

# **PERFORMANCE AUDIT OF TRANSIT**

## **TECHNICAL REPORT E: VEHICLE MAINTENANCE**



# **King County**

Presented to  
the Metropolitan King County Council  
Government Accountability and Oversight Committee  
by the  
County Auditor's Office

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# EXECUTIVE SUMMARY

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## **Transit Has High Standards for Vehicle Maintenance**

This technical report evaluates two aspects of Transit’s vehicle maintenance program: preventive maintenance and maintenance productivity. Although Transit has an outstanding record of on-time preventive maintenance inspections, it is not currently tracking unplanned maintenance, which is a useful measure of preventive maintenance productivity. Transit employs some productivity standards and performance measures, but has opportunities to better manage its productivity by developing standards for more maintenance activities and establishing its standards and measures systemwide.

# 1 INTRODUCTION

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## Chapter Summary

This chapter provides background on our evaluation of vehicle maintenance. We describe the objectives and methodology used in analyzing preventive maintenance, standard repair times, and maintenance productivity; and conclude with a summary of the findings and recommendations.

## Background

Our review of preventive maintenance looks at two key components: on-time preventive maintenance inspections (PMIs) and distribution of work between planned and unplanned maintenance. An effective vehicle maintenance program requires regular PMIs designed to ensure maximum vehicle longevity.

## **We Looked at Preventive Maintenance and Planned and Unplanned Maintenance**

Planned maintenance increases service reliability, reduces overtime expenditures, and supports planning for staffing levels. Of course not all activities can be planned in advance; accidents, vandalism, and trouble calls from the road by operators and other “reactive” work are not completely avoidable. The distribution of maintenance labor between planned and unplanned maintenance is a critical tool to manage the efficiency of the maintenance operation.

Productivity standards specify the duration of time that is expected to carry out a particular maintenance activity, such as a PMI. Multiplying workload by internal time standards provides vehicle maintenance decision-makers with a clear estimate of the staff resources needed for these activities. More broadly, a well-documented, consistent, systemwide productivity program, including productivity standards and measures facilitates tracking

and monitoring performance. In addition to its usefulness as a planning tool, close oversight of adherence to productivity standards can help managers improve workforce productivity, identify problem areas that can be addressed with remedial training, and enhance overall accountability.

### **Objectives and Methodology**

The entire Transit audit spanned multiple areas of work, including Transit's service design practices, financial and capital planning, technology and information management, vehicle maintenance, operator and transit police staffing, and paratransit. The objectives of this portion of the Transit audit were to examine Transit's vehicle maintenance management and practices.

To achieve this objective, the office and its consultants:

- Interviewed Transit leadership, management, and line staff,
- Surveyed relevant industry literature and best practices,
- Observed practices at maintenance facilities,
- Reviewed Transit documents and labor agreements, and
- Analyzed Transit data including Maintenance Management Information System reports and Vehicle Maintenance performance reports.

### **Summary of Findings**

#### **Performance Exceeded Goals**

For 2008, Transit conducted 98.8 percent of its preventive maintenance inspections on time, which exceeds both Transit's own goal and the Federal Transit Administration's standards. However, Transit's high standards may result in some unnecessary costs. In addition, although monitoring the amount of unplanned work is an important management tool that helps contain maintenance costs, we found that Transit does not categorize maintenance work into planned and unplanned work and does not monitor unplanned work hours on a regular basis.

**Enforcement of Standards Varies**

While Transit has established productivity standards for certain vehicle maintenance activities, enforcement of these standards varies from base to base. In addition, Transit has not yet implemented productivity standards for tasks that would be appropriate for maintenance activities beyond preventive maintenance inspections. At the agency level, Transit tracks a variety of vehicle maintenance productivity indicators. However, each maintenance base manages their maintenance activities and performance measurement. Transit has not formalized a maintenance productivity program across the agency.

**Summary of Recommendations**

To resolve the issues identified in the analysis of Transit's vehicle maintenance, Transit should:

*Chapter 2*

- Initiate a pilot program to shift the preventive maintenance interval for a control fleet at the Bellevue base.
- Track and monitor planned and unplanned work and formulate a strategic approach to manage unplanned work.

*Chapter 3*

- Monitor adherence to vehicle maintenance and inspection productivity standards and work to ensure consistency in the standards across bases.
- Expand the productivity standards beyond preventive maintenance inspections (PMIs) to other routine jobs.
- Establish a systemwide maintenance productivity program, expanding on current productivity standards and performance measures.

