Methodology

Our main objective was to determine whether AMS provides sound data and decision-making tools and whether Transportation properly uses this information to allocate and use maintenance funding based on need. We interviewed key Transportation personnel and reviewed relevant documentation to understand AMS, the data it contains, and the maintenance funding allocation process. We researched and evaluated similar practices used by other states to determine best practices for maintenance funding practices.

Conclusions

We found that Transportation's Asset Management System is capable of providing an accurate, independent, and consistent assessment of the Commonwealth's highway infrastructure maintenance needs. The system can provide a list of assets and their corresponding needed repair. This information is available, not only to high-level decision makers, but also to the districts who carry out the maintenance activity. Transportation should improve how they use the Asset Management System information to determine maintenance funding levels and distribute those funds among the districts based on needs determined by AMS. Transportation should also improve how the districts use the system information to determine maintenance activity for the year.

Exit Conference and Report Distribution

We discussed this report with Transportation's management on July 14, 2010. Management's response to the findings identified in our audit is included in the section titled "Transportation's Response." We did not audit Management's response and, accordingly, we express no opinion on it.

This report is intended for the information and use of the Governor and General Assembly, management, and the citizens of the Commonwealth of Virginia and is a public record.

AUDITOR OF PUBLIC ACCOUNTS

DBC/clj

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219 2000

Gregory A. Whirley
Acting Commissioner

July 15, 2010

Mr. Walter J. Kucharski
Auditor of Public Accounts
P.O. Box 1295
Richmond, Virginia 23218

Dear Mr. Kucharski,

On behalf of the Department of Transportation, I want to express my deep gratitude for the work your staff performed on the "Review of Transportation's Asset Management System and Maintenance Funding Practices." I appreciate the time your staff spent working on this review and the quality of the report. Your recognition of the many accomplishments we have made over the past three years gives all of us great satisfaction.

Your report highlights the focus the Department has on using information from the asset management system to distribute maintenance funds to the districts and to focus funding to specific types of highway infrastructure assets. I was pleased to see that findings in the report include that the asset management system can provide an accurate, independent, and consistent assessment of highway infrastructure maintenance needs.

The report recommends that the Department continue its practice of gradually increasing or decreasing funding to districts based on the needs identified from the asset management system. Transportation agrees with this recommendation and will continue the current practice of adjusting funding based on needs. The report also recommends that Department management needs to ensure that the districts' use of maintenance funds supports the Department's efforts to meet its established performance measures and targets. Transportation agrees with this recommendation. Transportation management will continue to establish maintenance priorities and provide recommended allocation distributions to the districts. Transportation will implement a process to review each district's maintenance plan to ensure it is consistent with the established priorities.

Please share with your staff my appreciation for their work and diligence during this review.

Sincerely,

Gregory A. Whirley, Sr.

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APPENDIX A

Detailed Procedures for Condition Assessment

Bridges

Qualified Transportation staff conduct bridge inspections and assessments. Transportation contracts with consultant bridge inspectors for complex inspections. Consultant bridge inspectors perform approximately 20 percent of bridge inspections and condition assessments. The National Bridge Inspection Standards heavily regulate the bridge inspection process. All inspectors meet the qualifications established by the National Bridge Inspection Standards (NBIS-23 CFR 650). Transportation and the Federal Government each perform their own rigorous quality review process.

Transportation performs bridge and structure assessments in accordance with the condition standards set by the American Association of State Highway Transportation Officials (AASHTO). AASHTO provides a guide to assist bridge inspectors in condition assessment and data collection. Transportation enhanced the AASHTO collection guide for its own use to increase procedure detail. In addition to assessing all bridge maintenance needs, Transportation also follows the requirements set by the National Bridge Inspection Standards (NBIS-23 CFR 650) and collects federally reportable data in accordance with the National Bridge Inventory (NBI) of the Federal Highway Administration (FWHA). The NBI standards require a bridge inspection within two years (24 months) of the last inspection. Transportation inspects each bridge within one year of the last inspection and inspects them upon completion of repair or rehabilitation. The FWHA also selects one bridge a year to inspect to ensure compliance.

