Determining Highway Maintenance Costs

DETAILS

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AUTHORS

Transportation Research Board

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 688

Determining Highway Maintenance Costs

Cambridge Systematics, Inc.
Cambridge, MA

WITH

EVS, Inc.
Eden Prairie, MN

Michael J. Markow
Teaticket, MA

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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Crawford F. Jencks, *Deputy Director, Cooperative Research Programs*
Amir N. Hanna, *Senior Program Officer*
Eileen P. Delaney, *Director of Publications*
Doug English, *Editor*

NCHRP PROJECT 14-18 PANEL
Field of Maintenance—Area of Maintenance of Way and Structures

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Edgardo D. Block, *Connecticut DOT, Newington, CT*
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FOREWORD

By Amir N. Hanna
Staff Officer
Transportation Research Board

This report presents a practical process for determining an agency's full costs associated with performing highway maintenance. The process can be applied to any specific maintenance activity and ensures that the resulting full cost incorporates a fair share of both maintenance program and enterprise support costs. In addition, the report documents the application of the full cost determination process for a number of highway agencies and different maintenance activities to demonstrate the types of options, exceptions, and decisions that would be needed in order to perform the full cost calculation. The material contained in the report should be of immediate interest to state maintenance engineers and others involved in the maintenance of highway infrastructure.

Because of growing demands and resource limitations for highway maintenance, state departments of transportation (DOTs) and other highway agencies often consider nontraditional means for financing and contracting these services. For example, some state DOTs have considered the options of outsourcing and public–private partnership of some maintenance services. The transportation agency's costs associated with a specific maintenance activity are usually considered when exploring alternative delivery methods for such activity. However, some of the elements making up the total agency cost of an activity are often not properly considered or, in some instances, are not included.

Although knowledge of the costs associated with specific maintenance activities if done by the transportation agency itself is necessary for exploring alternative delivery methods, there is no widely accepted process for determining such costs. Thus research was needed to identify current practices, review relevant information, and develop a rational process that considers all cost elements.

Under NCHRP Project 14-18, "Determining Highway Maintenance Costs," Cambridge Systematics, Inc., of Massachusetts worked with the objective of developing a process for determining an agency's costs associated with performing highway maintenance. It was also required that the process be flexible enough that it can be applied to any specific maintenance activity. To accomplish this objective, the research (a) reviewed available information relevant to the practices for determining costs associated with performing highway maintenance activities, identified the cost elements required to accurately determine the full cost of any specific highway maintenance activity, performed a preliminary evaluation of available cost determination approaches, and developed a preliminary full cost determination process and (b) evaluated the process using data from a number of state DOTs, introduced the necessary changes, and developed the recommended full cost determination process. The process is supplemented with examples to illustrate application of the process

using data from six state DOTs as well as examples of tracking maintenance activity costs by three other state DOTs.

The full cost determination process will be particularly useful to highway agencies because it provides a realistic estimate of the costs of maintenance activities and helps highway agencies in evaluating alternatives for performing maintenance activities and making decisions that would result in better use of resources. The adoption of this process by AASHTO is, therefore, suggested.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

SUMMARY

Determining Highway Maintenance Costs

There is broad recognition that recent investment levels in transportation infrastructure have been and remain inadequate. In addition, future funding levels are generally uncertain. As a result, the pressure on state departments of transportation (DOTs) to do more with less has never been greater, and agencies continue to actively pursue opportunities to lower costs while striving to maintain or even improve performance. In the maintenance arena, this has led an increasing number of state DOTs to consider the options of outsourcing and public–private partnership of some maintenance services.

Cost is most often cited as a factor that must be considered when exploring such alternative delivery methods. To date, however, there has been no widely accepted process for determining the costs associated with performing highway maintenance if done entirely, or in large part, by the transportation agency itself. Furthermore, a review of any number of existing reports and audits that address the issue of in-house versus outsourced costs clearly demonstrates that often, some of the elements making up the total agency cost of an activity are not properly considered or, in some instances, are not included. In particular, the cost elements most frequently missed or mishandled are those related to maintenance program and agency-wide (or enterprise) support.

Project Objectives

The primary objective of this research was to develop a practical and robust process for determining an agency's full costs associated with performing highway maintenance. The process needed to be flexible enough that it can be applied to any specific maintenance activity, and it needed to ensure that the resulting full cost incorporates a fair share of both maintenance program and enterprise support.

A secondary objective of the research was to document the application of the full cost determination process for a number of different state DOTs and different maintenance activities. The documented examples were intended to supplement the detailed process description and provide real-world examples that could serve as guides to practitioners wanting to apply the full cost determination process in their agency. The examples would serve to demonstrate the types of options, exceptions, and decisions that would be needed in order to perform the full cost calculation.

Findings

At the highest level, a transportation agency's expenditures can be divided into two categories of programs: line and support. A line program is one that delivers one or more of the primary work products of the agency, such as maintenance or construction. A support

program is one that does not deliver any of the agency's main work products but serves in support of one or more of the line programs, such as the executive management, human resources, legal, and financial functions of an agency. The sum of an agency's support program costs can be referred to as the agency's enterprise support costs.

Similarly, activities and expenditures within the line program that is maintenance can be subdivided into two categories: line and support. A line activity is one that involves the actual performance of work on one or more transportation infrastructure assets or work responding to an unpredictable event, such as pothole patching, mowing, snow and ice control, and accident and disaster recovery. A support activity is one that serves in support of one or more line activities, such as maintenance program administration, training, and radio operations. The sum of a maintenance program's support activity costs can be referred to as its program support costs. In this context, the full cost of any line activity is comprised of three basic elements:

1. Line activity cost,
2. A share of program support cost, and
3. A share of enterprise support cost.

Building from this full cost framework, the full cost determination process developed during this study consists of the following five steps:

1. Gather and classify maintenance program activities and expenditures,
2. Allocate maintenance support expenditures to line activities,
3. Gather and classify enterprise programs and expenditures,
4. Allocate a portion of enterprise support expenditures to the maintenance program, and
5. Combine cost categories to derive full cost.

Step 1 identifies the cost elements that are directly related to the performance of a particular line activity [i.e., labor, equipment, material, and other (LEMO)]. Next, the sequence recognizes that certain maintenance activities and expenditures support one or more line activities and identifies a share of these expenditures that must be allocated to each line activity (Step 2). Furthermore, it recognizes that the maintenance program as a whole is supported by a variety of enterprise support programs and expenditures and identifies a share of these expenditures that must be allocated to the maintenance program (Steps 3 and 4). Finally, it combines the results of Steps 1 through 4 to determine the full cost of each line activity (Step 5).

The full cost determination process requires an understanding of agency expenditures beyond the maintenance program itself. In addition, it requires data and information from multiple sources, including agency management systems and annual agency financial and maintenance program reports. As a consequence, its application by any state DOT will be significantly enhanced when maintenance practitioners collaborate with agency experts in agency finance and information systems.

The full cost determination process leverages well-established Office of Management and Budget (OMB) guidelines for the identification and allocation of indirect costs and existing state DOT approaches to satisfying FHWA's indirect cost allocation requirements.

The full cost determination process does not vary as a result of differences in agency, maintenance program, and/or maintenance activity characteristics. The only variation between calculations relates to the inputs and sources of data that are leveraged in each step of the process. The full cost process developed is practical and robust, as demonstrated by its application to six state DOTs, with considerable variation in maintenance program structure, geographic location and characteristics, agency size, and information systems environment.

The benefits of performing the full cost calculation go beyond providing a critical input into agency decisions regarding in-house versus contractor performance of any particular maintenance activity. Gathering the necessary data and performing the calculation requires a thoughtful review of the maintenance program structure and activities as well as the distribution of expenditures between activities and between the different elements of cost. Additional applications and benefits of performing the full cost calculation may include

- The identification of potential improvements to the maintenance program structure and activities as well as the processes and management systems used for recording accomplishments and expenditures associated with each activity (e.g., identification of opportunities to establish separate in-house versus contractor activities in order to improve the allocation of contract support and administration expenditures, recording of accomplishment data, and full unit-cost calculations).
- Providing an ability to compare maintenance costs between different geographic areas and/or highway functional classes, which may in turn provide insight into the influences of other, external effects on costs (e.g., road characteristics, traffic volume and composition, terrain altitude, and weather).
- Performing the calculation annually may help agencies improve level of service (LOS) based budgeting models and reduce reliance on prior-year expenditures during budget development cycles.
- Helping agencies to identify training needs for maintenance field personnel and supervisors in the area of recording man hours, equipment usage, and material consumption.

Finally, the sole purpose of the full cost determination process described in this report is to enable an agency to estimate its full cost for performing any particular maintenance activity. The recommended process is provided in the attachment. It is supplemented with documented examples of the full cost calculation for six DOTs and examples of maintenance cost tracking activities at three DOTs. However, each agency differs with respect to overall agency structure and scope, organizes its maintenance program differently, has different numbers and definitions of maintenance activities, and differs in its treatment and classification of different expenditure types based on these characteristics as well as its information systems environment. As a result, comparing full costs, full unit costs, program support multipliers, enterprise support multipliers, and/or overhead rates of the calculations documented here or undertaken externally is meaningless and should not be attempted.

CHAPTER 1

Introduction

1.1 Background

Because of growing demands and resource limitations for highway maintenance, state departments of transportation (DOTs) and other highway agencies often consider nontraditional means for financing and contracting these services. For example, some state DOTs have considered the options of outsourcing and public–private partnership of some maintenance services. However, identifying the most desirable option for a specific maintenance activity requires knowledge of the transportation agency's full costs associated with such activity. Often, some of the elements making up the total cost of an activity are not appropriately considered or, in some instances, are not included. The cost elements most frequently missed or mishandled are those related to maintenance program and agency-wide (or enterprise) support.

There is no widely accepted process for determining the costs associated with performing highway maintenance if done by the transportation agency itself. Research was needed to identify current practices, review relevant information, and develop a rational process that considers all cost elements and thus provides a realistic estimate of the costs of maintenance activities. NCHRP Project 14-18 was conducted to address this need.

1.2 Objective and Research Approach

The objective of this research was to develop a practical and robust process for determining an agency's full costs associated with performing highway maintenance. The process needed to be flexible enough that it can be applied to any specific maintenance activity, and it needed to ensure that the resulting full cost incorporates a fair share of both maintenance program and enterprise support. The primary application of the process will be to enable agencies to compare the cost of in-house versus contractor delivery of any particular maintenance activity, which is a key consideration for decisions regarding service delivery. This objective was accomplished through the following tasks:

1. Collection and review of information relevant to the practices for determining the costs associated with performing highway maintenance activities. The literature review spanned a variety of sources, including agency reports and audits exploring maintenance costs and comparisons of in-house and contractor costs, research findings, government requirements, as well as other information relating to transportation agency cost tracking in general and maintenance activity costs specifically. In addition, structured interviews were conducted with maintenance and finance personnel at 10 state DOTs. The DOTs were selected in order to provide a range of combinations of three characteristics: geography (climate, terrain, degree of urbanization), size of system (lane miles, bridge deck area), and management information systems sophistication. The interviews focused on how each agency determines and tracks maintenance costs, the systems and processes used, and agency attempts, if any, to determine the full cost of maintenance activities.
2. Identification of the cost elements required to accurately determine the full cost of any specific highway maintenance activity. These cost elements included salaries and benefits, materials, equipment, and other charges that routinely make up maintenance activity costs; maintenance program support costs such as program administration and the state maintenance engineer; and enterprise support costs such as executive management, finance, human resources, and legal offices or departments.
3. Preliminary evaluation of cost determination approaches identified in Task 1 for the full set of cost elements identified in Task 2. This task focused on the practices and procedures available for determining the costs associated

with maintenance activities. Promising cost determination practices were identified for further investigation, and an initial full cost framework was developed.
4. Preparation of a detailed work plan for developing the full cost determination process leveraging the initial full cost framework developed in Task 3 and an enhanced understanding of the data and practices at the state DOTs contacted.
5. Execution of the work plan and development of the full cost determination process. This task focused on working with a number of state DOTs to obtain the necessary data and perform the full cost calculation for all maintenance activities at the agencies. This task resulted in the refinement of the full cost determination process, the identification of options and exceptions for each step of the process, and the development of a prototype spreadsheet tool used to support the full cost calculations performed in this task.
6. Documentation of the full cost calculations performed in Task 5. The full cost calculations were documented in a way that will help agency personnel to use the full cost determination process at their agency and understand the process, level of effort, who should be involved, potential sources of information, and the options and decisions that must be considered at each step.
7. Submittal of a final report that documented the entire research effort and included a stand-alone document describing the process developed (provided as the attachment).

1.3 Applications of the Full Cost Determination Process

The benefits of performing the full cost calculation go beyond providing a critical input into agency decisions regarding in-house versus contractor performance of any particular maintenance activity. Gathering the necessary data and performing the calculation requires a thoughtful review of the maintenance program structure and activities, as well as the distribution of expenditures between activities and between the different elements of cost. Additional applications and benefits of performing the full cost calculation may include:

- The identification of potential improvements to the maintenance program structure and activities, as well as the processes and management systems used for recording accomplishments and expenditures associated with each activity (e.g., the identification of opportunities to establish separate in-house versus contractor activities in order to improve the allocation of contract support and administration expenditures, recording of accomplishment data, and full unit-cost calculations).
- Providing an ability to compare maintenance costs between different geographic areas and/or highway functional classes, which may in turn provide insight into the influences of other, external effects on costs (e.g., road characteristics, traffic volume and composition, terrain altitude, and weather).
- Performing the calculation annually may help agencies improve level of service (LOS) based budgeting models and reduce reliance on prior-year expenditures during budget development cycles.
- Help agencies to identify training needs for maintenance field personnel and supervisors in the area of recording man hours, equipment usage, and material consumption.

1.4 Introduction to Tenets of Full Cost Determination

Several tenets form the foundation of the results of this project. These tenets are listed below; explanations of each tenet and implications for the study's findings and recommendations are provided in Chapter 2.

1. The recommended full cost determination process should build on the existing management practices, procedures, data, and systems typically found within state DOTs.
2. The focus of this study is state DOTs; however, its findings may be useful to other transportation agencies with a maintenance program.
3. The focus of this study is highway maintenance programs; however, the basic principles of full cost determination may be applied to other agencies' line programs.
4. The recommended full cost determination process should encompass all activities performed by an agency's maintenance organization and program.
5. Maintenance activity full cost results should be expressed as either total or unit cost rather than overhead percentages.
6. The results of the full cost determination process apply to each agency individually; comparisons of full costs between agencies are not meaningful for several reasons and should be avoided.
7. The recommended full cost determination process should ensure complete coverage of an agency's expenditures, with no overlaps, duplicates, or gaps.
8. A practical and consistent full cost determination process is more useful than one that is complex and variable, even if the latter delivers greater accuracy in some cases.
9. Agency application of the full cost determination process will benefit significantly from the collaboration of maintenance with other units within the DOT.
10. Utilization of year-end reports and data simplifies the full cost determination process and reduces the chances of errors and inconsistencies.

11. The full cost determination process will provide only one input to the agency's decision making regarding maintenance delivery.
12. The full cost determination process should incorporate general principles of good analytic technique, including transparency and repeatability.
13. Performing full cost calculations requires care and attention to detail; however, the data and tools needed to do it can be and have been assembled successfully by state DOTs.

1.5 Report Organization

The remainder of this report includes the following chapters:

- Chapter 2 presents definitions and nomenclature that are critical to understanding the process, identifies and describes the spectrum of cost elements that must be considered by the full cost determination process as well as the management systems and other sources for this information, and introduces key tenets of the full cost determination process.
- Chapter 3 provides a description of the process, identifies sources of information and key considerations, presents a fully worked example with commentary, and addresses options and exceptions for each step, including references to the documented examples included in the attachment.
- Chapter 4 presents conclusions with respect to the full cost determination process developed and its benefits, as well as suggestions for additional research that would complement this research and help to advance the state of the practice with respect to maintenance cost determination.
- The attachment provides a standalone description of the full cost determination process developed in this project, supplemented with documented examples of full cost calculations for six state DOTs and summary information about the systems and processes used to track and report maintenance costs for another three state DOTs.

CHAPTER 2

Full Cost Determination Framework

2.1 Introduction

The literature review and the discussions with 10 state DOTs conducted in this study provided ideas for a general approach to maintenance full cost determination. Ideas and practices of agencies that had advanced the farthest in implementing comprehensive, integrated cost accounting processes that could support full cost determination were considered. However, also considered were the range of practices in other DOTs and the fact that cost determination processes could be supported with simpler analytic procedures. This chapter outlines a conceptual framework for cost determination to meet these diverse needs and lays the foundation for more-detailed explanations and examples in subsequent chapters of the report.