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# 2 PREVENTIVE MAINTENANCE

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## Transit Exceeds Its Preventive Maintenance Goals

### Chapter Summary

This chapter evaluates Transit's preventive maintenance management. We found that for 2008, Transit conducted 98.8 percent of its preventive maintenance inspections on time, which exceeds both Transit's goal and the Federal Transit Administration's (FTA's) standards. Transit's high preventive maintenance goal may result in some unnecessary costs. Although monitoring the amount of unplanned work is an important management tool that helps contain maintenance costs, we found that Transit does not categorize its work into planned and unplanned work, nor does it monitor unplanned work hours on a regular basis.

We recommend that Transit initiate a pilot program to extend the on-time preventive maintenance inspection interval for buses to the FTA standard. If the pilot is successful, Transit should expand the practice to other bases. We also recommend that Transit begin monitoring planned and unplanned work and develop a strategic approach to managing the level of unplanned maintenance.

### Preventive Maintenance Inspections

An effective maintenance program requires regular preventive maintenance inspections (PMIs) designed to ensure maximum vehicle longevity. PMIs include a series of diagnostic tests and checks as well as scheduled replacement of fluids and filters. Well-planned and scheduled PMIs will reduce the incidence of unscheduled repairs and ensure the vehicles meet their useful life. While early inspections are undesirable because they

commit resources sooner than needed, late inspections may compromise safety as well as drive up costs.

### **Transit Has Stricter Inspection Intervals Than the FTA**

The FTA requires its grantees to develop preventive maintenance programs and to define preventive maintenance intervals. The FTA specifies that inspections that are conducted no later than 10 percent of schedule (e.g., 600 miles for a 6,000-mile inspection) are considered on time. In assessing compliance with PMI requirements, the FTA requires that 80 percent or more of the inspections must be performed on time (i.e., no more than 20 percent may be late). As long as that standard is achieved, grantees meet FTA's requirements. Transit's inspection target is stricter than the FTA standard. To be considered on-time, Transit targets a window of plus or minus 400 miles of the scheduled inspection interval.

Instead of the mileage-based interval used for diesel and hybrid diesel electric buses referenced above, the FTA inspection interval for electric trolley buses is time based. For example, Transit's 60-foot trolley buses are inspected at 28, 56, 168, and 336 days. Transit's target for on-time trolley bus inspections is plus or minus seven days of the scheduled time interval.

### **Transit's Preventive Maintenance Inspections**

Across the seven bases, Transit has a high level of adherence to their own standard for PMI intervals, as shown in Exhibit A.

| <b>EXHIBIT A</b>                                                                |                       |                             |                     |                            |
|---------------------------------------------------------------------------------|-----------------------|-----------------------------|---------------------|----------------------------|
| <b>Adherence to Transit's Preventive Maintenance Inspection Standards, 2008</b> |                       |                             |                     |                            |
| <b>Base</b>                                                                     | <b>Buses Assigned</b> | <b>Total PMIs Performed</b> | <b>PMIs On-Time</b> | <b>On-Time Performance</b> |
| Atlantic                                                                        | 57                    | 363                         | 363                 | 100.0%                     |
| Atlantic (Trolleys)                                                             | 159                   | 1,344                       | 1,257               | 93.5%                      |
| Bellevue                                                                        | 136                   | 774                         | 774                 | 100.0%                     |
| Central                                                                         | 158                   | 858                         | 857                 | 99.9%                      |
| East                                                                            | 234                   | 1,602                       | 1,596               | 99.6%                      |
| North                                                                           | 195                   | 869                         | 865                 | 99.5%                      |
| Ryerson                                                                         | 233                   | 1,237                       | 1,231               | 99.5%                      |
| South                                                                           | 271                   | 2,021                       | 2,015               | 99.7%                      |
| <b>Total</b>                                                                    | <b>1,443</b>          | <b>9,068</b>                | <b>8,958</b>        | <b>98.8%</b>               |

**SOURCE:** Transit's Maintenance Management System, Booz Allen Hamilton

In 2008, Transit inspected its buses on time 98.8 percent of the time, exceeding its systemwide goal of 98 percent of inspections on time. Transit also far exceeds FTA's 80 percent standard for on time PMI adherence.