A bridge consists of components such as deck, superstructure, substructure, channel/waterways, and culvert. A component consists of elements. Transportation assesses each component at the element level. Each bridge can have between 12 and 20 elements such as: railing, deck joints, riding surface, bearing devices, abutments, and girders. Bridge inspectors assess the condition of components to ensure the bridge's compliance with Federal Safety Regulations and to determine maintenance needs for the bridge. For the purposes of fulfilling the Commonwealth's established performance goal of no more than eight percent of total bridges determined to be deficient, an entire bridge is one unit. A bridge is deficient when the assessment shows a general condition rating of five or lower.

AMS consists of three functions or modules. The Bridge Management System (BMS) module stores all bridge inspection and assessment data. This system uses software called PONTIS to provide a comprehensive database of bridge, traffic, cost, and safety data. Inspectors begin by downloading an inspection form from BMS, containing prior year assessment data, to a tablet. Inspectors gather all current year assessment information in that form and then upload it into BMS by synchronizing the tablet with the system. This process occurs at the individual districts.

Pavements

Transportation assesses interstate, primary, and secondary road systems through a contracted company called Fugro-Roadware using hardware/software called WiseCrax. WiseCrax is an automated crack detection system that uses proprietary image recognition algorithms to locate, identify, and measure pavement distresses. Fugro-Roadware collects images with vehicles equipped with high-speed cameras, synchronized strobe lights, and motion detection equipment. Fugro-Roadware processes the data collected at the office workstations overnight. This assessment method removes, to a degree, subjectivity from the assessment process and is highly repeatable and consistent. Transportation assesses 100 percent of interstate and primary road systems and 25 percent of secondary road systems every year.

For interstate, primary, and secondary road system pavement assessments, no national standard exists. Transportation has developed its standards based on guidelines from the USACE.

Chapter 3 of the USACE's Unified Facilities Criteria, Pavement Maintenance Management Technical Manual relates best to the pavements condition assessment procedures developed at Transportation. These standards, created over 20 years ago, have no references to more advanced electronic condition assessment procedures but the basic procedures are still relevant. The following is a very basic summary of Chapter 3 of the USACE's Pavement Maintenance Management Technical Manual.

Pavement condition depends on many factors including structural integrity, structural capacity, roughness, skid resistance/hydroplaning potential, and rate of deterioration. The Fugro-Roadware vehicle observes and measures distresses in the pavement to assess these factors. Pavement Condition Index (PCI) quantifies the pavement's structural integrity and surface operational condition by a numerical indicator based on a scale of 0 to 100. The PCI is determined by measuring pavement distress. The method has been field-tested and has proven to be a useful device for determining maintenance needs and priorities.

In the case of jointed concrete pavement sections and asphalt, tar-surfaced and/or asphalt over concrete pavement, there are two methods used to inspect a pavement. The first method, entire section inspection, requires the inspection of all sample units of an entire pavement section. The second method, inspection by sampling, requires the inspection of only a portion of the sample units in a section. The inspector will use a hand odometer to measure distress lengths and areas, a ten-foot straightedge, and a ruler to measure the depth of ruts or depressions. The inspector uses one form for each sample unit. Each column on the form represents a distress type. The form indicates the corresponding number of that distress type at the top of the column. The inspector lists the amount and severity of each distress in the appropriate column. The inspector computes the PCI based on the total distress data collected for the sample unit.

As stated above, Transportation modified the USACE's pavement assessment guidelines to create their own pavement assessment standards. The following is a summary of general requirements followed during the collection of assessment data.