For simplicity throughout this report, references to a *maintenance* organization, function, program, or activity are intended to refer also to entities that may go by somewhat different names [e.g., (highway) maintenance and operations, (highway) asset maintenance, or (highway) infrastructure maintenance].

2.2 Definitions

General Terms

The following definitions will clarify the terms used in developing, explaining, and applying the full cost determination process. While many of these terms have a general management or financial meaning, definitions will often be narrowed for purposes of this report to address highway maintenance specifically.

- **Maintenance activity:** A specific classification of maintenance work or service that is defined in the agency's maintenance program and maintenance management system (MMS) and/or financial management system (FMS). The full cost determination process deals with all defined activities that relate to maintenance, regardless of number or detail. Cost data are required and accomplishment units are preferred for each activity to be considered.
- **Maintenance job:** The performance of a maintenance activity at a particular highway location (or length) on a particular day and time.
- **Cost objective:** A financial accounting term defined as "a function, organizational subdivision, contract, grant, or other activity for which cost data are needed and for which costs are incurred" (OMB, 2004). Unless otherwise indicated, a "cost objective" will refer in this report primarily to a maintenance job.
- **Direct costs:** Costs "that can be identified specifically with a particular final cost objective" (OMB, 2004). In a road maintenance context, typical direct costs include wages or salaries paid to employees for work performed on a maintenance job, costs of materials acquired for or consumed on a maintenance job, costs of equipment use on a maintenance job, and costs of travel to and from a maintenance job. Where maintenance is performed by contract, direct costs refer to contractor payments.
- **Indirect cost:** Costs that are: "a) incurred for a common or joint purpose benefiting more than one cost objective, and b) not readily assignable to the cost objectives specifically benefitted, without effort disproportionate to the results achieved" (OMB, 2004). For example, the guidance, oversight, supervision, and assistance of a district maintenance office may be said to benefit all maintenance crews and jobs within its jurisdiction, but there is no direct connection or nexus between the district office personnel and each individual maintenance job. A reasonable but efficient method must be found, often informed by judgment, to relate district office costs to all the maintenance jobs under its responsibility.
- **Allocation (also attribution or distribution or assignment):** For the purposes of this report, the process of relating indirect costs to the maintenance jobs or organizational units

that have benefitted from the expenditures of these indirect costs. For example, the indirect costs of a maintenance district office need to be related to maintenance jobs and units that benefit from the guidance, oversight, supervision, and assistance of the district office. This relationship is generally analytic (i.e., able to be computed) but is also informed by judgment since the relationship is not immediately obvious (i.e., if it were, the costs might be considered as direct costs). An acceptable relationship is one that is reasonable (i.e., its logic is understandable) and felt to be fair by affected parties, but also efficient (i.e., not requiring excessive time and effort that is burdensome relative to the magnitude and importance of the costs being considered). Often an account or pool is created to accumulate indirect costs and allocate them efficiently to the maintenance jobs or organizational units that benefit from the expenditure of these costs.

- **Base** or **basis:** The analytic quantity by which indirect costs are assigned pro rata to different functions, programs, groups, or activities. Many potential bases are available. For example, indirect costs could be allocated by the relative shares, respectively, of labor costs, total costs, number of employees, or square footage of building space occupied by an organizational unit.
- **Cost base** or **cost basis:** For purposes of this report, a basis that is expressed in the overall direct cost of maintenance for an activity, function, or program. The overall direct cost of maintenance in this context means the sum of all direct labor, including fringe benefits, equipment, materials, and other expenditures, including contractor payments, to perform and complete the specified maintenance work.
- **OMB Circular A-87:** A document issued by the Office of Management and Budget (and last revised on May 10, 2004) that establishes principles and standards for treating costs in connection with federal awards, including discussions of direct and indirect costs, and explanations of allowable and unallowable costs.
- **Indirect cost plan (ICP):** For purposes of this study, a document prepared and submitted by a state DOT and approved by the FHWA, according to requirements of OMB Circular A-87, for use in administering reimbursements of the federal share of costs for federal-aid highway work.
- **Allowable cost:** A direct or indirect cost that is valid to include in requests for federal reimbursement. Governing principles for cost allowability are contained in Attachment B of OMB Circular A-87.
  - At a general level, allowable cost criteria include broad institutional requirements such as to be necessary and reasonable for proper and efficient performance and administration of federal-aid monies, to be authorized or not prohibited under state or local laws and regulations, to conform to federal laws and terms and conditions of the award of federal-aid monies, and so forth.
  - At a detailed level, 43 categories of cost are discussed with explanations of whether or not they are allowable or under what conditions they might be allowable. Examples of cost categories include compensation for personal services of employees; employee morale, health, and welfare; bonding, insurance and indemnification; advisory councils; depreciation and use allowances; idle facilities and idle capacity; interest; meetings and conferences; rental costs of buildings; and equipment, training, and travel.
  - These principles relate to this study in that only allowable costs may be included in a state's approved ICP.
- **Full cost:** For purposes of this report, the direct cost plus the indirect cost of a maintenance activity, function, or program.
- **Full cost determination process:** For purposes of this report, the process of determining the full costs of maintenance for an activity, function, or program, whether statewide or by district or other geographical or organizational coverage.

Reasonableness in Addressing Indirect Costs

As OMB Circular A-87 notes, indirect costs are "incurred for common or joint purposes," which introduces an element of judgment in how these costs are allocated across cost objectives. OMB Circular A-87 therefore incorporates rules of reasonableness in dealing with indirect costs by stating the following:

> *". . . there is no universal rule for classifying certain costs as either direct or indirect under every accounting system. A cost may be direct with respect to some specific service or function, but indirect with respect to the Federal award or other final cost objective. Therefore, it is essential that each item of cost be treated consistently in like circumstances either as a direct or an indirect cost."*

One rule of reasonableness is therefore recognition of the latitude and due consideration needed in judging costs as direct or indirect, together with the requirement that these decisions be made in a consistent manner. The practical implication for maintenance cost determination is therefore to examine whether a decision to classify a cost item as direct or indirect can hold up statewide throughout the maintenance program. If so, the decision would likely be viewed as consistent treatment, subject to other requirements of allowable costs.

A second rule of reasonableness is the allowance to treat minor items of direct cost "as an indirect cost for reasons of practicality where such accounting treatment for that item . . . is consistently applied . . . " (OMB, 2004). A petty cash account is a simple example of a potential direct cost that is instead accumulated in an indirect cost pool for subsequent

allocation across cost objectives. Care must be taken, however, that similar items are not pooled as indirect costs in some cases but considered as direct costs in others.

A third rule of reasonableness is the recognition that a level-of-effort consideration is important in determining whether a cost item is direct or indirect. For example, even if it is theoretically possible to relate field office supervisory and back-office personnel costs to specific maintenance jobs, the time and paperwork needed to make these connections could be excessive. In this case it is appropriate to treat these office-related costs as indirect costs. Again, the DOT must be consistent in this decision across all similar field office expenses.

Issues in Defining and Applying Indirect Costs

Even with the allowable reasonable practices described above, it may not always be possible to distinguish clearly between direct and indirect costs among DOTs and other transportation agencies nationwide. One reason is the different interpretations, judgments, practices, procedures, and maintenance activity definitions that have evolved in individual agencies. Another is the situation recognized in OMB Circular A-87 that even within a single agency, certain costs may be viewed as direct in some contexts but as indirect in others. The combination of these two effects may lead to differences and ambiguities, as illustrated in the following examples:

- Assume two large states in which DOTs manage highway maintenance costs. From time to time, maintenance crews in each state must travel long distances to remote work sites to perform a number of jobs involving different maintenance activities.

  One DOT accumulates these long-distance travel expenses within an indirect cost pool, consistent with the fact that each travel expense serves multiple cost objectives (maintenance jobs). The long-distance travel cost pool is distributed periodically across all maintenance activities in proportion to their cumulative direct costs. The approach is felt to be simple and fair, since over time the likelihood is that most or all activities will have been performed at these remote sites, at about the same frequency with which they occur elsewhere throughout the state.

  Another DOT, by contrast, has programmed its MMS to recognize long-distance travel costs when they occur and to distribute them to each activity that was performed in proportion to its total labor, material, and equipment costs. This approach treats these long-distance travel costs as direct costs (i.e., although the costs apply to more than cost objective and therefore serve a joint purpose, they can fairly be assigned to each maintenance job without disproportionate effort). The second DOT also regards this approach to be simple and fair.

  The result is two different perspectives on the treatment of long-distance travel expenses as a direct or an indirect cost. Both are likely to yield reasonable and fair results so long as the assumptions on which each analysis is based are realistic.
- One agency accumulates its planning, legal, and research expenditures within three indirect cost pools, each of which is allocated across other agency functions (e.g., design, construction, maintenance, safety) on some basis. Another agency accumulates these expenditures within a more detailed set of accounts in which each planning, research, or legal expense is related to a specific project, job, or function wherever possible. Only those expenses that cannot be explicitly related to an individual cost objective are accumulated in a general account (e.g., the costs to prepare a general guidance document or an annual report). The planning, legal, and research expenditures that are related to specific cost objectives (projects, jobs, or functions) take on the character of direct costs; only those remaining expenditures in the general accounts are allocated as indirect costs. The two agencies thus differ in their perspectives on the degree to which their planning, legal, and research expenditures are treated as direct costs versus indirect costs.
- An agency typically regards the expenditures related to central office functions (e.g., the office of the chief executive, planning, human resources, and information technology) as indirect costs to be allocated among the direct costs of field-oriented functions such as design, construction, maintenance, safety, environmental mitigation, and traffic services. However, the agency's legal office not only serves the field-oriented functions (e.g., in lawsuits involving construction projects, maintenance services, road traffic safety issues, and disputes regarding environmental mitigation) but also addresses the legal matters involving the central office functions listed above (e.g., suits citing the department's leadership team, legal challenges involving human resources or information technology, and disputes involving the agency's long-range plan). Assume that legal office expenditures are to be distributed as indirect costs among all of these other functions, based on each function's relative share of professional labor costs annually. Within this limited context, the costs of professional labor in each of these functions—both central office as well as field-oriented units—might be regarded as direct costs, with the indirect costs of the legal office being distributed in proportion to each function's relative share of these professional direct costs. Thus, the agency's perspective on whether to regard central-office costs as direct or indirect depends on the context within which these costs are being analyzed.

These types of issues are resolved in this study in a consistent, understandable way by adopting concepts explained in the following two sections:

1. Additional nomenclature that distinguishes the different types of costs that are important to cost determination without using the terms "direct costs" and "indirect costs."
2. A hierarchy of cost attribution that helps guide managers in handling different types of costs for purposes of cost determination, without explicit resort to direct or indirect costs.

Nomenclature for Cost Determination

The following terms are used in this report to provide general guidance and avoid ambiguities due to possibly different interpretations of direct costs and indirect costs among agencies or within a single agency in different contexts. The notion of line costs and support costs is often evident in agencies' analyses of their full costs, even though they do not use these particular terms. It is understood that agencies must continue to use "direct costs" and "indirect costs" as part of the financial accounting and management and in connection with the indirect cost plans. Furthermore, "line costs" and "support costs" are not to be taken as synonymous with "direct costs" and "indirect costs," respectively. It is entirely possible that line costs, for example, will include a combination of direct costs and indirect costs, and that support costs will likewise include a mix of direct costs and indirect costs.

- **Line costs:** The labor (including fringe benefits), equipment, material, and other (LEMO) costs to perform actual maintenance work (i.e., line activities) on highway assets or to provide maintenance services to the public. For example, pavement patching, mowing, snow and ice control, repair of pavement markings, traffic sign and signal repairs, litter pickup, rest area maintenance, and incident response.
- **Program support costs:** The subset of support costs that is closely associated with the maintenance function and program. Program support costs can be divided into two types. The first type supports all line activities, such as the costs associated with the headquarters- and district-level maintenance organization, office supplies, office facilities, and utilities. The second type supports only a subset of line activities, for example, the fence inspection support activity supports the fence installation and repair line activities.
- **Enterprise support costs:** Other expenditures of the transportation agency that can reasonably and fairly be allocated to highway maintenance. For example, a portion of the costs of agency executive management, human resources, finance and accounting, information technology, planning and research, and legal counsel.

These definitions provide a general guide to the nomenclature used in this report. Recognizing different practices among agencies in both maintenance management and financial accounting, the categorization of costs between line and support varies by agency, as does the further division of support costs between program support and enterprise support. The subsequent discussion in this section, the example in Chapter 3, and the documented calculations in the attachment will show, however, that minor differences in how costs are categorized will not significantly affect the result of the full cost determination process. Rather, it is much more important to identify all relevant costs completely and to perform a fair and reasonable allocation to maintenance. If cost identification and allocation are done properly, the result will be a reliable indication of full maintenance costs.

Decision Structure for Cost Attribution

This section builds on an approach developed by Texas DOT to guide the treatment of costs. The approach has been adapted and modified to relate to highway maintenance specifically and to use the cost determination nomenclature introduced in this project, with examples added by the authors. The resulting guidance is provided in Table 2.1.

The value of this guidance for cost determination is that it focuses on a systematic approach to relating all agency costs to a particular cost objective—in this case, maintenance jobs (although it applies equally to maintenance activities)—without resorting to using terms such as "direct costs" or "indirect costs." Rather, it essentially attempts to define how closely a particular agency cost relates to performing and completing one or more maintenance jobs or if there is a fair, reasonable, and practical method to attribute all or part of a given cost to these maintenance jobs. If there is a relationship or nexus between the cost and maintenance jobs, the guidance recommends allocating a fair, reasonable share of the cost in a practical, efficient way. If not, the cost is regarded as relating to other agency line functions and can be excluded from the maintenance cost determination process.

2.3 Building the Full Cost Determination Process

This section explains how the cost determination process is built for a highway maintenance program. The explanation is given in bottom-up order since line costs—the primary constituent of MMS calculations and reports—provide a familiar point of departure for DOT maintenance managers. Once line costs are established, the explanation broadens and proceeds up the cost structure hierarchy to program support costs and enterprise support costs. This explanation is given in a logical, step-by-step fashion to facilitate understanding of the composition and the treatment of each category of cost. Figure 2.1

Table 2.1. Hierarchy of decisions on cost attribution.

Consider Different Types of Agency Expenses	Action to Handle This Type of Expense with Respect to Maintenance	Example(s) of This Type of Maintenance-Related Expense
Consider potential maintenance-related expenses reported from various activities and locations, and analyze them in the following way:		
1. Is the expense reasonably attributable to a single maintenance job? (If yes, see columns to right).	(If yes from left column) Charge the expense to the individual maintenance job.	Labor, equipment, and material charges reported for an individual maintenance job.
If answer to above is no, consider the following:		
2. Is the expense reasonably attributable to more than one maintenance job? (If yes, see columns to right).	(If yes from left column) Subjectively prorate the expense among individual maintenance jobs.	Significant travel costs to one or more remote sites requiring multiple maintenance jobs: distribute travel expenses among these jobs [e.g., equally (if jobs are roughly of same scale) or in proportion to some basis (e.g., relative total cost of each job)].
If answer to above is no, consider the following:		
3. Is the expense reasonably attributable to a maintenance program service center or clearing account? (If yes, see columns to right).	(If yes from left column) Charge to the maintenance program service center or clearing account for subsequent distribution to maintenance line costs or other service centers/accounts as appropriate.	A. Costs of district or field offices: maintenance personnel, office facility, utilities and services, equipment, materials and supplies, and other operating expenses. B. Costs of a sign fabrication shop.
If answer to above is no, do the following:		
4. Consider the expense an enterprise support cost for distribution across agency line functions or other service centers/accounts as appropriate (see columns to right).	Charge the expense to the appropriate enterprise support cost account. Allocate a fair share of each cost account to maintenance line costs.	A. A share of costs associated with the executive office. B. A share of costs of central agency functions (e.g., payroll, legal, accounting, human resources, planning, research).

Note: This guidance is adapted from a more general accounting approach developed by the Texas DOT. The approach has been modified to focus on maintenance expenses and Project 14-18 cost determination nomenclature. Maintenance-related examples in the right-hand column have been added by the report authors.