**Transit's On-Time Performance for Preventive Maintenance Is Outstanding**

Overall, Transit's on-time performance on preventive maintenance inspections is outstanding. This performance helps ensure maximum vehicle longevity and reliability. However, the window of tolerance for these inspections (every 400 miles instead of every 600 miles) may result in some level of unnecessary inspection. For the Bellevue Base, it is estimated that conducting PMIs within a 400-mile window rather than a 600-mile window increases the level of effort associated with PMIs by 5.2 percent.<sup>1</sup>

Transit may have an opportunity to save maintenance resources by extending its on-time window to the FTA standard. In order to evaluate this possibility, Transit could extend the window at one base and monitor the resulting maintenance costs and reliability statistics. If the program shows cost savings and no degradation

<sup>1</sup> In 2008, buses stationed at Bellevue Base averaged 5.7 PMIs per year. Assuming the same mileage for buses, but a wider inspection interval would reduce the average inspections to 5.4 per bus per year, resulting in a 5.2 percent decrease in PMIs.

of reliability statistics, then Transit should expand the practice to other bases.

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**RECOMMENDATION E1**

Transit should initiate a pilot program to extend the preventive maintenance interval to +600/-200 miles on a control fleet at Bellevue Base.

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**Decreasing Unplanned  
Maintenance Increases  
Reliability, Reduces  
Costs**

**Planned Versus Unplanned Work**

Planned maintenance increases service reliability, reduces overtime expenditures, and supports planning for staffing levels. Not all activities can be planned in advance; accidents, vandalism, trouble calls and other “reactive” work are not completely avoidable. While there is no industry standard on the ideal balance between planned and unplanned maintenance, understanding the actual distribution of maintenance labor by activity type is a critical management tool to assess the efficiency of the maintenance operation.

**Transit’s Planned Versus Unplanned Work**

Transit has not set a target for unplanned work. Rather than specifically tracking planned and unplanned maintenance, Transit tracks maintenance work by more discrete categories in its Maintenance Management Information System. Exhibit B shows Transit’s maintenance work types, categorized by Transit staff working with the audit team into planned and unplanned work.

| <b>EXHIBIT B</b>                                   |                              |
|----------------------------------------------------|------------------------------|
| <b>Planned and Unplanned Work Order Categories</b> |                              |
| <b>Planned Maintenance</b>                         | <b>Unplanned Maintenance</b> |
| Rebuild                                            | Accident repair              |
| CSC body overhauls                                 | Operator request             |
| Prep for disposal                                  | Shop request                 |
| Inspection                                         | Trouble call                 |
| Capital project labor                              | Vandalism                    |
| Preventive maintenance                             | Yard truck                   |
| Project work                                       |                              |
| Retrofit                                           |                              |
| New unit preparation                               |                              |
| Work center-CSC                                    |                              |
| Inspection BO (Bad Order)                          |                              |

**SOURCE:** Transit's Maintenance Management System, Booz Allen Hamilton

While acknowledging that Transit does not track planned vs. unplanned work, vehicle maintenance supervisors estimated that 70 percent of their maintenance operation was planned work. Exhibit C shows that systemwide, 47 percent of maintenance work was planned in 2008.

| <b>EXHIBIT C</b>                                                             |               |           |           |           |           |           |           |           |
|------------------------------------------------------------------------------|---------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| <b>Percentage of Planned Maintenance Work by Base,<sup>2</sup> 2004-2008</b> |               |           |           |           |           |           |           |           |
| <b>Year</b>                                                                  | <b>System</b> | <b>AB</b> | <b>BB</b> | <b>CB</b> | <b>EB</b> | <b>NB</b> | <b>RB</b> | <b>SB</b> |
| 2008                                                                         | <b>47.4%</b>  | 46.1%     | 46.3%     | 55.8%     | 54.3%     | 45.6%     | 41.5%     | 51.4%     |
| 2007                                                                         | <b>48.3%</b>  | 47.9%     | 48.3%     | 58.1%     | 57.2%     | 42.9%     | 40.2%     | 52.1%     |
| 2006                                                                         | <b>48.0%</b>  | 45.2%     | 61.1%     | 56.3%     | 54.8%     | 45.2%     | 42.4%     | 50.6%     |
| 2005                                                                         | <b>48.6%</b>  | 48.0%     | 58.7%     | 54.1%     | 53.1%     | 46.1%     | 52.1%     | 47.9%     |
| 2004                                                                         | <b>47.0%</b>  | 47.0%     | 56.4%     | 49.5%     | 52.6%     | 45.4%     | 52.6%     | 43.5%     |