A Guide to Evaluating Pavement Distress Through the Use of Digital Images

PMS is the module that collects all pavement assessment data from Fugro-Roadware using WiseCrax software. PMS uses pavement condition data to prioritize pavement maintenance and rehabilitation projects, predict pavement performance, and develop optimum strategies for future maintenance and rehabilitation of pavements on the state highway network. Digital images are used for automated distress interpretation and processing. Transportation determines PCI values using the pavement distress data. Transportation then uses PCI to make pavement management, maintenance, and rehabilitation estimates. The following standards ensure that Transportation consistently collects the data used for analysis and decision-making.

General data requirements include using equipment that meets specification, calibration, and quality control requirements. The standard portion of pavement imaged by the equipment includes the full pavement surface of the rightmost travel lane along with right and left edges of the roadway. The standards require operators to note all roadway impediments that force the survey vehicle to leave the normal travel lane. The standards also require operators to halt data collection during rain, snow, or other conditions that would contribute to poor pavement visibility.

General distress evaluation rules are applicable to all types of pavement and ensure good evaluation of all distresses visible on the digital images and of all parameters measured by laser. These rules include:

- Rating the full width of the lane represented on the computer monitors;
- Excluding portions of the images that fall on bridges, approach slabs or bridge decks;
- Reviewing distressed areas several times in order to correctly characterize pavement conditions;
- Rating distress levels according to severity as a 1 or 2, the higher number indicating more severe distress; and
- Checking the total length of longitudinally measured distress of all severity levels to ensure it does not exceed the length of pavement surveyed.

Data collection and data processing requirements ensure consistency. For instance, inspectors summarize all pavement condition data in one-tenth mile sections starting at the mile point zero beginning at the state or county boundary, therefore collection always begins at the southern or western most part of the state or county. Before data collection begins, the vehicle operator calibrates each survey vehicle to produce vehicle measurement differences of five percent or less. The vehicle will always capture downward perspective and forward perspective images of a full 14-foot width view of the pavement surface.

Data processing requirements include evaluating 100 percent of the pavement sections using the downward and forward perspective images. Fugro-Roadware collects all distress and sensor data

and calculates indices (PCI) separately for each tenth of a mile of roadway that is a homogenous section of pavement. All ratings include the pavement between the pavement stripes. For quality control, Fugro-Roadware submits automated pavement distress ratings along with the semi-automated visual review of all pavement sections to check the automated rating and identify any cracks, joint sealant, patching, bleeding, or other distresses not classified by the automated system.

Transportation also institutes an independent validation and verification check that monitors the contractor's assessment of pavement distress data. The data must be statistically sound, if not the burden is on the contractor to make the required adjustments, at no cost to Transportation. Once the third party quality assurance company confirms the data, Transportation enters it in PMS as a batch upload from the WiseCrax access database. This process occurs at the Central Office.

The assessable unit for pavements is a homogeneous pavement section measured in lane miles. The Fugro-Roadware operated vehicles collect data on pavements in one-tenth mile segments. A homogeneous pavement sections is a length of pavement with similar surface material type, for example; asphalt or concrete, the environment, and the age of the road treatments including the treatments below the first layer. For the purpose of fulfilling the Commonwealth's established performance goal of no more than 18 percent of interstate and primary roads determined to be deficient, a combined critical index (CCI) of less than 60 percent, a mile of homogeneous pavement section is deemed to be one unit.

Other Assets

Transportation developed standards for condition assessment of other modeled assets between the Maintenance Division and Traffic Engineering Division. Transportation included input from both the central office and field experts in the development process. The Random Condition Assessment Data Collection Manual provides criteria by which the inspection team uniformly evaluates maintenance assets and an illustrated guide to methods of rating the maintenance condition of Transportation's assets. All other asset condition assessments are by human evaluation. No automated condition assessment for such assets exists.

The standard's general procedures provide consistent data collection and ensure the safety of workers performing evaluations. Teams of two or three persons perform the overall data collection and site evaluation. On divided highways, the sample section will include only one direction but on an undivided roadway, sections will include both directions. The evaluation teams are to drive to the beginning point indicated on the printout, establish traffic control, mark their beginning point, measure the length of the section, and mark the ending point. Then they are to begin rating the section by walking the right shoulder looking at the assets on the right of way.