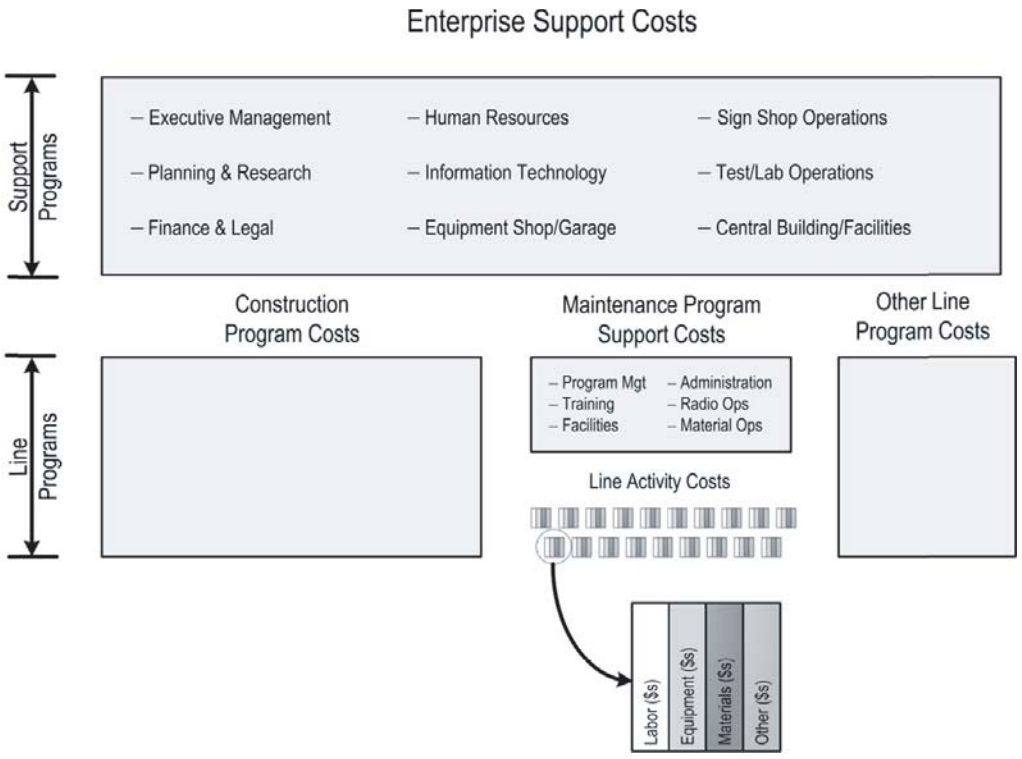

Figure 2.1. State DOT maintenance activity full cost context.

illustrates how the three categories of cost included in the full cost determination process relate to each other as well as to other agency expenditures. The following descriptions should help explain how the complete set of line and support costs are identified and allocated to maintenance.

Line Maintenance Costs

Line maintenance costs are the costs of accomplishing actual work or services through line maintenance activities. The bulk of activity-related costs in an MMS report are typically line costs. Line costs comprise costs related to labor, equipment, material, and other (including payments to contractors).

- **Labor costs:** The sum of agency payments to (or on behalf of) employees for performing maintenance jobs. These payments encompass compensation (wages, salaries, temporary or part-time payments, etc.), any overtime for hourly employees, Social Security and Medicare payments, and applicable fringe benefits (e.g., vacation, sick time, other leave, health and other insurance premiums, and retirement fund contributions). All of the DOTs interviewed in this study included travel time as a legitimate part of activity labor costs. Labor costs for crews brought in to supplement state DOT workers (but excluding contractors) also should be incorporated in the totals (e.g., costs of convict/inmate/correctional department labor and costs of any agency personnel from outside the maintenance organization assigned to work on a maintenance activity). While volunteer programs such as Adopt-a-Highway may not entail identifiable labor costs, it is useful to document the use of such programs for particular maintenance activities as a matter of record and to help establish the context within which the cost determination process is applied. The insertion of an equivalent agency labor cost for work accomplished by volunteers is not needed unless this equivalent cost is judged be a significant percentage of the maintenance program or it is felt that a placeholder cost should be estimated for other reasons.
- **Equipment costs:** The total equipment charges incurred in performing maintenance jobs, whether for agency-owned equipment or use of equipment owned by other entities. Typically these charges are structured as rental rates for each class of equipment. Some agencies have further organized these rates to support an enterprise-fund operation, in which the equipment function is financially self-supporting. In these cases the rental rates may be set for each individual piece of equipment to cover the respective costs of depreciation of the initial purchase price, fuel and other operating expenses, routine equipment maintenance, and repairs and overhauls through an estimated service life. For purposes of full cost determination, if any of these sources of cost have been excluded for the rental rate (e.g., depreciation or shop overhead), it is important to determine how significant these excluded cost elements are and, if they are significant, to ensure that the costs are picked up fully and correctly in either the maintenance program or the enterprise support categories.
- **Material costs:** The total charges for materials and supplies in performing maintenance jobs. These charges can be for consumption of materials that are maintained in agency inventories or stockpiles, the use of materials fabricated in agency shops, or materials purchased specifically from outside vendors to complete a particular maintenance job. The costs to be applied within the cost determination process should be the costs of materials actually used in maintenance jobs and not the overall cost of bulk purchases. Agencies may use unit material prices that are determined by their stockpile management or inventory stores management programs, where available, or other methods consistent with their financial accounting and maintenance management practices, so long as these reflect the raw material costs themselves. Additional costs such as overhead for inventory stores/stockpile operation and management should be treated as support costs, not line costs.
- **Other costs:** Total charges for other items associated with maintenance jobs that do not fit into the labor, equipment, or material categories. For example, utility charges, private equipment rental (i.e., not part of the agency fleet), and the sum of payments made to contractors to complete maintenance jobs in cases where maintenance activities are delivered through a combination of agency and contractor resources. These jobs, which may be bid for work on individual activities, for multiple activities within a given geographic area, or for multiple activities for a given length of highway route, must be within the scope of the routine maintenance program as the agency defines it and not within other programs (e.g., construction or capital preservation). A challenge that many agencies may face in treating contract costs within a cost determination process is to identify the maintenance units of accomplishment that relate to contract expenditures for each maintenance activity. Ideally, total units of accomplishment would be calculated before the contract is awarded rather than leaving the calculation as an afterthought that later becomes difficult to complete in a timely way. Accomplishment data enable contract costs to be combined with the costs of state-force maintenance work in calculating an overall unit cost for each activity, thus satisfying the principle of considering the complete set of costs. Some agencies also have raised the issue of the timing of contract payments as a potential issue (i.e., situations where payment of the entire contract amount occurs at one time even though services are delivered incrementally over a period of time). In fact, this issue

should not affect cost determination if all work performed and payments expended occur within the same fiscal year. In this case, the date of posting of the charge is immaterial since it is recommended that cost determination be applied based on data for a completed fiscal year. If there are significant misalignments between work performance and contract payments across two or more fiscal years, adjustments to posted charges can be made to bring work accomplishment and payment to contractors into better alignment within each fiscal year.

Information on maintenance line costs is typically available from an agency's MMS and potentially its financial management system. Steps in preparing this information for the cost determination process are as follows:

- Identify which activities are properly considered as line cost items (i.e., they involve the performance of actual work or services to the public that are the intended outcomes of the agency's maintenance program). Other activities (e.g., training, maintenance management, building and yard maintenance) should be included with program support costs.
- Develop a good understanding of the relationship between costs reported in the MMS and maintenance costs reported in the financial accounting system.
  - Agencies that have a well-integrated system architecture and a financial system that tracks specific maintenance activities should consider using the financial system data for cost determination. An important prerequisite for this decision is that financial system totals for the maintenance program be close to, and preferably match exactly, the corresponding MMS totals. If this is not the case, a reconciliation and adjustment review should be done to bring the respective totals closer together. Typical reasons for such differences include variations between the two systems in how individual costs are recorded, inclusion of projects for which judgments differ on whether they are part of the agency's routine maintenance program, and errors by agency personnel in reporting work (and whether the MMS and the financial system have isolated and corrected these errors). Once adjustments have been identified and agreed to, the financial system data can be used in further calculations.
  - If the financial system does not break down maintenance expenditures by activity, a hybrid approach should be investigated in which the financial system provides estimates of overall line costs and the MMS is used to disaggregate these costs by line activity. A prerequisite is to reconcile differences between financial and MMS data before proceeding. The objective is to identify the full, complete set of line maintenance costs as closely as possible with a reasonable level of effort. Estimates are appropriate when needed; it is more important to account for all likely sources of line costs in a realistic way than to spend excessive time determining every cost to the penny.
  - If the financial system does not address line maintenance costs directly (e.g., it includes only a line item for "maintenance labor" that encompasses both line and support costs), the MMS should then be used as the primary source of line-cost data by activity. Regarding this example, however, it would be advisable—once maintenance program costs also are computed—to compare total estimated maintenance line labor plus maintenance program support labor costs from the MMS and other sources to the total "maintenance labor" item in the financial system to determine adjustments needed.
  - In all of these and subsequent calculations, it is recommended that all analyses that are based on historical cost data be conducted using fiscal year-end financial and MMS reports. The reason is that the data for such reports are typically adjusted to close out calculations for the fiscal year (some agencies employ a "13th-month adjustment," while others perform an adjustment based on adding costs from the prior year's closing month and dropping costs from the just-completed year's closing month). Furthermore, all month-to-month reconciliations of indirect costs are cleared, ensuring that indirect costs in the accounting system are treated such that they are closed out with, ideally, no gains or losses in actual versus estimated items.
- Using the guidelines above, establish the maintenance line costs by activity.

Maintenance Program Support Costs

Transportation agency maintenance organizations perform a variety of planning, management, research, and other functions that support the line activities. These functions occur at several organizational levels encompassing headquarters and district and field offices. The maintenance program support cost category accumulates the costs of these maintenance-related support functions. The types of costs to be included in this category include the following:

- **Program management and field supervision:** Costs associated with the staff responsible for managing the maintenance program, including the state maintenance engineer; district/regional managers; and area/shed/foreman-level managers, supervisors, and roving patrols. Only the time used for general management functions is included here, not any time spent directly supervising line activities.
- **Program administration:** Costs associated with office personnel, equipment, and supplies at the several levels of maintenance management above.

- **Buildings, facilities, and grounds:** Costs associated with buildings, facilities, and grounds occupied by maintenance personnel and items used by the maintenance function. These costs include building leasing, rental, or depreciation; grounds maintenance; utilities; and communications (e.g., costs of radio system operation).
- **Training:** Costs incurred by attendance of maintenance personnel at training, and the costs to prepare and provide training sessions and materials.
- **Material stores/inventory operation:** Costs associated with operating the agency's maintenance inventory, stores, and stockpiles.
- **Fabrication shops and laboratories:** Costs associated with agency shops that fabricate items for use by maintenance forces (e.g., signs), and laboratories whose work in research and testing supports line maintenance activities (e.g., a materials laboratory supporting pavement and pavement marking maintenance activities).

Agencies recognize and deal with maintenance program support costs in several ways:

- **Maintenance activities capturing program support:** A number of agencies interviewed in this study identify program support activities explicitly within their maintenance activity structure. Common examples include maintenance training; handling and management of material stockpiles; buildings and yard maintenance; and general support activities identified within particular categories or groups of maintenance activity (e.g., pavement/road surface, bridge and structures, roadside, traffic operations).
- **Cost center/clearing accounts:** Agencies also may establish program cost centers or clearing accounts where charges associated with maintenance program support are accrued for later allocation to maintenance line activities or potentially other functions.
- **Inclusion within broader enterprise support:** Some agencies include costs associated with maintenance program management as part of agency-wide management, particularly for items like district-level and headquarters management. Within cost determination, the maintenance component of these costs must be identified and accumulated for allocation to maintenance line activities.

Regardless of which method(s) are used by an agency, the cost determination process calls for (1) identification of the complete set of maintenance program support costs, and (2) decisions on how to allocate these costs to maintenance line items or other functions/accounts as appropriate. Interviews with several DOTs conducted in this study indicate that a variety of allocation approaches are used. These approaches range from very straightforward development of a single program functional rate that is applied to all line maintenance activity costs (e.g., Caltrans), to more complex allocations where certain program support costs are allocated to the subset of line activities that benefit from those costs. There also are allocation procedures that impose an intermediate step before extending to line maintenance activities. For example, Texas DOT does not allocate the costs of its sign fabrication shop directly to signage-related maintenance activities. Rather, it allocates the fabrication shop direct and indirect costs to its materials and supplies inventory-management cost account. These costs are then passed on to those maintenance line activities that use signs by including the costs in the amount charged for each sign by the materials and supplies inventory system. All of these examples point to the need for maintenance managers to coordinate with financial accounting managers in ensuring that the cost determination procedures are consistent with, and supported by, applicable calculations in the agency's financial management accounting system.

It is important to consider the guidance in OMB Circular A-87 regarding reasonable levels of effort in identifying and treating cost items when considering how to allocate program support costs. For example, while it may be theoretically possible to allocate the costs of each individual training session to a particular set of line activities, it is not clear that the benefit gained by this exercise will warrant the time and effort required. The preferable approach is to pool all training costs and allocate them across all maintenance activities using a suitable base (e.g., total expenditures or total labor costs) according to agency practice. In this context, the agency's treatment of maintenance training costs should be consistent with its treatment of training costs for its personnel in other functions.

As a general rule, many maintenance program support items will be allocated completely (i.e., 100%) to maintenance line activities or a subset of those activities. Some agencies consider certain program support items essentially as direct costs because of their close relationship to the performance of maintenance work. Even where program support costs are considered as indirect costs, they are often allocated 100% to the maintenance function because the cost determination result will differ only a small amount from the case where they would have been considered direct costs. As stated earlier, determining the complete set of maintenance line and support costs and the appropriate methods of allocating support costs to line costs are more important than whether individual costs are classified as "support" or "line." Exceptions to this 100% guideline are (1) where maintenance program support costs are shared with other agency functions (e.g., materials laboratory services are used by the construction program as well as the maintenance program, in which case these costs may be better treated as enterprise support costs), and (2) in situations such as those described for the Texas DOT sign shop above,

in which program support costs are allocated to another cost account (materials-and-stores inventory) rather than to maintenance line activities directly.

Enterprise Support Costs

Highway maintenance is one of a number of programs and functions that are managed by a typical transportation agency. In the same way that a maintenance program comprises line and support activities, the operations of a transportation agency comprise line and support programs and cost items. Typical agency line programs include construction, maintenance, safety, environmental protection/mitigation, and other investment and operations categories of work across different modes. These programs are supported by a number of enterprise support functions that typically include the following:

- Agency executive management;
- Planning, programming, and research;
- Financial accounting, budgeting, payroll, and procurement;
- Legal and audit divisions;
- Human resources;
- Information technology;
- Central office buildings, facilities, and grounds, including utilities and communications services;
- Shops, laboratories, and other support functions and cost items that have not already been included in the program support category; and
- Support of the DOT provided by external agencies (e.g., the state attorney general's office or the state auditor's office).

As with the program support costs, the key objectives regarding enterprise support costs are (1) to identify the complete set of enterprise support costs, and (2) to allocate an appropriate share of these enterprise support costs to maintenance line costs to complete the cost determination process. As with program support costs, current agency practices on how to compute this allocation vary from a straightforward division of total enterprise support costs by total line program costs to produce a single percentage rate allocation across all line programs (e.g., Caltrans), to more complex calculations that consider different enterprise initiatives and different categories of line programs, projects, and activities (e.g., Florida DOT). Those agencies that have developed a financial management system that is consistent with their approved indirect cost plan may define the enterprise support costs within a number of indirect cost pools. For each indirect cost pool, the plan identifies which of the other indirect cost pools and direct program pools (i.e., the line programs/functions) should bear a share of its costs and what should be the basis of this allocation. Typical bases of indirect cost allocation are total expenditures or total employee counts for each line program/function, respectively.

It is important to seek complete cost coverage while avoiding double-counting when compiling enterprise support costs. For example, in cases where agencies include all vehicle-related expenditures in developing equipment rental rates, the enterprise support costs should not include any equipment-related expenditures. However, in cases where certain vehicle expenditures are excluded from the equipment rental rate calculation, the enterprise support category should include an equipment component that covers these costs.