**SOURCE:** Transit's Maintenance Management System, Booz Allen Hamilton

The percentages of planned work may be higher than shown in Exhibit C. Transit staff estimate that approximately 21 percent of shop requests (categorized as unplanned work in Exhibit B) could be reclassified as scheduled work, since maintenance chiefs typically bundle shop and operator requests to be performed when the bus is being serviced for other non-safety

<sup>2</sup> AB=Atlantic Base, BB=Bellevue Base, CB=Central Base, EB=East Base, NB=North Base, RB=Ryerson Base, SB=South Base

reasons. Transit does not currently code these activities as scheduled work.<sup>3</sup>

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**RECOMMENDATION E2** Transit should track and monitor planned and unplanned vehicle maintenance work and formulate a strategic approach to manage unplanned work.

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<sup>3</sup> Transit's current practice of excluding this work from planned work is consistent with industry definitions.

# 3 PRODUCTIVITY

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## Chapter Summary

### **Productivity Standards Are Not Enforced Systemwide**

This chapter evaluates Transit's management of vehicle maintenance productivity. We found that while Transit has established productivity standards for PMIs, enforcement of these standards varies from base to base and Transit does not use the standards in calculating resource needs or deploying resources. In addition, Transit has not yet implemented productivity standards for repeatable tasks beyond PMIs. At the agency level Transit tracks a variety of vehicle maintenance productivity indicators, and individual maintenance bases manage their own performance measurement. However, Transit has not formalized a systemwide maintenance productivity program.

We recommend that Transit begin regular monitoring of adherence to productivity standards at the seven bases and work to ensure consistency in the standards across the bases. We also recommend that Transit expand its productivity standards beyond PMIs to other routine jobs. Finally, building on these standards and on current and new performance measures, Transit should establish a systemwide vehicle maintenance productivity program.

## Productivity Standards

### **Oversight of Standards Can Increase Workforce Productivity**

Productivity standards specify duration of time, generally in hours, that is expected to carry out a particular maintenance activity, such as the PMIs mentioned in Chapter 2. Multiplying workload by internal time standards provides vehicle maintenance decision-makers with a clear estimate of the staff resources needed for these activities. In addition to its usefulness

as a planning tool, closer oversight of the standards can help managers improve workforce productivity, identify problem areas that can be addressed with remedial training, and enhance overall accountability.

### **Transit's Productivity Standards**

Transit has implemented what they call “internal time standards” for the major preventive maintenance inspections that meet collective bargaining agreement provisions. The standards specify the time, in hours, that is expected to carry out a particular inspection. The standards vary by base and by type of bus, as shown in Exhibits D and E. For example, at Atlantic Base a 168-day trolley bus inspection is expected to last up to 2.5 hours. A 12,000-mile 60-foot diesel bus inspection at South Base is expected to take up to three hours.

#### **EXHIBIT D**

##### **Internal Time Standards for Atlantic Base**

| <b>Bus Type</b>              | <b>28-day Inspection</b> | <b>56-day or 6,000-mile Inspection</b> | <b>168-day or 12,000-mile Inspection</b> | <b>336-day or 24,000-mile Inspection</b> |
|------------------------------|--------------------------|----------------------------------------|------------------------------------------|------------------------------------------|
| 40-Foot Trolley: 4100 Series | 1 hour                   | 1.5 hours                              | 2.5 hours                                | 3.5 hours                                |
| 60-Foot Trolley: 4000 Series |                          | 2 hours                                | 3 hours                                  | 4 hours                                  |
| 60-Foot Trolley: 4200 Series | 1.5 hour                 | 2 hours                                | 3 hours                                  | 4.5 hours                                |
| 60-Foot Diesels: 2800 Series |                          | 1.5 hours                              | 3 hours                                  | 4 hours                                  |