The assessable units for other assets vary with the type of asset. For assets such as paved and unpaved ditches, unpaved shoulder, guardrail, and pavement marking, the assessable unit is linear feet. Transportation assesses assets such as cross pipes, signs, and guardrail terminals individually.

Random Condition Assessment (RCA) is the module that collects all other modeled asset assessment data from a database prepared by the contractor, Virginia Tech. The contractor provides

the data in an Access database, which Transportation uploads to the AMS-SCADSS database by Transportation's Information Technology Division.

Transportation, through contract with Virginia Tech, assessed all other assets during the 2007 calendar year. Transportation does not plan to assess the condition of items identified as other assets in the future. Transportation currently is adjusting their contract with the Fugro-Roadware/WiseCrax to include an inventory and pictures of other assets along with the pavement condition assessment data. The other asset part of AMS will change from an investment basis to service basis. Since other assets are not capital in nature as bridges and pavements, these will just be maintained or replaced as needed.

APPENDIX B

Detailed Information on Condition Assessment Data Analysis within AMS

The table below shows the different notations and terminologies used in the process to describe pavement distress densities, severity levels, and recommended maintenance activities.

Notation	Terminology
Distress Density	
N	None
R	Rare
O	Occasional
F	Frequent
P0	No Patching
P1	<10 Percent Pavement Area Patched
P2	>10 Percent Pavement Area Patched
Distress Severity Levels	
NS	Not Severe
S	Severe
VS	Very Severe
Maintenance Activity Category	
DN	Do Nothing
PM	Preventive Maintenance
CM	Corrective Maintenance
RM	Restorative Maintenance
RC	Rehabilitation/Reconstruction

The table below describes typical pavement maintenance activities AMS considers for cost calculations and the expected life for each activity category.

Activity Category	Expected Life (Years)	Activities
Do Nothing	NA	NA
Preventive Maintenance	2-5	1. Minor patching (<5 percent of pavement area, surface patching, depth 2”)
		2. Crack sealing
		3. Surface treatment (chip seal, slurry seal, latex, macro texture, novachip, etc)
Corrective Maintenance	7-10	1. Moderate patching (<10 percent of pavement area, partial depth, patching, depth 6”)
		2. Partial depth patching (<10 percent of pavement area, depth 4”-6”) and surface treatment and thin (≤2”) AC overlay
		3. Partial depth tatching (<10 percent of pavement area, depth 4”-6”) and thin (≤2”) AC overlay
		4. ≤2” milling and ≤2” AC overlay
Restorative Maintenance	8-12	1. Heavy patching (<20 percent of pavement area, full depth patching, depth 12”
		2. ≤4” milling and replace with ≤4” AC overlay
		3. Full depth patching (<20 percent of pavement area, full depth patching, depth 9”-12”) and 4” AC overlay
Rehabilitation Reconstruction	15+	1. Mill, break, and seat 9”-12” AC overlay
		2. Reconstruction

All rated pavement sections will run through the following sets of decision matrices to determine the recommended maintenance activity suitable for the section. The following are examples of single distress matrices:

Alligator Cracking			
Frequency	**R**	**O**	**F**
Severity			
NS	DN	DN	PM
S	DN	PM	CM
VS	CM	CM	RM

Transverse Cracks/Per Mile				
Frequency	**0-50**	**51-74**	**75-199**	**>200**
Severity				
NS	DN	DN	DN	PM
S	DN	DN	PM	CM
VS	CM	RM	RC	RC
Note: For Transverse Cracking, VS applies to composite pavements only				

Decision matrices can hold multiple distresses but this gets very complex and therefore not recreated for this report. AMS can evaluate several distresses on one decision matrix and determine a corresponding maintenance activity that leads to an enhanced decision tree.