Expressing Cost Determination Results

When all applicable support costs have been allocated to maintenance line costs, the cost determination process can be completed. The recommendation from this study is that results be expressed as the full unit costs of each maintenance activity. A unit cost result is superior to an overhead percentage or other method of expressing full costs. In fact, DOTs that were interviewed for case study development and that have well-developed financial accounting methods to support full cost determination strongly discourage the use of overhead percentages for the following reasons:

- A maintenance overhead percentage (indirect cost divided by direct cost) depends on the cost basis used. For example, an overhead rate on the basis of total direct costs (e.g., the sum of labor, equipment, and material costs for maintenance) will differ from one based on direct maintenance labor costs alone. Comparisons of overhead rates, say, between the public and the private sector may thus be misleading if different cost bases are used by the respective parties.
- A maintenance overhead percentage depends on external factors that are unrelated to maintenance. For example, agencies with large highway construction programs, where the annual construction budget is a relatively large portion of total agency budget, will exhibit relatively low maintenance overhead rates. This occurs because the distribution of indirect costs among programs is driven by their respective direct cost bases—assume them to be equal to the total direct expenditures for each program. A large construction program will thus attract a large percentage of enterprise-level indirect costs, depressing the overhead percentages computed for all nonconstruction programs, including maintenance.
- Variability in maintenance overhead rates (e.g., between districts in a state DOT) may be misconstrued as indicating variations in maintenance efficiency. Maintenance overhead rates are sensitive to the volume of work in other programs such as construction, as noted above, which in turn may be driven by differences in factors such as traffic volume/composition and degree of urbanization. If districts

vary in the relative volume of their construction work, and if the unit cost of construction in each district is further influenced by local factors such as geography, climate, traffic, and degree of urbanization, it is easy to see that the observed variability in maintenance overhead rates may have nothing to do with relative maintenance efficiency. Additional influences such as the geographic size of a district and the density of the road network may have similar distorting effects.

- Results expressed as overhead rates are more sensitive to the categorization of costs as direct or indirect than are results in terms of full unit costs. The problem arises because this categorization can be subjective, with variability in results among agencies—a fact recognized in OMB Circular A-87. This issue is highly unlikely to affect costs that are referred to as line costs in the recommended process, but it can occur with respect to support costs, particularly the program support costs. Given uncertainty in what costs are considered direct versus indirect, the ratio of indirect to direct maintenance costs—the maintenance overhead rate—may vary solely due to how costs have been categorized and not to meaningful distinctions in how maintenance has been performed.
- Results expressed as unit costs are less prone to categorization problems. The reason is that regardless of how program support costs might be categorized as direct or indirect, these costs tend to be 100% attributable to maintenance line costs or a subset thereof. For example, it would be reasonable to distribute the support costs related to a district maintenance office to all maintenance activity line costs on a prorated basis. Program support costs related to sign fabrication, however, would be reasonable to distribute to sign-related activity line costs, again on a prorated basis. In each of these cases, the attribution of program support costs remains completely within the sphere of maintenance line costs. Therefore, regardless of how one might categorize them as direct or indirect, these program support costs are fully captured within the total unit maintenance costs that result from the cost determination process.

2.4 Tenets of Full Cost Determination

Several tenets that have guided the development of this cost determination process were listed in Chapter 1. The items below elaborate on each tenet and provide its rationale and implications for study findings and recommendations in later sections.

1. **The recommended full cost determination process should build on the existing management practices, procedures, data, and systems typically found within state DOTs.**

Among these capabilities are maintenance management systems; financial management and accounting systems; procedures and/or systems for payroll, equipment management, materials-and-stores/inventory management, and maintenance contract management; and approved indirect cost plans according to FHWA requirements for federal-aid reimbursement, based on OMB Circular A-87. The recommended cost determination approach can be structured to be consistent with an agency's cost data and computational methods such as those included in its maintenance and other applicable management systems and to conform to the general principles, methods, and assumptions in its approved indirect cost plan. The guidelines and examples in Chapter 3 and the attachment identify the types of data needed from these systems and explain the computations involved. Case studies developed for several DOTs illustrate applications of the methodology under different conditions and assumptions. Where certain systems or data are not available, the descriptions in Chapter 3 identify options for obtaining information from other sources and estimating or approximating values.

2. **The focus of the process is state departments of transportation; however, it may be useful to any transportation agency with a maintenance program.**

Identifying state DOTs as the target of this research establishes an explicit context for designing an effective maintenance cost determination process. Key factors defining this context are as follows:

- Capabilities in planning, tracking, and managing agency functions such as highway maintenance, financial accounting, equipment and material usage, and other functions described below. These management capabilities play key roles in developing and supporting a viable cost determination process. Moreover, personnel in these disciplines—particularly in maintenance management and financial accounting management—need to work cooperatively in conducting analyses and reconciling cost data.
- A funding environment that includes federal-aid program requirements governing reimbursement of applicable highway-related expenditures, including indirect costs. Admittedly, many routine maintenance activities and maintenance work on non-federal-aid highways are not directly affected by these FHWA provisions. However, agency procedures and data needed to conform to FHWA requirements for federal-aid program reimbursements—including an indirect cost plan approved by the FHWA—can assist greatly in developing and implementing a maintenance cost determination process, particularly if DOT cost analyses and reporting are comprehensive and disciplined.

This study has adopted the model comprising typical state DOT management capabilities, interdisciplinary collabora-

tion in analyzing agency costs, and joint state DOT–FHWA program funding as the context for designing and developing a maintenance cost determination process. Chapter 3 and the attachment provide guidelines with several examples of how the cost determination process can be applied to state DOTs with different characteristics and situations. Other transportation agencies also may find the cost determination process to be helpful if they also are trying to estimate the full costs of maintenance. They would, of course, need to adjust and compensate for differences in their own operating context, whether in the availability of management tools and data or in the documentation of their own direct and indirect cost analyses.

3. **The focus of the process is highway maintenance programs; however, the basic principles of full cost determination may be applied to any of an agency's line programs.**

Highway maintenance is the focus of this cost determination study. The main objectives of the research were to develop a process for determining the full cost associated with performing highway maintenance and to document its application using a number of real-world examples. However, the principles and fundamental procedures in cost determination are general in scope and can be applied conceptually to any program or transportation mode once appropriate adjustments are made for the different activities and cost elements involved. The generality of the approach strengthens the rationale that if a department is considering outsourcing road maintenance services, it should commit the resources needed to conduct cost determination comprehensively but efficiently.

4. **The recommended full cost determination process should encompass all activities performed by an agency's maintenance organization and program.**

The general approach to assigning full maintenance costs by activity is fundamentally the same across all line activities. Straightforward procedures also are available for support activities. There are variations in the details of specific activities, but these do not fundamentally affect the methodology involved. For example, if a materials laboratory supports maintenance work in pavement repair and pavement markings, those activities may bear a share of the cost of the laboratory. Similarly, the costs of a sign fabrication shop may be borne by activities related to signage, and the costs of salt sheds may be attributed to winter maintenance activities. Once these distributions have been calculated and assigned properly, the distribution of other program support costs to individual activities can be done on a prorated basis.

5. **Maintenance activity full cost results should be expressed as either total or unit cost rather than overhead percentages.**

This tenet is important because the purpose, analytic basis, and results of a cost determination process are sometimes misunderstood, with the potential for misuse. Expressing the full costs of a maintenance activity as a computed unit cost provides the most correct and reliable metric. For a given activity, the numerator of the unit cost is the sum of all line and support costs attributable to that activity; the denominator is the accomplishment unit assigned to that activity in the maintenance management system (e.g., area of pavement, length of guardrail, acres of mowable grass). Only those activities that have defined, physical measures of accomplishment can have these unit cost results. Expressing results as overhead percentages is unreliable and potentially misleading and is therefore discouraged because such percentages depend on several factors having nothing to do with the efficiency of agency maintenance.

6. **The results of the full cost determination process apply to each agency individually; comparisons of full costs between agencies are not meaningful for several reasons, and should be avoided.**

The logic and implications of this tenet are similar to those of the previous one. Comparisons among peers based on overhead percentages are inappropriate for all the reasons discussed previously. Even comparisons based on unit costs may not be meaningful because of effects similar to those already discussed as well as differences in items such as program structure (i.e., the number of maintenance activities and how they are defined) and the overall size of the maintenance program as compared with that of construction and other programs. These differences can affect the values of line costs and the distribution of prorated support costs, complicating comparisons with other agencies. Comparisons with private-sector costs should, therefore, be done on the basis of the existing agency maintenance activity specification, units of accomplishment, level of service achieved, and the associated full unit costs. In addition, if agency full costs are derived from a review of past expenditures, appropriate consideration for inflation must be incorporated into the comparison.

7. **The recommended full cost determination process should ensure complete coverage of an agency's expenditures, with no overlaps, duplicates, or gaps.**

The cost determination process must account for all relevant line and support (or direct and indirect) costs so that they can be part of the calculation, even if values and percentage distributions must be estimated. Overlapping or duplicated costs lead to double-counting and must be avoided. Gaps or incomplete tallies of relevant costs likewise must be corrected to prevent distorted results. Care in assembling cost data according to the categories recommended in this report

(i.e., line costs, program support costs, and enterprise support costs) will help eliminate these errors. Some examples follow:

- Check the totals of corresponding line and support items between the MMS and the financial system to ensure that they are reasonably close or that variances can be accounted for. Differences may be due to errors in data reporting, varying cost calculations and analyses between the two systems, use of different sets of data implied by queries of the two systems (e.g., number and location of personnel identified as belonging to the maintenance organization), or other factors. Understanding the reasons for these differences can help determine exactly what costs have or have not been considered.
- Since agency practices differ on what cost items to include in equipment rental rates, these costs need to be understood within each agency to avoid gaps or overlapping costs. For example, if agency equipment rental rates include depreciation, and other identified costs include equipment capital purchases, this is a cost overlap. Removal of one of these overlapping categories of cost before proceeding with the analysis is necessary.
- Similar categories of costs should be scrutinized to ensure that they do not duplicate one another. For example, a materials research lab may be included as either a program-support cost (if it serves primarily maintenance) or an enterprise-support cost (if it supports functions besides maintenance, such as construction, safety, and traffic operations). There also may be a general research expenditure item in enterprise support costs, representing a broad set of sponsored research projects, studies, and reports on behalf of the agency. Determining whether the research lab costs are included in the research item and, if so, eliminating the duplication by removing the redundant costs, would be necessary.

8. A practical and consistent full cost determination process is more useful than one that is complex and variable, even if the latter delivers greater accuracy in some cases.

Nowhere is there a requirement that estimates of the full costs of highway maintenance must be accurate to the penny. However, a rule of reason should apply in arriving at realistic but sensible treatments of costs using calculations that are practical and efficient. Agencies having well-developed, well-integrated management systems for maintenance and financial accounting can and in fact do come close (if not exactly) on cost totals. In other situations, estimates of costs are permissible so long as they are realistic. Moreover, distributions of indirect costs necessarily involve subjective judgments, a fact recognized in OMB Circular A-87. Guidelines in OMB Circular A-87 further emphasize the importance of consistency in treating similar types of costs in a similar way. Consistency applies in a number of ways within cost determination (e.g., in how costs are categorized; in the programs, functions, or activities to which they are assigned or distributed; and in the analytic bases by which they are distributed).

9. Agency application of the full cost determination process will benefit significantly from the collaboration of maintenance with other units within the DOT.

At a minimum, a team involving representatives of maintenance and financial accounting is needed to ensure that costs are fully identified; that the cost determination computations are consistent as much as possible with general agency accounting practices, including the approved indirect cost plan; and that the needed computations can be done correctly and efficiently. Other groups may be needed to check on details and to provide cost-related information in particular instances. These units may include, for example, equipment management, materials-and-stores-inventory/stockpile management, payroll, and other functions classified as support (e.g., information technology, research, training). The effort needed to account for the contributions of these support units to the cost analysis may be minimized by basing analyses on completed fiscal year data.

10. Utilization of year-end reports and data simplifies the full cost determination process and reduces the chances of errors and inconsistencies.

Agencies routinely close out fiscal years by completing adjustments to reported costs, reconciling cost variances, and closing indirect cost accounts to zero out inadvertent gains or losses due to differences in estimated versus actual monthly totals. It therefore makes sense to base a cost determination study on the most recent fiscal year-end results, when cost tallies are complete and correct, rather than to try to conduct the analysis mid-year. Using year-end results ensures complete and consistent data across all agency units and largely eliminates the need to deal with cost reconciliations, revenue-to-cost adjustments, and direct versus indirect cost flows within individual support functions (e.g., materials and stores, sign fabrication shops, central office functions) and enterprise funds where they exist (e.g., in equipment management).

11. The full cost determination process will provide only one input to an agency's decision making regarding maintenance delivery.

The focuses of this research effort are maintenance cost determination and the process of identifying the full costs of agency highway maintenance. The project does not deal with contractors' costs to provide highway maintenance, nor does it address cost comparisons between public- and private-sector delivery of maintenance services. The study's recommendations do not attempt to provide guidance in making main-

tenance contracting decisions. The project does not address other factors and criteria that may enter a contracting decision such as legislative requirements for outsourcing, limits on agency staffing levels, and need for specialized labor skills and other resources.

12. The full cost determination process should incorporate general principles of good analytic technique, including transparency and repeatability.

Cost determination is a wide-ranging analytic process that involves agency-wide cost data and several stages of cost distribution and summation. Good practices that have been identified for analytic techniques in general apply here as well, including

- **Transparency:** The ease of understanding the basic calculations and assumptions involved and the specific assumptions, adjustments, or exceptions that have been made in particular years.
- **Replicability:** The principle that reasonable, knowledgeable people, presented with the same data, assumptions, and objectives, could perform the analysis and arrive at the same result.
- **Repeatability:** Application of tried-and-true management systems, data sources, and other analytic tools such that the same data, when subjected to repeated analyses, yield the same results.

Satisfying these principles of good practice suggests that cost determination be supported by the appropriate resources and capabilities:

- Designation of a team with the appropriate knowledge, experience, and analytic resources to organize and conduct the cost determination process when needed. Experts from financial management and maintenance management should form the core of this team.
- The performing of key computations by recognized agency management systems (particularly in financial accounting management and maintenance management) that demonstrate verifiable performance in terms of accuracy, consistency, and data integrity. Resorting to informal spreadsheets and back-of-the-envelope calculations for other than simple analyses/summaries is discouraged. Where supplementary calculations are needed (e.g., in spreadsheets or custom programs), they should at a minimum be verified by other team members. If they are a significant part of the process, the tools should be formalized within agency practice (i.e., as named procedures with identified responsibilities for custody, system maintenance and support, and periodic upgrades assigned to a specific agency unit).
- Documentation of the cost determination procedure identifies general procedures and sources of data, underlying assumptions (e.g., cost items to be treated as line, program support, or enterprise support), bases to be used in cost attribution/allocation, and special notes. A general document with annual supplements (e.g., similar to programming and budgeting instructions issued annually/biennially by agencies) should be considered.
- A library of useful references such as annual maintenance and financial reports, the indirect cost plan, and the general and annual documentation recommended previously should be maintained.
- Archiving procedures and identified repositories to maintain cost determination records, reports, and other documents should be established.

13. Performing full cost calculations requires care and attention to detail; however, the data and tools needed to do it can and have been assembled successfully by state DOTs.

Appendix A of the attachment illustrates the application of the recommended cost determination process to DOTs of varying characteristics with different maintenance programs. Some of these computations are relatively straightforward, while others are more detailed and sophisticated, taking full advantage of the capabilities of the agency's financial accounting system and maintenance management system. One of these agencies (Texas DOT) applies a state-of-the-art approach characterized by the following properties:

- Full cost coverage, encompassing all agency programs, accounts, and cost centers, with a scope extending department wide.
- Cost elements organized in a way that supports full cost determination, including explicit representation of highway maintenance activities within the financial accounting system.
- Fully integrated management systems—including the financial accounting system, maintenance management system, payroll system, equipment management system, and system for managing materials-and-stores inventories and stockpiles—in which the cost elements are unified and communicated among all systems using a common language.
- A defined and clear cost analysis methodology that is documented within, and consistent with, the agency's approved indirect cost plan.
- Complete, up-to-date cost data available for the most recent completed fiscal year, and accomplishment data for the set of key activities performed by state employees as well as private-sector contractors.

CHAPTER 3

Full Cost Determination Process

This chapter describes and demonstrates the full cost determination process developed during this project. The remainder of the introduction summarizes the overall process and identifies the five steps involved. Sections 3.1 through 3.5 present the details of the benchmark approach for each step and illustrate their application using a simplified discussion example. The example includes a small number of maintenance activities in order that the complete full cost calculation can be clearly presented within the confines of this report format. The benchmark approach is designed for ease of use—that is, to satisfy the practical requirement—and should be feasible/attainable in most, if not all, state DOTs. Section 3.6 includes a discussion of options and exceptions that draws upon the details of the documented full cost calculations for six agencies that are included as Appendix A of the attachment.