**SOURCE:** Booz Allen Hamilton

#### **EXHIBIT E**

##### **Internal Time Standards for South Base**

| <b>Bus Type</b>              | <b>6,000-mile Inspection</b> | <b>12,000-mile Inspection</b> | <b>24,000-mile Inspection</b> |
|------------------------------|------------------------------|-------------------------------|-------------------------------|
| 40-Foot Diesels: 3200 Series | 1 hour                       | 2 hours                       | 3 hours                       |
| 40-Foot Diesels: 9000 Series | 1 hour                       | 2 hours                       | 3 hours                       |
| 60-Foot Diesels: 2300 Series | 1 hour                       | 3 hours                       | 4 hours                       |
| 60-Foot Hybrids: 2600 series | 1 hour                       | 3 hours                       | 4 hours                       |

**SOURCE:** Booz Allen Hamilton

### Base Supervisors Take Some Steps to Monitor Productivity, More Can Be Done

Transit Base Supervisors indicated that they review time charged by staff to regular recurring tasks, and when obvious exceptions or patterns are noted, they interview the mechanics or service persons to ascertain the reasons. At one base, the Chief checks every couple of weeks to look for outliers. Where such outliers are found, the Chief discusses them with the employee(s) and works to determine an explanation. Supervisors believe that mechanics and service persons generally adhere to expectations.

At the system level, Transit does not run regular reports to assess adherence to productivity standards. Such reports would not only allow Transit to evaluate its performance against its standards, they would also allow Transit to refine its standards when appropriate.

The audit team evaluated records for 2008 for all Transit fleets for the 6,000-, 12,000- and 24,000-mile PMIs. The results are summarized in Exhibit F.

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#### EXHIBIT F Transit Mechanic Systemwide Adherence to Productivity Standards, 2008

| Inspection Type | Total Inspections Performed | Percent Adherence to Standard |
|-----------------|-----------------------------|-------------------------------|
| 6,000-mile      | 3,707                       | 41%                           |
| 12,000-mile     | 1,806                       | 68%                           |
| 24,000-mile     | 1,791                       | 58%                           |

**SOURCE:** Transit's Maintenance Management System, Booz Allen Hamilton

Systemwide, adherence to PMI standards ranges from 41 percent to 68 percent. Since productivity standards vary by bus type, it is important to analyze specific fleets. Regular comparisons of actual inspection times to productivity standards are a powerful means to evaluate actual performance and to establish meaningful standards.

**RECOMMENDATION**  
**E3a**

Transit should regularly monitor adherence to vehicle maintenance productivity standards and work to ensure consistency in the standards across bases.

Productivity standards could easily be expanded beyond PMIs to heavy repair activities, as well as other replicated maintenance activities at the operating bases, such as component removal and replacement, brake relines, and AC servicing. While Transit has conducted research into expanding productivity standards to other repeatable maintenance activities, it has not yet implemented these standards.

**RECOMMENDATION**  
**E3b**

Transit should expand vehicle maintenance productivity standards beyond preventive maintenance inspections (PMIs) to other routine jobs.

**Transit Does Not Have  
a Formal Productivity  
Program**

**Productivity Program**

A well-documented and consistent productivity program facilitates tracking and monitoring productivity. Such programs involve setting performance goals, choosing performance measures and setting targets, and establishing productivity standards. Over time, agencies manage productivity improvement by tracking and monitoring their progress toward achieving their productivity program goals.

Transit does not have a formal maintenance productivity program. However, Transit has established a performance reporting framework that tracks key maintenance productivity and performance metrics. At the system level, Transit currently tracks the following indicators monthly:

- Cost per bus and cost per mile
- Miles between trouble calls
- Inspections conducted on time
- Out of service buses
- Number of engine and transmission rebuilds performed

In addition, a number of other productivity indicators are used informally throughout the year, both by the base supervisors and by members of Vehicle Maintenance Administration. Transit assigns a considerable level of autonomy and responsibility to each base supervisor. Supervisors are responsible for establishing productivity standards at their respective bases. These approaches however are neither unified nor formalized at the agency level.

**Transit Could Expand  
Current Productivity  
Practices**

Without a well-documented and consistent productivity program, productivity changes cannot be measured incrementally by category. While the autonomy of the base supervisors has some benefits (such as trying new approaches that can evolve into best practices), carrying out system-wide improvements requires all bases to conform to the same productivity measures and targets. In order to identify the most productive (and replicable) practices at different bases, Transit needs to be able to compare operations using the same metrics.

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**RECOMMENDATION  
E3c**

Transit should establish a systemwide vehicle maintenance productivity program, expanding on current productivity standards and performance measures.

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