Once AMS analyzes the condition assessment data through the distress matrices, additional triggers based on the pavement condition indices determine the maintenance treatment. Pavement condition indices typically provide aggregated measures of several related pavement distresses. AMS assigns road sections a rating of 100, meaning the pavements have no discernable distress or other characteristics that detract from engineering or user perception of pavement conditions or functionality. AMS relates deductions from the perfect score to the type and degree of a given distress. Transportation prepared the "Development of Pavement Condition Indices for Transportation – Flexible Pavements and Rigid Pavements" to document the procedures for arriving at critical indices.

There are three major classes of distress leading to most maintenance and rehabilitation decisions. These are (1) cracking and other surface distress related to loads on the pavement, (2) cracking and surface distress related to environmental effects on the pavement surface, and (3) roughness or smoothness of the pavement surface. There are three defined indices, Load Related Distress Index (LDR), Non-Load Related Distress Index (NDR), and Combined Condition Index (CCI).

LDR relates to distresses such as alligator cracking, patching, potholes, delaminations, and rutting. LDR is a deduction based index having a value of 100 when the pavement evaluated has no discernible load related distress. AMS assigns deduct points for each distress listed above. The magnitude of the deduction relates to the distress type as well as the severity and frequency of occurrence of that distress. NDR relates to distresses such as block cracking, patching and longitudinal cracking out of wheel path, transverse cracking, reflective cracking, and bleeding. NDR is calculated the same as LDR, the distresses are just non load related. CCI is the lower of LDR or NDR and used as a "one measure" indicator over all pavement conditions.

Once an assessable unit of road passes through the decision matrices documented above, AMS evaluates that same unit's CCI against the following:

Interstate:

CCI values above 89 the treatment category is DN
CCI values above 84 the treatment category is DN or PM
CCI values below 60 the treatment category is at least CM (i.e. CM, RM or RC)
CCI values below 49 the treatment category is at least RM (i.e. RM or RC)
CCI values below 37 the treatment category is always RC

Primary:

CCI values above 89 the treatment category is always DN
CCI values above 79 the treatment category is always DN or PM
CCI values below 60 the treatment category is at least CM (i.e. CM, RM or RC)
CCI values below 41 the treatment category is at least RM (i.e. RM or RC)
CCI value below 26 the treatment category is always RC

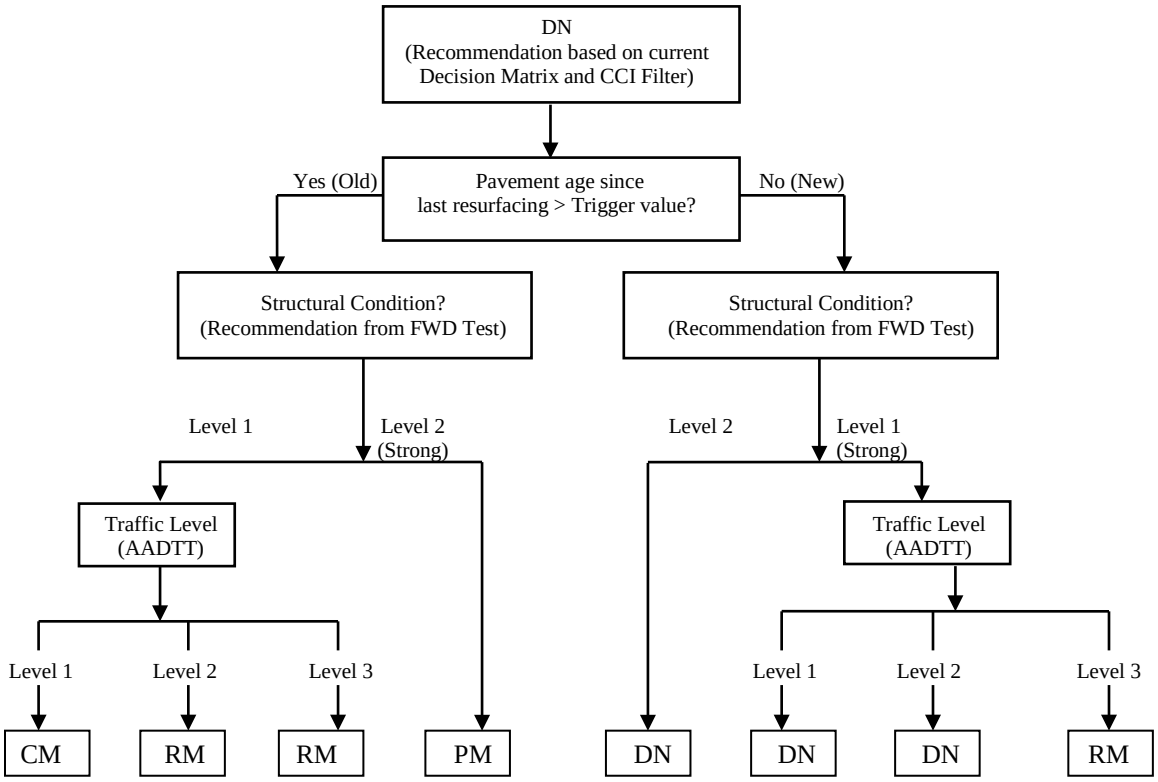
The additional analysis using the roads CCI evaluation, takes into account not only the visible surface distresses but also underlying problems with the road. The final maintenance activity moves ahead to the corresponding enhanced decision tree.