Figure 3.1 illustrates the full cost determination process. The sequence is deliberate and starts out in Step 1 by identifying the cost elements that are directly related to the performance of a particular line activity (i.e., LEMO). Next, it recognizes that certain maintenance activities and expenditures support one or more line activities, and identifies a share of these expenditures that must be allocated to each line activity (Step 2). Furthermore, it recognizes that the maintenance program as a whole is supported by a variety of enterprise support programs and expenditures, and it identifies a share of these expenditures that must be allocated to the maintenance program (Steps 3 and 4). Finally, it combines the results of Steps 1 through 4 to determine the full cost of each line activity (Step 5). The full cost of any particular line activity can be considered to be composed of three discrete categories of cost:

- Line activity expenditures (LEMO);
- An allocation of maintenance program support expenditures; and
- An allocation of enterprise support program expenditures.

The full cost calculation requires an in-depth understanding of agency organization, activities, and financial and other information that goes beyond the maintenance program. As a result, it is critical that input be sought from agency experts in the areas of the agency finance and information systems as well as the maintenance program itself. Such a team approach will ensure full cost coverage, ease the computational task, and enhance the credibility of the calculation.

The following sections describe each step of the calculation in more detail and present an illustrative example.

3.1 Step 1: Gather and Classify Maintenance Program Activities and Expenditures

Objective

The objective of Step 1 is to collect information on all maintenance program activities and expenditures and to classify them as either line or support.

Sources of Information and Key Considerations

The source of maintenance activity expenditure information varies by agency and depends on the information systems in place and agency reporting procedures and infrastructure. The most common sources of expenditure data include maintenance and/or financial management systems as well as annual maintenance program reports that often summarize program accomplishments and expenditures in a number of ways (e.g., by activity, activity group, geographic areas, highway functional class). In most cases, maintenance activity expenditures are broken down into the four LEMO components of labor, equipment, material, and other for each activity.

In order to ensure the validity of the full cost calculation, there are a number of key considerations:

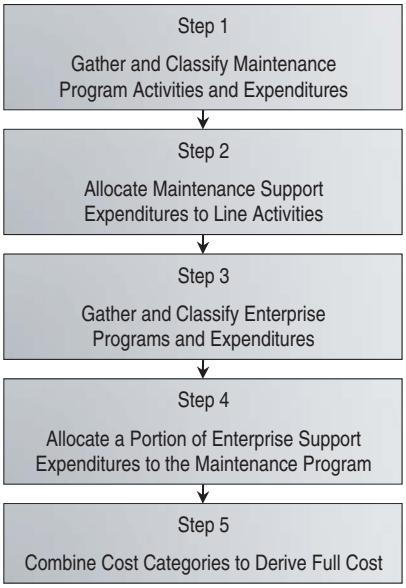

Figure 3.1. Full cost determination process.

- Labor expenditures must include regular and overtime, as well as being fully burdened—that is, salary plus fringe benefits.
- Agency rental rates must account for all equipment charges.
  - Any excluded charges must be identified and included in either program or enterprise support.
- Sign installation and maintenance costs must be calculated based on all sign shop expenditures.
  - Any excluded charges must be identified and included in either program or enterprise support.
- Material charges must be based on material consumption.
- All expenditures associated with maintenance and operation of maintenance facilities, including utilities, stores operation, and others, must be identified.
  - Any missing expenditures must be included in enterprise support.
- All maintenance program management expenditures must be identified, including the costs associated with state and regional maintenance engineers and managers, which are sometimes excluded from maintenance management systems.
  - Any missing management expenditures must be obtained from another source, for example, the financial management system, and included in program support.

Classification of Maintenance Expenditures

Once all of the maintenance program activities and expenditures have been gathered, they must be classified as either line or support activities according to the following definitions.

Line activity. An activity that involves the actual performance of work on, or inspection of (if required by law), one or more transportation infrastructure assets, as well as work responding to an unpredictable event. Examples of line activities include pothole patching, mowing, snow and ice control, bridge inspection, and accident and disaster recovery.

Support activity. An activity that is done in support of one or more line activities. Examples of support activities include administrative support, training, inspection and patrol activities that identify locations where line activities must be performed, radio operations, maintenance program management, and stores operations.

In most cases, the classification of a particular activity is obvious from its name; however, activity descriptions provided in agency maintenance and procedure manuals can guide the classification where there is any question.

Illustrative Example

Table 3.1 identifies the set of maintenance activities, total expenditures and associated accomplishment, and the classification of expenditures as either line or support for the example.

For this example, the total line activity expenditure is $17,800,000 and the total support activity expenditure is $2,200,000.

3.2 Step 2: Allocate Maintenance Support Expenditures to Line Activities

Objective

The objective of Step 2 is to establish the relationship between support and line activities in order to allocate an appropriate portion of maintenance program support expenditures to each line activity.

Sources of Information and Key Considerations

The best source of information regarding the relationships between maintenance support and line activities is the agency's maintenance personnel. This can be supplemented by documentation about agency maintenance procedures and definitions, which can often be found in agency maintenance manuals, maintenance management system documentation, and training materials. The effort required to establish the relationships between activities depends on both the number of activities and the clarity of definition.

A key consideration for this step in the process is the objective that the full cost determination process be as practical as possible. To satisfy this objective it is recommended that unless

Table 3.1. Example classification of maintenance activities and expenditures.

Activity Name	Type	Total Expenditure	Accomplishment	Units
Crack sealing	Line	$500,000	75,000	Pounds
Deicing	Line	$10,000,000	9,000,000	Pounds
Sign washing	Line	$300,000	20,000	Each
Striping	Line	$7,000,000	18,000	Linear feet
Subtotal		**$17,800,000**		
Mix deicer	Support	$250,000	N/A	None
Training	Support	$200,000	N/A	None
Management	Support	$1,500,000	N/A	None
Stores	Support	$250,000	N/A	None
Subtotal		**$2,200,000**		
Total		**$20,000,000**		

a particular maintenance support expenditure is unambiguously associated with only a subset of the line activities, it should be associated with all line activities. Examples of support activities that are only associated with a subset of line activities (drawn from Appendix A of the attachment) include

- Inspection and patrol support activities that result in the initiation of one or more line activities (e.g., a fence inspection support activity and fence repair, maintenance, and installation line activities).
- Sign shop support activities in cases where material-related line activity sign charges do not capture all sign shop expenditures. Sign shop support activities should be allocated to sign repair, maintenance, and installation line activities.
- Nonspecific, other activities that are a catchall for administrative and/or other activities that cannot be classified as one of the specific line activities within a particular group of related activities (e.g., the Other Paved Surface Maintenance activity that supports 14 specific line activities) (Arizona DOT, 2002).
- Support activities that are exclusively in support of its Snow and Ice Control Operations line activities (e.g., Winter Field Maintenance and Dining Room and Dormitory Operations) (Washington State DOT, 2007).
- Contract solicitation and administration support activities, which should only be allocated to contractor line activities when separate line activities exist for in-house and contractor performance of a particular activity.

The other key consideration for this step is selecting the basis by which each support activity expenditure is allocated to the line activities. The benchmark approach allocates support activity expenditures to all supported line activities on the basis of the line activity costs identified in Step 1.

Illustrative Example

Table 3.2 presents a crosswalk between maintenance line and support activities for the example. Line activities are represented by the rows, and support activities are represented by the columns. In the event that a particular line activity is supported by a particular support activity, an X is displayed in the corresponding cell. In this case, three of the four support activities provide support to all four line activities. However, as might reasonably be interpreted from its name, the mix-deicer support activity is only related to the deicing line activity.

Table 3.3 illustrates the results of applying the benchmark approach to allocate support activity expenditures to the line

Table 3.2. Example line and support activity crosswalk.

	Support Activities			
Line Activities	Mix Deicer	Training	Management	Stores
Crack sealing		X	X	X
Deicing	X	X	X	X
Sign washing		X	X	X
Striping		X	X	X

Table 3.3. Example allocation of support activity expenditures to line activities.

Line Activities	Allocation of Support Activity Expenditures				Total Support Activity Allocation
	Mix Deicer	Training	Management	Stores	
Crack sealing		$5,618	$42,135	$7,022	**$54,775**
Deicing	$250,000	$112,359	$842,697	$140,449	**$1,345,506**
Sign washing		$3,371	$25,281	$4,213	**$32,865**
Striping		$78,652	$589,887	$98,315	**$766,854**
Totals	**$250,000**	**$200,000**	**$1,500,000**	**$250,000**	**$2,200,000**

Note: Some totals rounded to the nearest dollar.

activities. The allocation calculation is performed for each valid combination of line and support activities—that is, for each X in Table 3.2. The support activity allocation is equal to:

$$(\$LAIQ/\$ASLA) * \$SAIQ$$

Where
$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$SAIQ = cost of support activity in question.

For example, the allocation of the mix deicer support activity to deicing equals

$$(\$10{,}000{,}000/\$10{,}000{,}000) * \$250{,}000 = \$250{,}000.$$

3.3 Step 3: Gather and Classify Enterprise Programs and Expenditures

Objective

The objectives of Step 3 are to collect information on all enterprise programs and expenditures and to classify them as line, support, or special/pass-through.

Sources of Information and Key Considerations

In most agencies there are multiple sources of information on enterprise program expenditures. The most common sources of this data include agency and/or state financial management systems and data warehouses, as well as annual agency reports. For example, a number of state DOTs prepare a comprehensive annual financial report (CAFR). A CAFR presents detailed financial information, including changes in asset values, sources and amounts of revenue, expenditures broken down in a variety of ways, and associated notes and commentary. Other potential sources include agency indirect cost allocation plans and reports detailing annual budgets, as well as budget versus expenditure reports.

In order to ensure the validity of the full cost calculation, there are a number of key issues that must be considered. For example:

- If enterprise expenditure data is obtained from a CAFR or other financial report, care must be taken to ensure that all expenditure categories are fully accounted for and that no expenditures are double counted.
- If enterprise expenditure data is extracted from an FMS, it is important to understand whether any expenditures are automatically allocated, and if so, which ones, on what basis, and to which other expenditures they are allocated.

Classification of Enterprise Expenditures

Once all of the enterprise expenditures have been gathered, they must be categorized as line, support, or special/pass-through according to the following definitions.

Line program. A line program is a logical grouping of similar activities or projects that are primarily focused on actually delivering the main work products of a state DOT. For example, construction projects make up a construction program, and maintenance activities and projects make up a maintenance program.

Support program. A support program is one that supports the delivery of one or more line programs (e.g., agency executive management, information systems, human resources, legal, and finance).

Special/pass-through. Many state DOTs report expenditures that do not fit nicely into either the line or support categories (e.g., debt-related expenditures associated with past bond issuance, or direct payments or pass-throughs to other state and local agencies).

Debt-related expenditures are, in most cases, the result of agency efforts to advance larger construction programs sooner than traditional revenues would permit. In this case, debt-related expenditures have nothing whatsoever to do with the maintenance program. Furthermore, the guidance provided in OMB Circular A-87 related to debt (Attachment B, cost item 23) is that in virtually all cases it is considered unallowable

to classify debt expenditures as an enterprise support program allocable to maintenance because this would falsely increase the allocation of enterprise support expenditures to line activities.

Direct payments or pass-throughs to other state or local government agencies, unlike construction and maintenance programs, do not involve DOT personnel administering, overseeing, or performing work, nor do they benefit the agency in any way. The classification of direct payments or pass-throughs as a line program would falsely reduce the allocation of enterprise support expenditures to line activities.

The examples described, or any similar expenditures, must be excluded from the calculation. The full cost determination process therefore identifies a third category of enterprise expenditures, special/pass-through, and any expenditure identified as such is indeed excluded.

In most cases, the classification of a program is obvious from its name; however, program descriptions provided in agency annual reports and budget documents can guide the classification where there is any question.

Illustrative Example

Table 3.4 lists the set of enterprise programs, total expenditures, and classification of programs as line, support, or special/pass-through for the example. In this case, the equipment fund is classified as special/pass-through because it represents all expenditures associated with the agency vehicle fleet, which are in turn charged in their entirety to the line programs through rental rates. In this case, classifying the equipment fund as a special/pass-through expenditure ensures that these charges are not double counted.

For the purposes of this example, therefore, total line program expenditure is $127,500,000, total support program expenditure is $8,000,000, and $7,500,000 associated with the equipment fund is excluded from the calculation.

3.4 Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Objective

The objective of Step 4 is to establish the relationship between enterprise support and line programs in order to allocate an appropriate portion of enterprise support expenditures to the maintenance program.

Sources of Information and Key Considerations

The best source of information regarding the relationships between enterprise support and line programs is the agency's personnel. This can be supplemented by documentation about agency programs, which can usually be found in agency annual reports and budget documents.

As with Step 2, a key consideration for this step in the process is the objective that the full cost determination process be as practical as possible. To satisfy this objective, it is recommended that unless a particular enterprise support program is unambiguously associated with only a subset of the line programs, it should be associated with all line programs. The full cost calculations for both Alabama DOT and Washington State DOT, documented in Appendix A of the attachment, include real-world examples of enterprise support programs that support only a subset of line programs. In the case of Alabama DOT, there are separate central office administration and geographically focused (division and district) supervisory expenditures for both the construction and maintenance programs. In the case of Washington State DOT, its program H, Program Delivery Management and Support, only provides support to its Maintenance, Preservation, and Improvement programs.

Table 3.4. Example classification of enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Maintenance	Line	$20,000,000
Construction	Line	$100,000,000
Traffic operations	Line	$2,500,000
Public transportation	Line	$5,000,000
Subtotal		**$127,500,000**
Administration	Support	$5,000,000
Program delivery support	Support	$3,000,000
Subtotal		**$8,000,000**
Equipment fund	Special/pass-through	$7,500,000
Total		**$143,000,000**

Table 3.5. Example line and support program crosswalk.

Line Programs	Support Programs	
	Program Delivery Support	Administration
Maintenance	X	X
Construction	X	X
Traffic operations		X
Public transportation		X

The other key consideration for this step is selecting the basis by which expenditures in each enterprise support program are allocated to the line programs. The benchmark approach allocates support program expenditures to line programs on the basis of the line program costs identified in Step 3.

Illustrative Example

Table 3.5 presents a crosswalk between the enterprise line and support programs for the example. Line programs are represented by the rows, and support programs are represented by the columns. In the event that a particular line program is supported by a particular support program, an X is displayed. In this case, the program delivery support program is only related to the maintenance and construction line programs.

Table 3.6 illustrates the results of applying the benchmark approach to allocate support program expenditures to the line programs. The allocation calculation is performed for each valid combination of line and support programs (i.e., for each X in Table 3.5). The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = line cost of line program in question,
$ASLP = line cost of all supported line programs, and
$SPIQ = cost of support program in question.

For example, the allocation of the program delivery support program to maintenance is

$$(\$20{,}000{,}000/\$120{,}000{,}000) * \$3{,}000{,}000 = \$500{,}000.$$

The share of enterprise support that must be allocated to the maintenance program is therefore $1,284,314.

3.5 Step 5: Combine Cost Categories to Derive Full Cost

Objective

The objective of Step 5 is to combine the line activity cost with the appropriate allocations of both maintenance program and enterprise support expenditures to determine the full cost of the line activities.

Sources of Information and Key Considerations

All of the information required to complete the full cost calculation is produced through Steps 1 through 4. At this point, the process has identified the line activity expenditures, an allocation of maintenance program support expenditures for each line activity, and the allocation of enterprise support expenditures that must be applied to the maintenance program. The next step, therefore, is to allocate the maintenance program share of enterprise support expenditures to the line activities themselves. Consistent with the approach

Table 3.6. Example allocation of support program expenditures to line programs.

Line Programs	Allocation of Support Program Expenditure		Total Support Program Allocation
	Program Delivery Support	Administration	
Maintenance	$500,000	$784,314	**$1,284,314**
Construction	$2,500,000	$3,921,569	**$6,421,569**
Traffic operations	N/A	$98,039	**$98,039**
Public transportation	N/A	$196,078	**$196,078**
Total	**$3,000,000**	**$5,000,000**	**$8,000,000**

Table 3.7. Example full cost breakdown for line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Crack sealing	$500,000	$54,775	$36,076	**$590,851**
Deicing	$10,000,000	$1,345,506	$721,525	**$12,067,031**
Sign washing	$300,000	$32,865	$21,646	**$354,511**
Striping	$7,000,000	$766,854	$505,067	**$8,271,921**
Total	**$17,800,000**	**$2,200,000**	**$1,284,314**	**$21,284,314**

for program support expenditures, the benchmark approach involves doing this on the basis of line activity cost.

The result of this calculation is the total cost for each line activity. Dividing this amount by the accomplishment recorded by the agency for each activity (where available) provides the full cost per unit of production, which now incorporates a fair share of both maintenance program and enterprise support expenditures.

Illustrative Example

Table 3.7 draws upon Tables 3.1 and 3.3 and the results of the enterprise support cost allocation calculations. It shows the breakdown of the full cost between the three cost categories: line, program support, and enterprise support.

The allocation of enterprise support to each line activity is

$$(\$LAIQ/\$ALA) * \$AESM$$

Where

$\$LAIQ$ = line cost of line activity in question,
$\$ALA$ = line cost of all line activities, and
$\$AESM$ = allocation of enterprise support to the maintenance program.

For example, the allocation of enterprise support to sign washing equals

$$(\$300{,}000/\$17{,}800{,}000) * \$1{,}284{,}314 = \$21{,}646.$$

Table 3.8 presents the full unit costs for production of each of the line activities in the example.

3.6 Calculation Options and Exceptions

The preceding sections describe and illustrate the benchmark approach to the full cost calculation. The benchmark approach is specifically designed for ease of use (i.e., to meet the practical requirement) and should therefore be feasible/attainable in most, if not all, state DOTs. A fundamental finding of this research is that although the input data used and the details of each step may vary, the overall full cost determination process can and must be the same for all activities and all agencies. Depending on the data available, the knowledge of the personnel performing the calculation, and the resources/time available, there are options at each step that should be considered and are described in the remainder of this section.

Simplified Benchmark Approach (All to All)

The benchmark calculation described in the previous sections accounts for two different types of maintenance program and enterprise support expenditures. The first type is general in nature and effectively supports all line activities and all line programs, respectively—for example, the maintenance program and agency executive management. The second type of support expenditure is for more focused support activities and programs that only support a subset of line activities and line programs, respectively. For example, sign shop activities not recouped through sign material expenditures support only sign installation and maintenance activities. The second type of support expenditure

Table 3.8. Example full unit costs for line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Crack sealing	$590,851	75,000	Pounds	$7.88
Deicing	$12,067,031	9,000,000	Pounds	$1.34
Sign washing	$354,511	20,000	Each	$17.73
Striping	$8,271,921	18,000	Linear feet	$459.55

Table 3.9. Example simplified allocation of support activity expenditures to line activities.

Line Activities	Allocation of Support Activity Expenditures				Total Support Activity Allocation
	Mix Deicer	Training	Management	Stores	
Crack sealing	$7,023	$5,618	$42,135	$7,022	**$61,798**
Deicing	$140,449	$112,359	$842,697	$140,449	**$1,235,954**
Sign washing	$4,213	$3,371	$25,281	$4,214	**$37,079**
Striping	$98,315	$78,652	$589,887	$98,315	**$865,169**
Totals	**$250,000**	**$200,000**	**$1,500,000**	**$250,000**	**$2,200,000**

can occur at both the maintenance program and enterprise levels; however, on the basis of the full cost calculations performed in this study, it is more common within the maintenance program itself.

The number of maintenance activities and enterprise programs varies by agency and in some cases can be quite large. As the number increases, so does the effort required to relate line and support activities and programs. In addition, activity and program definitions tend to become closer and differences more nuanced, which further increases the knowledge, time, and effort that can be expended developing the line and support crosswalks in Steps 2 and 4. Finally, although it is recommended that the full cost calculation be undertaken by a team with representatives from the maintenance program or finance division or office, as well as people knowledgeable in agency information systems, there may be circumstances where such a team approach is not possible. In any of these situations, the simplified benchmark approach can be used to determine the full cost of maintenance activities.

As its name suggests, this benchmark approach simplifies Steps 2 and 4 with the assumption that all maintenance program and enterprise support expenditures support all line activities and all line programs, respectively, essentially placing Xs in every cell of the crosswalk matrices in Steps 2 and 4.

Step 2. Table 3.9 illustrates the results of applying the simplified benchmark approach to allocate support activity expenditures to the line activities for the example described previously. The allocation calculation is now performed for every combination of line and support activities. The support activity allocation is equal to:

$$(\$LAIQ/\$ASLA) * \$SAIQ$$

Where

$\$LAIQ$ = line cost of line activity in question,
$\$ASLA$ = line cost of all supported line activities, and
$\$SAIQ$ = cost of support activity in question.

Using the simplified benchmark approach, now the allocation of the mix deicer support activity to deicing equals

$$(\$10{,}000{,}000/\$17{,}800{,}000) * \$250{,}000 = \$140{,}449$$

(versus $250,000 calculated previously).

Step 4. Table 3.10 illustrates the results of applying the simplified benchmark approach to allocate support program expenditures to the line programs. The allocation calculation is now performed for every combination of line and support programs. The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$\$LPIQ$ = cost of line program in question,
$\$ASLP$ = cost of all supported line programs, and
$\$SPIQ$ = cost of support program in question.

Table 3.10. Example simplified allocation of support program expenditures to line programs.

Line Programs	Allocation of Support Program Expenditure		Total Support Program Allocation
	Program Delivery Support	Administration	
Maintenance	$470,588	$784,314	**$1,254,902**
Construction	$2,352,941	$3,921,569	**$6,274,510**
Traffic operations	$58,824	$98,039	**$156,863**
Public transportation	$117,647	$196,078	**$313,725**
Total	**$3,000,000**	**$5,000,000**	**$8,000,000**

Using the simplified benchmark approach, now the allocation of the program delivery support program to maintenance is

$$(\$20{,}000{,}000/\$127{,}500{,}000) * \$3{,}000{,}000 = \$470{,}588$$

(versus $500,000 calculated previously).

Now the allocation of enterprise support expenditures to the maintenance program is $1,254,902 (versus $1,284,314 calculated previously).

Step 5. Table 3.11 draws upon Tables 3.1 and 3.9 and the results of the simplified enterprise support cost allocation calculation just completed, whereby the maintenance program share of enterprise support is now $1,254,902. It shows the breakdown of the full cost between the three cost categories: line, program support, and enterprise support that results from using the simplified benchmark approach.

The allocation of enterprise support to each line activity is

$$(\$LAIQ/\$ALA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ALA = line cost of all line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Using the simplified benchmark approach, now the allocation of the enterprise support to sign washing equals

$$(\$300{,}000/\$17{,}800{,}000) * \$1{,}254{,}902 = \$21{,}150$$

(versus $21,646 calculated previously).

Table 3.12 presents the full unit costs for production of each of the line activities in the example using the simplified benchmark approach.

Table 3.13 shows a comparison of the full unit costs for the example calculated using the benchmark and simplified benchmark approaches. The difference in this case is very modest. However, comparisons of full unit costs for selected activities using the benchmark and simplified benchmark

Table 3.11. Example simplified full cost breakdown for line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Crack sealing	$500,000	$61,798	$35,250	**$597,048**
Deicing	$10,000,000	$1,235,955	$705,001	**$11,940,956**
Sign washing	$300,000	$37,079	$21,150	**$358,229**
Striping	$7,000,000	$865,168	$493,501	**$8,358,669**
Total	**$17,800,000**	**$2,200,000**	**$1,254,902**	**$21,254,902**

Table 3.12. Example simplified full unit costs for line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Crack sealing	$597,048	75,000	Pounds	$7.96
Deicing	$11,940,956	9,000,000	Pounds	$1.33
Sign washing	$358,229	20,000	Each	$17.91
Striping	$8,358,669	18,000	Linear feet	$464.37

Table 3.13. Example comparison of benchmark and simplified benchmark full unit cost.

Line Activity	Units	Full Unit Cost		Percent Difference
		Benchmark	Simplified Benchmark	
Crack sealing	Pounds	$7.88	$7.96	1.01%
Deicing	Pounds	$1.34	$1.33	-0.75%
Sign washing	Each	$17.73	$17.91	1.01%
Striping	Linear feet	$459.55	$464.37	1.04%

approaches are made at the end of the calculations for Arizona DOT and Missouri DOT in Appendix A of the attachment, and in these real and complete examples, the impacts are more significant.

Forward-Looking or Budgetary Approximation

The sources, calculation, and tracking details for the line activity, program support, and enterprise support expenditures vary by agency. However, irrespective of these variations, the full cost calculation requires that these costs be obtained from somewhere. The prior descriptions of Steps 1 and 3 focus on a backward-looking, accounting approach to determining the contributions to full cost for each category of cost. If such a forensic approach is possible, combining actual expenditures would appear to be the most straightforward and practical solution. However, it is also possible to make a forward-looking cost projection of the type that is done during the budget development process.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

The following steps provide an example of a forward-looking or budgetary approximation for determining the cost of maintenance activities. The example is based on the way the Alabama DOT's Maintenance Bureau uses its maintenance management system to prepare line activity budgets for each year. The basic steps in the process are as follows:

1. Estimate the number of crew days of a particular maintenance activity that will be required during the next budget year;
2. Determine the crew profile that will be required to perform each activity (i.e., number and classes of maintenance personnel);
3. Estimate the average daily crew cost using current average loaded rates by personnel class as well as any cost-of-living or other adjustments;
4. Multiply the results of Steps 1 and 3 to estimate the projected labor cost for the activity;
5. Review past expenditures on the activity in question and calculate the percentage of the total cost contributed by LEMO; and
6. Estimate equipment, material, and other costs using the results of Steps 4 and 5 and combine them with the labor estimate—this gives an estimate of the sum of line cost elements for the activity.

The process must be completed for all activities prior to moving on to Step 2. In addition, it is important to understand the extent to which maintenance program support is covered by the budget activities. In the event that certain support expenditures are not covered—say, for example, expenditures for the state maintenance engineer and other maintenance program support and administration—these must either be added as additional activities here and their expenditures estimated, or they must be identified as a maintenance-program–specific enterprise support expenditure in Step 3.

Step 2: Gather and Classify Enterprise Programs and Expenditures

As with Step 1, the preferred approach to obtaining this information is to extract it from agency information systems and/or financial reports for a complete fiscal year in the past (i.e., actual expenditure information). However, just as for maintenance program activities and expenditures, another option is to use forward-looking budgetary information as the principal input for this step.

Allocation Basis

Step 3: Allocate Maintenance Support Expenditures to Line Activities

In order to help ensure the practicality of the full cost determination process, both the benchmark and simplified benchmark approaches described and illustrated in this report consistently use the line cost as the basis for allocating all program support expenditures to line activities. However, an agency may choose a different basis for allocating all program support expenditures, or even choose different bases for different support activities.

Beyond line activity cost, the most obvious alternative allocation basis can be found within the elements of line cost as follows:

- Workman's compensation support activity expenditures (or other support activity expenditures reasonably related to labor expended) could be allocated on the basis of labor expenditure for each line activity;
- Material stores and handling support activities expenditures could be allocated on the basis of material expenditure for each line activity;
- Unused equipment and other equipment support activity expenditures could be allocated on the basis of equipment expenditure for each activity; and
- Contractor solicitation, administration, and oversight support activities could be allocated on the basis of other expenditures for each activity (provided other expenditures are predominantly contractor payments).

In addition, labor hours and equipment hours could be used as the basis of allocating support activity expenditures.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

As with the allocation of program support expenditures, both the benchmark and simplified benchmark approaches described and illustrated in this report consistently use the line cost as the basis for allocating all enterprise support expenditures to line programs. However, an agency may choose a different basis for allocating all enterprise support expenditures, or even choose different bases for different support programs. For example, Florida DOT's Indirect Cost Allocation Plan (Florida Department of Transportation, 2008) identifies 25 different bases of allocation. Each of these bases is used for allocating one or more of its 34 indirect cost pools (support programs) to 21 direct programs (line programs). Examples of the different bases include total department expenditures, total district expenditures, consulting services expenditures, federal construction expenditures, nonlabor expenditures, total number of employees, total number of headquarters building employees, total right-of-way expenditures, total construction charges, and maintenance charges.

Step 5: Combine Cost Categories to Derive Full Cost

All allocations of enterprise support expenditures to line activities so far have been made on the basis of the line activity expenditures identified in Step 1. However, alternative approaches to allocating the maintenance program's share of enterprise support expenditures can be considered in much the same way as has been discussed for Steps 2 and 4. In addition to the various allocation bases previously discussed (some of which might similarly be candidates here), another candidate for consideration is the line activity plus program support cost basis, whereby the allocation of enterprise support to each line activity is

$$[(\$LAIQ + \$PSLAIQ)/(\$ALA + \$PSALA)] * \$AESM$$

Where

$\$LAIQ$ = line cost of line activity in question,
$\$PSLAIQ$ = program support cost of line activity in question,
$\$ALA$ = line cost of all line activities,
$\$PSALA$ = program support cost of all line activities, and
$\$AESM$ = allocation of enterprise support to maintenance program.

Applying this approach to the benchmark example, the allocation of the enterprise support to sign washing equals

$$[(\$300,000 + \$32,865)/(\$17,800,000 + \$2,200,000)] * \$1,284,314 = \$21,375$$

(versus $21,646 calculated previously).

Allocation Basis Considerations

Provided that the data is available for all activities and/or programs, there are clearly a number of allocation bases for an agency to choose from. However, before pursuing allocation bases other than line activity costs, agencies must consider two important issues:

1. **Calculation complexity and level of effort:** If an agency chooses to use different bases for allocation for different support activities, the complexity of the calculation will increase, as will the level of effort required and the potential for error.
2. **Potential for disagreement:** By introducing multiple bases for allocation, an agency opens the door for debate about which basis should be used for which support activities, which may ultimately weaken the perception of the validity/correctness of the full cost determination processes results.

Maintenance Program Expenditure Reconciliation

Step 4 of the full cost process involves allocating a share of enterprise support expenditures to the maintenance program on the basis of maintenance program expenditure. As a result, in any case where the expenditure data for the full cost calculation is drawn from both agency maintenance and financial management systems, the total maintenance program expenditures from both sources must be compared. In the event that there is a significant discrepancy (say greater than or equal to 10%), a reasonable attempt must be undertaken to identify its source, and a fair assessment of total maintenance program expenditures is used as the basis for determining the enterprise support expenditure allocation. The full cost calculations documented in Appendix A of the attachment indicate that the enterprise support component of any line activity's full cost ranges between 2% and 10%. At 10%, a 10% discrepancy in the enterprise support allocation to maintenance will result in only a 1% difference in full cost.

The documented full cost calculation for Arizona DOT described in Appendix A of the attachment provides an example of this situation. In this case, the total maintenance program expenditure from the maintenance management system

is $152,617,001, versus $135,629,139 from the financial management system. Discussion about the reasons for the discrepancy with agency personnel resulted in the determination that the higher expenditure amount is the better value, and thus the decision was made to scale up the allocation enterprise support cost to maintenance by the same factor as between total maintenance program expenditures from both sources. In this way, the calculation ensured that the maintenance program received a fair, and in this case higher, allocation of enterprise support expenditures than would have resulted from using the financial management system data alone.

Full Cost Versus Full Unit Cost of Production

The full cost calculations result in both a total full cost for each activity considered and a full unit cost, derived by dividing the full cost by reported accomplishment. Although there is value in both figures, from a practical standpoint, the full unit cost is more useful and therefore more valuable. The calculation of full unit cost relies on the agency selecting useful units of accomplishment for line activities (for example, tons, yards, square feet, linear feet, each), and then capturing and recording this data accurately. Based on performing these calculations with data from six different state DOTs and discussions with personnel from these agencies, it is clear that adherence to these requirements is mixed. As a consequence and at a minimum, any agency undertaking the full cost calculation should consider its level of confidence in its accomplishment data and treat full unit costs accordingly. In addition, in the event that a single line activity is performed by a combination of in-house personnel and contractors, it is critical to understand whether accomplishment data is being recorded consistently in both cases. If, as it appears to sometimes be the case, contractor accomplishment data is either questionable or absent, then full unit costs calculated will be skewed.