In the second phase, AMS enhances the initial maintenance activity decision using traffic levels, asset types, and maintenance history information. In many cases, AMS could identify the need for maintenance by the visible surface distresses, but not always. For sound maintenance and rehabilitation decision making, Transportation must program AMS to consider structural factors, traffic levels, and pavement ages from the date of the last resurfacing.

The enhancement is actually an extension of the current distress matrices. The condition assessment data passes through the first set of matrices and results in one of five maintenance activities; Preventive Maintenance (PM), Corrective Maintenance (CM), Restorative Maintenance (RM), Rehabilitation/Reconstruction (RC) or to Do Nothing (DN). AMS analyzes that decision through the enhanced decision trees depending on the road system, Interstate or Primary, pavement type, and the maintenance activity determined by the decision matrices and the CCI analysis.

AMS divides structural capacity into two levels, strong and weak, for all types of pavements but with different indicators derived from a Falling Weight Deflectometer (FWD) Analysis. AMS divides traffic, in terms of annual average daily truck traffic (AADTT), into three levels for all types of pavement but with different ranges of values. AMS divides age, in terms of years since last resurfacing, into levels depending on the road system. AMS divides Interstate roads into two levels, new and old; and primary roads into three levels, new, moderate, and old.

Below is an example of an Interstate Highway (BIT/BOC/BOJ) Flow Chart for a Do Nothing Decision from the first "condition" analysis:



Augmented Decision Tree for Interstate System (BIT/BOC/BOJ) with "Do Nothing"

	Trigger Values		
Age (Years)	New	Old	
	≤6	>6	
FWD (BIT: SN & MR BOC/BOJ: Area and k)	SN ≥ 6 and MR ≥10,000 psi Or Area ≥ 32 in. and k ≥ 175 pci	Otherwise	
Traffic (AADTT)	Level 1	Level 2	Level 3
	<1500	[1500, 5000]	>5000

The result of the enhanced decision tree is the systems final maintenance activity decision. Unlike the bridge module of AMS, maintenance cost has no bearing on the final AMS determined maintenance activity. The section entitled "Determining Cost to Meet Performance Goals" discusses how AMS estimates maintenance cost.

Other Assets

The AMS RCA module uses matrices, similar to those for pavements, to determine maintenance activity for other assets. There are as many matrices, conditions, and maintenance activities as there are other asset types. Just as in the case of pavements, maintenance cost has no bearing on the final maintenance activity determined by AMS.

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