Implications of Automatic Indirect Cost Allocation

A number of the state DOTs interviewed for this study have implemented indirect cost allocation procedures of different types directly within their financial management systems. If expenditure data for the full cost determination process is extracted from the financial management system, it is important to understand what, if any, indirect cost allocations already have occurred. Depending on the agency, indirect cost allocation plans can be quite complex and it can take considerable effort to understand them. It is therefore recommended that, whenever possible, raw and unallocated agency expenditure data be used as the point of departure for the full cost determination process. In this way, all classification and allocation activities for both program and enterprise support expenditures occur through the full cost determination process itself, increasing the transparency of the calculation. Of course, if automatic indirect cost allocations are performed in a way that is entirely consistent with the full cost determination process described in this report, the full cost of activities can be obtained directly from the financial management system. However, it is paramount that the allocation procedures used to derive the full cost be reviewed, understood, and confirmed as being consistent with the full cost determination process.

Full Cost Calculation for Network and Geographic Subsets

The full cost determination process described in this report was developed in order to calculate the full unit cost of maintenance activities on a statewide basis. However, there is nothing to prevent its application to a subset of a state (e.g., a particular functional class or another geographic designation such as a district or region), provided that the requisite portion of total line expenditure and accomplishment data for a particular maintenance activity can be readily identified. The approach for allocating program and enterprise support expenditures to a subset of total line activity expenditure is no different than to the statewide line activity total—that is, based on the line cost amount. It must be noted, however, that from a practical standpoint there are limits to how finely the line cost data can be sliced. At some point, it is possible that a particular maintenance activity has not been performed in the selected geographic subset within the timeframe for which cost and accomplishment data has been obtained. It is therefore recommended that the full cost process be applied at higher levels of aggregation—for example, by functional class or by district, and not, for example, from milepost A to milepost B on a specific highway.

3.7 Additional Considerations

The full cost determination process described in this report enables the calculation of an agency's full cost to perform a particular maintenance activity. However, in order to support the use of the resulting dollar amount in any other analysis or comparison, it is critical that it be placed into context. At a minimum and as previously stated, this context should include a combination of cost and units of measure for the particular activity, in order to derive an agency's total (or full) unit price for the activity. In addition, it is critical to consider the impact on level of service resulting from this expenditure. In other words, what was the condition or level of service

associated with the maintenance activity at the beginning and end of the analysis period? Did the level of service fall or rise (and if so by how much) or remain flat as a result of the expenditure?

In addition, if the resulting cost is intended for use as an input for a forward-looking decision and it has been derived from a backward-looking analysis (i.e., a forensic accounting exercise), inflation must be considered. Although historically inflation has been relatively modest in the area of highway construction and maintenance, more recently agencies have experienced periods of much higher inflation. This is particularly important in the area of oil and petroleum products, which are important to most maintenance activities in that they drive the price of the fuel that is used by all of the equipment. For this reason and depending on the purpose of determining the agency's full cost for performing a particular line activity, it will be important to ensure appropriate consideration for inflation and apply a factor to the resulting full unit cost.

CHAPTER 4

Conclusions and Suggested Research

There is broad recognition that recent investment levels in transportation infrastructure have been and remain inadequate. As a result, the pressure on state DOTs to do more with less has never been greater, and agencies continue to actively pursue opportunities to lower costs while striving to maintain or even improve performance. In the maintenance arena, this has led an increasing number of state DOTs to consider the options of outsourcing and public–private partnership for some maintenance services.

Although cost is not the only factor that must be considered when exploring such alternative delivery methods, it is most often cited by advocates, both for and against, in order to support their position. To date, however, there has been no widely accepted process for determining the costs associated with performing highway maintenance if done by the transportation agency itself. Furthermore, on review of many existing reports and audits that compare in-house and outsourced costs, it is evident that often, some of the elements making up the total agency cost of an activity are not properly considered or, in some instances, are not included. The cost elements most frequently missed or mishandled are those related to maintenance program and agency-wide (or enterprise) support. The full cost determination process described and demonstrated in this report is designed to fill this gap.

4.1 Full Cost Determination Process

The process developed is flexible enough that it can be applied to any specific maintenance activity, and it ensures that the resulting full cost incorporates a fair share of both maintenance program and enterprise support. The full cost determination process is composed of the following five steps:

1. Gather and classify maintenance program activities and expenditures,
2. Allocate maintenance support expenditures to line activities,
3. Gather and classify enterprise programs and expenditures,
4. Allocate a portion of enterprise support expenditures to the maintenance program, and
5. Combine cost categories to derive full cost.

The process strongly encourages a team approach and should include agency personnel that are knowledgeable about the maintenance program, agency financial accounting practices, and agency information systems. The process developed leverages well-established OMB guidelines for the identification and allocation of indirect costs, and existing state DOT approaches to satisfying FHWA's indirect cost allocation requirements. Consistent with the use of a team approach and OMB guidelines, and contrary to initial expectations, the full cost determination process does not vary as a result of differences in agency, maintenance program, and/or maintenance activity characteristics. The only variation between calculations relates to the inputs and sources of data that are leveraged in each step of the process. The full cost process developed is practical and robust, as demonstrated by its application to six state DOTs, with considerable variation in maintenance program structure, geographic location and characteristics, agency size, and information systems environment.

The benefits of performing the full cost calculation go beyond satisfying the objective to enable the calculation of any maintenance activity's full cost, thereby providing a critical input into agency decisions regarding in-house versus contractor performance of any particular maintenance activity. Gathering the necessary data and performing the calculation requires a thoughtful review of the maintenance program structure and activities as well as the distribution of expenditures to activities and to the different elements of

cost. Additional applications and benefits of performing the full cost calculation may include

- Identifying potential improvements to the maintenance program structure and activities as well as the processes and management systems used for recording accomplishments and expenditures associated with each activity (e.g., identification of opportunities to establish separate in-house versus contractor activities in order to improve the allocation of contract support and administration expenditures, recording of accomplishment data, and full unit-cost calculations).
- Providing an ability to compare maintenance costs between different geographic areas and/or highway functional classes, which may in turn provide insight into the influences of other, external effects on costs (e.g., road characteristics, traffic volume and composition, terrain altitude, and weather).
- Performing the calculation annually, which may help agencies improve LOS-based budgeting models and reduce reliance on prior-year expenditures during budget development cycles.
- Helping agencies to identify training needs for maintenance field personnel and supervisors in the area of recording man hours, equipment usage, and material consumption.

Finally, the purpose of the full cost determination process developed in this project is to enable an agency to estimate its full cost for performing any particular maintenance activity. This report includes documented examples of the full cost calculation for six DOTs. However, comparing various elements of these calculations should be avoided. Each agency differs with respect to overall agency structure and scope, organizes its maintenance program differently, has different numbers and definitions of maintenance activities, and differs in its treatment and classification of different expenditure types based on these characteristics as well as its information systems environment. As a result, comparing full costs, full unit costs, program support multipliers, enterprise support multipliers, and/or overhead rates of the calculations documented here, or undertaken externally, is both meaningless and futile.

4.2 Suggestions for Additional Research

Maintenance program structure, activity definitions, and management systems. It is clear from this study that the ability to determine the full cost of any particular maintenance activity is influenced by maintenance program structure, activity definitions and units of accomplishment, the quality of practices for recording expenditure elements, and the types and features of agency management systems. There is no doubt that certain program structures, activity definitions and units of accomplishment, practices, and management systems lend themselves to more accurate full cost calculations than others. Research to identify such characteristics might help agencies make adjustments to their maintenance programs and management systems in order to enhance their ability to calculate and understand the full costs of maintenance activities.

Indirect cost allocation procedures. A comprehensive review of state DOT indirect cost allocation plans might be a useful supplement to this study. These plans document the approaches used by state DOTs to allocate allowable indirect costs to projects and activities that are eligible for federal participation and may include additional approaches that could be used in the full cost determination process.

Maintenance delivery decisions. The process developed during this project provides transportation agencies with a methodology for determining the full cost for performing a particular maintenance activity. The primary application of this process is to provide input to agency decisions regarding in-house versus contractor delivery of maintenance. A logical next step would be to work with one or more agencies considering contracting maintenance activities, calculating their full cost using the process developed in this project, and comparing it to contractor prices, then identifying and describing the other key considerations when making this decision. The critical point here is that although the ability to assess and compare in-house versus contractor costs is very important, it is not the only issue, and research that explores the complete range of considerations associated with the maintenance delivery question would be very useful to the transportation community.

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Glossary

Allocation (also attribution or distribution or assignment): For the purposes of this report, the process of relating indirect costs to the maintenance jobs or organizational units that have benefitted from the expenditures of these indirect costs. For example, the indirect costs of a maintenance district office need to be related to maintenance jobs and units that benefit from the guidance, oversight, supervision, and assistance of the district office. This relationship is generally analytic (i.e., able to be computed) but also is informed by judgment since the relationship is not immediately obvious (i.e., if it were, the costs might be considered as direct costs). An acceptable relationship is one that is reasonable (i.e., its logic is understandable) and felt to be fair by affected parties, but also efficient (i.e., not requiring excessive time and effort that is burdensome relative to the magnitude and importance of the costs being considered). Often an **account** or **pool** is created to accumulate indirect costs and allocate them efficiently to the maintenance jobs or organizational units that benefit from the expenditure of these costs.

Allowable cost: A cost, either direct or indirect, that is reimbursable by the federal government. State DOTs' indirect cost allocation plans, which must be approved by FHWA, document how allowable indirect costs are allocated to allowable direct costs for the purposes of federal reimbursement. Attachments A and B of OMB Circular A-87 provide definitions and guidance with respect to which costs are and are not allowable.

Base or basis: The analytic quantity by which indirect costs are assigned pro rata to different functions, programs, groups, or activities. Many potential bases are available. For example, indirect costs could be allocated by the relative shares, respectively, of labor costs, total costs, number of employees, square footage of building space occupied by an organizational unit, or other metric that is felt to represent the relative benefit of the indirect cost expenditure.

Benchmark approach: A form of the full cost determination process that is designed to be feasible/attainable in most, if not all, state DOTs.

Cost base or basis: For purposes of this report, a basis that is expressed in the overall direct cost of maintenance for an activity, function, or program. The overall direct cost of maintenance in this context means the sum of all direct labor, including fringe benefits, equipment, materials, and other expenditures, including contractor payments, to perform and complete the specified maintenance work.

Cost objective: A financial accounting term defined as "a function, organizational subdivision, contract, grant, or other activity for which cost data are needed and for which costs are incurred" (OMB, 2004). Unless otherwise indicated, a "cost objective" will refer in this report primarily to a maintenance job.

Direct costs: Costs "that can be identified specifically with a particular final cost objective" (OMB, 2004). In a road maintenance context, typical direct costs include wages or salaries paid to employees for work performed on a maintenance job, costs of materials acquired for or consumed on a maintenance job, costs of equipment used on a maintenance job, and costs of travel to and from a maintenance job. Where maintenance is performed by contract, direct costs refer to contractor payments.

Enterprise: Another way of referring to the entire agency (i.e., the combination of all line and support programs).

Enterprise support: The combination of all agency (or enterprise) support programs and functions.

Enterprise support cost/expenditure: The sum of all agency (or enterprise) support programs' and functions' costs/expenditures.

Equipment cost/expenditure: The second element of line and support activity costs. This is the total equipment charges associated with a particular activity. In most cases this is derived by multiplying some measure of equipment usage (hours, days, miles) by an agency-developed equipment rental rate for each piece or type of equipment in the agency's fleet.

Full cost determination process: For purposes of this report, the process of determining the full costs of maintenance for an activity, function, or program, whether statewide, by district, or other geographical or organizational coverage.

Full cost: For purposes of this report, the combination of line activity costs/expenditures, a fair share of program support costs/expenditures, and a fair share of enterprise support costs/expenditures.

Indirect cost plan: For purposes of this study, a document prepared and submitted by a state DOT and approved by the FHWA, according to the requirements of OMB Circular A-87, for use in administering reimbursements of the federal share of costs for federal-aid highway work.

Indirect cost: Costs that are: "a) incurred for a common or joint purpose benefiting more than one cost objective; and b) are not readily assignable to the cost objectives specifically benefitted, without effort disproportionate to the results achieved" (OMB, 2004). For example, the guidance, oversight, supervision, and assistance of a district maintenance office may be said to benefit all maintenance crews and jobs within its jurisdiction, but there is no direct connection or nexus between the district office personnel and each individual maintenance job. A reasonable but efficient method must be found, often informed by judgment, to relate district office costs to all the maintenance jobs under its responsibility. Refer to the following definition.

Labor cost/expenditure: The first element of line and support activity costs. This is the product of labor hours and fully burdened (i.e., salary plus fringe benefits) labor rates associated with a particular activity. Depending on the agency, it also may include charges for third party labor such as other state or local agencies performing certain maintenance services and/or convict labor charges.

LEMO: A shorthand way of referring to the four elements of line and support activity costs (i.e., labor, equipment, material, and other).

Line activity: A maintenance program activity that involves the actual performance of work on, or inspection of (if required by law), one or more transportation infrastructure assets, as well as work responding to an unpredictable event. Examples of line activities include pothole patching, mowing, snow and ice control, bridge inspection, and accident and disaster recovery.

Line activity cost/expenditure: The sum of labor (including fringe benefits), equipment, material and other (including contractor) costs/expenditures incurred in the performance of a particular line activity.

Line program: A logical grouping of similar activities or projects that are primarily focused on actually delivering the primary work products of a state DOT. For example, construction projects make up a construction program, and maintenance activities and projects make up a maintenance program.

Line program cost/expenditure: The sum of all costs/expenditures associated with a particular line program.

Maintenance activity: A specific classification of maintenance work or service that is defined in the agency's maintenance program and maintenance management system (MMS) and/or financial management system (FMS). The full cost determination process deals with all defined activities that relate to maintenance, regardless of number or detail. Cost data are required and accomplishment units are preferred for each activity to be considered.

Maintenance job: The performance of a maintenance activity at a particular highway location (or on a particular length of highway) at a particular date and time.

Material cost/expenditure: The third element of line and support activity costs. This is the total material charges associated with a particular activity. In most cases this is derived by multiplying the quantity of each unit of material consumed by a unit price that is calculated and maintained by the agency's stores operation.

OMB Circular A-87: A document issued by the Office of Management and Budget (last revised on May 10, 2004) that establishes principles and standards for treating costs in connection with federal awards, including discussions of direct and indirect costs, and explanations of allowable and unallowable costs.

Other cost/expenditure: The fourth and final element of line and support activity costs. This element of activity cost is used to collect all other activity costs that do not fit in the first three elements. Sources for this element include contractor payments, private equipment rental, utility charges, and, depending on the agency, payments for services by other state and/or local agency personnel and/or convict labor charges.

Program support: The combination of maintenance program support activities and functions.

Program support cost/expenditure: The sum of all maintenance program support activities' and functions' costs/expenditures.

Simplified benchmark approach: A simplified form of the full cost determination process that eliminates the need for developing crosswalks of line and support activity and program expenditures by assuming that all line activities and programs are supported by all support activities and programs, respectively.

Special/pass-through: A classification for agency/enterprise programs that must be excluded from the full cost determination process. For example, debt-related expenditures associated with past bond issuance, or direct payments or pass-throughs to other state and local agencies.

Support activity: A maintenance program activity or function that is done in support of one or more line activities. Examples of support activities include administrative support, training, inspection and patrol activities that identify locations where line activities must be performed, radio operations, maintenance program management, and stores operations.

Support activity cost/expenditure: The sum of labor (including fringe benefits), equipment, material, and other costs/expenditures incurred in the performance of a particular support activity or function.

Support program: A program that supports the delivery of one or more line programs. For example, agency executive management, information systems, human resources, legal, and finance.

Support program cost/expenditure: The sum of all costs/expenditures associated with a particular support program.

ATTACHMENT

Recommended Process for Determining Full Cost of Highway Maintenance Activities

Contents

The proposed process is a recommendation of the research team at Cambridge Systematics, Inc., for NCHRP Project 14-18, Determining Highway Maintenance Costs. The process has not been approved by NCHRP or any AASHTO committee, nor has it been formally accepted for adoption by AASHTO.

Introduction and Objective

Because of growing demands and resource limitations for highway maintenance, state DOTs and other highway agencies often consider nontraditional means for financing and contracting these services. For example, some state DOTs have considered the options of outsourcing and public–private partnership of some maintenance services. However, identifying the most desirable option for a specific maintenance activity requires knowledge of the transportation agency's full costs associated with such activity. Often, some of the elements making up the total cost of an activity are not appropriately considered or, in some instances, are not included. The cost elements most frequently missed or mishandled are those related to maintenance program and agency-wide (or enterprise) support.

The objective of the process is to provide state DOTs with a practical and robust methodology for determining the full costs associated with performing any particular maintenance activity. The process can be applied to any maintenance activity, and it ensures that the resulting full cost incorporates a fair share of both maintenance program and enterprise support.

Full Cost Context

Figure 1 illustrates the state DOT maintenance activity full cost context that is the basis for full cost determination process. Various elements in this illustration will be referenced in the process description, but the following statements about the full cost context are intended to facilitate understanding:

- At their highest level, DOT expenditures can be divided into two categories: line programs and support programs. Line programs are groups of activities that actually deliver the work product of the DOT—for example, maintenance and construction. Support programs, as their name suggests, are groups of activities that support the DOT's line programs—for example, executive management and planning and research.
- Likewise, maintenance program expenditures can be divided into two categories: line activity costs and maintenance program support. Line activities are defined as activities that involve the actual performance of work directly on one or more transportation assets or work responding to an unpredictable event. Maintenance program support encompasses planning, administration, supervision, and

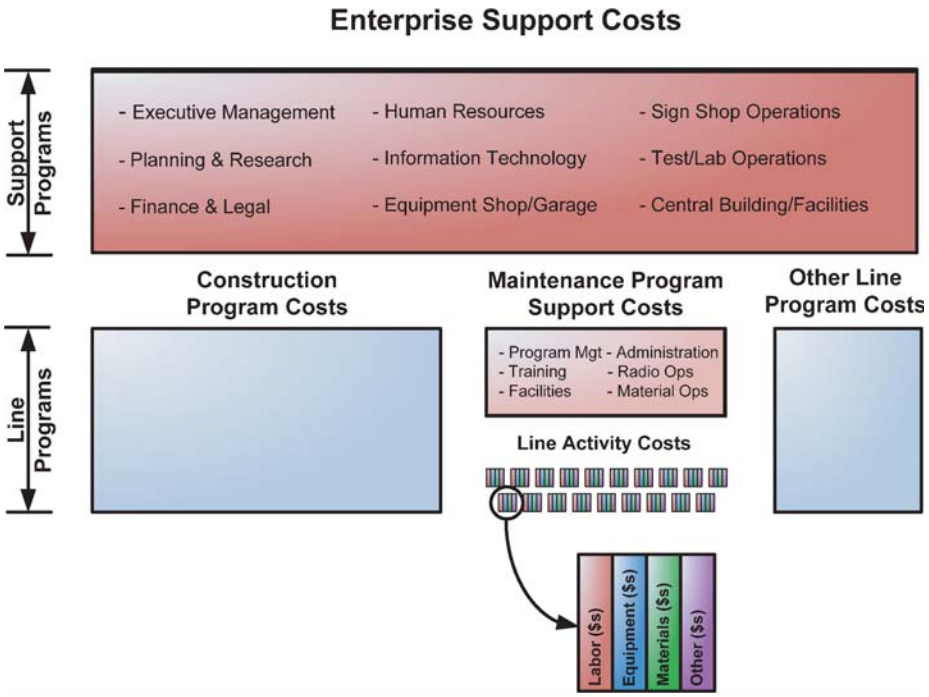

Figure 1. State DOT maintenance activity full cost context.

other functions that effectively support the maintenance program's line activities.
- Line activity costs are composed of four elements: labor, equipment, materials, and other.
- In order to determine the full cost of any particular line activity, a fair allocation of both maintenance program support and enterprise support expenditures must be added to the line activity cost.

Overview of Full Cost Determination Process

Figure 2 illustrates the full cost determination process. The sequence is deliberate and starts out in Step 1 by identifying the cost elements that are directly related to the performance of a particular line activity (i.e., LEMO). Next, the process recognizes that certain maintenance activities and expenditures support one or more line activities and identifies a share of these expenditures that must be allocated to each line activity (Step 2). Furthermore, it recognizes that the maintenance program as a whole is supported by a variety of enterprise support programs and expenditures and identifies a share of these expenditures that must be allocated to the maintenance program (Steps 3 and 4). Finally, the process combines the results of Steps 1 through 4 to determine the full cost of each line activity (Step 5). The full cost of any particular line activity can be considered to be composed of three discrete categories of cost:

- Line activity expenditures (LEMO),
- An allocation of maintenance program support expenditures, and
- An allocation of enterprise support program expenditures.

The following sections describe each step of the calculation in more detail and present an illustrative example.

Who Should Participate in the Calculation

The full cost calculation requires an in-depth understanding of agency organization, activities, and financial and other information that goes beyond the maintenance program. Therefore, it is critical that input is sought from agency experts in the areas of the agency finance and information systems as well as the maintenance program itself. Such a team approach will ensure full cost coverage, ease the computational task, and enhance the credibility of the calculation.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

Objective

The objectives of Step 1 are to collect information on all maintenance program activities and expenditures and to classify them as either line or support.

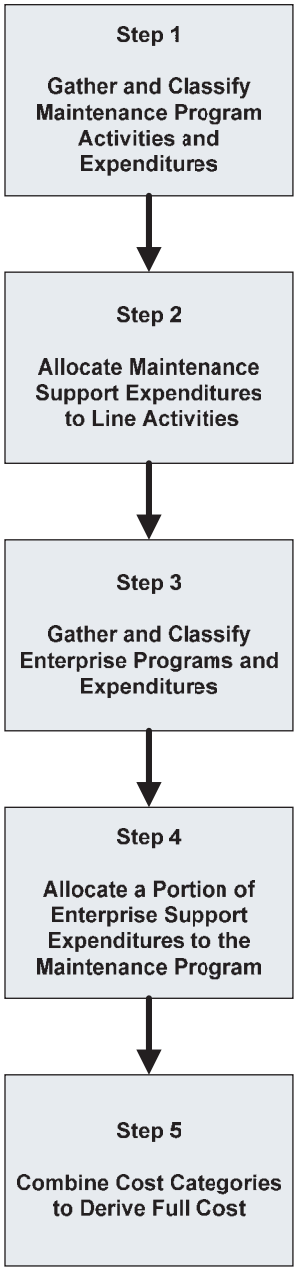

Figure 2. Full cost determination process.

Sources of Information and Key Considerations

The source of maintenance activity expenditure information varies by agency and depends on the information systems in place and agency reporting procedures and infrastructure. The most common sources of expenditure data include maintenance and/or financial management systems as well as annual maintenance program reports that often summarize program accomplishments and expenditures in a number of ways (e.g., by activity, activity group, geographic areas, highway functional class). In most cases, maintenance activity expenditures are broken down into the four LEMO components of labor, equipment, material, and other for each activity.

In order to ensure the validity of the full cost calculation, there are a number of key considerations:

- Labor expenditures must include regular and overtime, and must be fully burdened (i.e., salary plus fringe benefits).
- Agency rental rates must account for all equipment charges.
  - Any excluded charges must be identified and included in either program or enterprise support.
- Sign installation and maintenance costs must be calculated based on all sign shop expenditures.
  - Any excluded charges must be identified and included in either program or enterprise support.
- Material charges must be based on material consumption.
- All expenditures associated with maintenance and operation of maintenance facilities, including utilities, stores operation, and others, must be identified.
  - Any missing expenditures must be included in enterprise support.
- All maintenance program management expenditures must be identified, including the costs associated with state and regional maintenance engineers and managers, which are sometimes excluded from maintenance management systems.
  - Any missing management expenditures must be obtained from another source (for example, the financial management system) and included in program support.

Classification of Maintenance Expenditures

Once all of the maintenance program activities and expenditures have been gathered, they must be classified as either line or support activities according to the following definitions.

Line activity. An activity that involves the actual performance of work on, or inspection of (if required by law), one or more transportation infrastructure assets, as well as work responding to an unpredictable event. Examples of line activities include pothole patching, mowing, snow and ice control, bridge inspection, and accident and disaster recovery.

Support activity. An activity that is done in support of one or more line activities. Examples of support activities include administrative support, training, inspection and patrol activities that identify locations where line activities must be performed, radio operations, maintenance program management, and stores operations.

In most cases, the classification of a particular activity is obvious from its name; however, activity descriptions provided in agency maintenance and procedure manuals can guide the classification where there is any question.

Illustrative Example

Table 1 identifies the set of maintenance activities, total expenditures and associated accomplishment, and the classification of expenditures as either line or support for the example.

For the purposes of this example, therefore, total line activity expenditure is $17,800,000 and total support activity expenditure is $2,200,000.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Objective

The objective of Step 2 is to establish the relationship between support and line activities in order to allocate an appropriate portion of maintenance program support expenditures to each line activity.

Sources of Information and Key Considerations

The best source of information regarding the relationships between maintenance support and line activities is the agency's maintenance personnel. This can be supplemented by documentation about agency maintenance procedures and definitions, which can often be found in agency maintenance manuals, maintenance management system documentation, and training materials. The effort required to establish the relationships between activities depends on both the number of activities and the clarity of definition.

A key consideration for this step in the process is the objective that the full cost determination process be as practical as possible. To satisfy this objective it is recommended that unless a particular maintenance support expenditure is unambiguously associated with only a subset of the line activities, it should be associated with all line activities. Examples of support activities that are only associated with a subset of line include

- Inspection and patrol support activities that result in the initiation of one or more line activities. (e.g., a fence inspection support activity and fence repair, maintenance, and installation line activities).
- Sign shop support activities in cases where material-related line activity sign charges do not capture all sign shop expenditures. Sign shop support activities should be allocated to sign repair, maintenance, and installation line activities.
- Nonspecific, other activities that are a catchall for administrative and/or other activities that cannot be classified as one of the specific line activities within a particular group of related activities.
- Support activities that are exclusively in support of winter operations line activities (e.g., winter operations supervision, dining room and dormitory operations, mix deicer, and other winter-specific material functions).
- Contract solicitation and administration support activities, which should only be allocated to contractor line activities when separate line activities exist for in-house and contractor performance of a particular activity.

The other key consideration for this step is selecting the basis by which each support activity expenditure is allocated to the line activities. The benchmark approach allocates support activity expenditures to all supported line activities on the basis of the line activity costs identified in Step 1.

Illustrative Example

Table 2 presents a crosswalk between maintenance line and support activities for the example. Line activities are represented by the rows, and support activities are represented by the columns. In the event that a particular line activity is supported

Table 1. Example classification of maintenance activities and expenditures.

Activity Name	Type	Total Expenditure	Accomplishment	Units
Crack sealing	Line	$500,000	75,000	Pounds
Deicing	Line	$10,000,000	9,000,000	Pounds
Sign washing	Line	$300,000	20,000	Each
Striping	Line	$7,000,000	18,000	Linear feet
Subtotal		**$17,800,000**		
Mix deicer	Support	$250,000	N/A	None
Training	Support	$200,000	N/A	None
Management	Support	$1,500,000	N/A	None
Stores	Support	$250,000	N/A	None
Subtotal		**$2,200,000**		
Total		**$20,000,000**		

Table 2. Example line and support activity crosswalk.

Line Activities	Support Activities			
	Mix Deicer	Training	Management	Stores
Crack sealing		X	X	X
Deicing	X	X	X	X
Sign washing		X	X	X
Striping		X	X	X

by a particular support activity, an X is displayed in the corresponding cell. In this case, three out of the four support activities provide support to all four line activities. However, as might reasonably be interpreted from its name, the mix-deicer support activity is only related to the deicing line activity.

Table 3 illustrates the results of applying the benchmark approach to allocate support activity expenditures to the line activities. The allocation calculation is performed for each valid combination of line and support activities (i.e., for each X in Table 2). The support activity allocation is equal to:

$$(\$LAIQ/\$ASLA) * \$SAIQ$$

Where
$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$SAIQ = cost of support activity in question.

For example, the allocation of the mix-deicer support activity to deicing equals

$$(\$10{,}000{,}000/\$10{,}000{,}000) * \$250{,}000 = \$250{,}000.$$

Step 3: Gather and Classify Enterprise Programs and Expenditures

Objective

The objectives of Step 3 are to collect information on all enterprise programs and expenditures and to classify them as line, support, or special/pass-through.

Sources of Information and Key Considerations

In most agencies there are multiple sources of information on enterprise program expenditures. The most common sources of this data include agency and/or state financial management systems and data warehouses, as well as annual agency reports. For example, a number of state DOTs prepare a CAFR, which presents detailed financial information, including changes in asset values, sources and amounts of revenue, expenditures broken down in a variety of ways, and associated notes and commentary. Other potential sources include agency indirect cost allocation plans and reports detailing annual budgets, as well as budget versus expenditure reports.

In order to ensure the validity of the full cost calculation, there are a number of key issues that must be considered. For example:

- If enterprise expenditure data is obtained from a CAFR or other financial report, care must be taken to ensure that all expenditure categories are fully accounted for and that no expenditures are double counted.
- If enterprise expenditure data is extracted from an FMS, it is important to understand whether any expenditures are automatically allocated, and if so, which ones, on what basis, and to which other expenditures they are allocated.

Classification of Enterprise Expenditures

Once all of the enterprise expenditures have been gathered, they must be categorized as line, support, or special/pass-through according to the following definitions.

Table 3. Example allocation of support activity expenditures to line activities.

Line Activities	Allocation of Support Activity Expenditures				Total Support Activity Allocation
	Mix Deicer	Training	Management	Stores	
Crack sealing		$5,618	$42,135	$7,022	**$54,775**
Deicing	$250,000	$112,359	$842,697	$140,449	**$1,345,506**
Sign washing		$3,371	$25,281	$4,213	**$32,865**
Striping		$78,652	$589,887	$98,315	**$766,854**
Totals	**$250,000**	**$200,000**	**$1,500,000**	**$250,000**	**$2,200,000**

Note: Some totals rounded to the nearest dollar.

Line program. A line program is a logical grouping of similar activities or projects that are primarily focused on actually delivering the main work products of a state DOT. For example, construction projects make up a construction program, and maintenance activities and projects make up a maintenance program.

Support program. A support program is one that supports the delivery of one or more line programs (e.g., agency executive management, information systems, human resources, legal, and finance).

Special/pass-through. Many state DOTs report expenditures that do not fit nicely into either the line or support categories (e.g., debt-related expenditures associated with past bond issuance, or direct payments or pass-throughs to other state and local agencies).

Debt-related expenditures are, in most cases, the result of agency efforts to advance larger construction programs sooner than traditional revenues would permit. In this case, debt-related expenditures have nothing whatsoever to do with the maintenance program. The classification of debt expenditures as an enterprise support program allocable to maintenance would falsely increase the allocation of enterprise support expenditures to line activities.

Direct payments or pass-throughs to other state or local government agencies, unlike construction and maintenance programs, do not involve DOT personnel administering, overseeing, or performing work, nor do they benefit the agency in any way. The classification of direct payments or pass-throughs as a line program would falsely reduce the allocation of enterprise support expenditures to line activities.

The examples described, or any similar expenditures, must be excluded from the calculation. The full cost determination process therefore identifies a third category of enterprise expenditures, special/pass-through, and any expenditure identified as such is indeed excluded.

In most cases, the classification of a program is obvious from its name; however, program descriptions provided in agency annual reports and budget documents can guide the classification where there is any question.

Illustrative Example

Table 4 lists the set of enterprise programs, total expenditures, and the classification of programs as line, support, or special/pass-through for the example. In this case, the equipment fund is classified as special/pass-through because it represents all expenditures associated with the agency vehicle fleet, which are in turn charged in their entirety to the line programs through rental rates. In this case, classifying the equipment fund as a special/pass-through expenditure ensures that these charges are not double counted.

For the purposes of this example, therefore, total line program expenditure is $127,500,000, total support program expenditure is $8,000,000, and $7,500,000 associated with the equipment fund is excluded from the calculation.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Objective

The objective of Step 4 is to establish the relationship between enterprise support and line programs in order to allocate an appropriate portion of enterprise support expenditures to the maintenance program.

Sources of Information and Key Considerations

The best source of information regarding the relationships between enterprise support and line programs is the agency's

Table 4. Example classification of enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Maintenance	Line	$20,000,000
Construction	Line	$100,000,000
Traffic operations	Line	$2,500,000
Public transportation	Line	$5,000,000
Subtotal		**$127,500,000**
Administration	Support	$5,000,000
Program delivery support	Support	$3,000,000
Subtotal		**$8,000,000**
Equipment fund	Special/pass-through	$7,500,000
Total		**$143,000,000**

Table 5. Example line and support program crosswalk.

Line Programs	Support Programs	
	Program Delivery Support	Administration
Maintenance	X	X
Construction	X	X
Traffic operations		X
Public transportation		X

personnel. This can be supplemented by documentation about agency programs, which can usually be found in agency annual reports and budget documents.

As with Step 2, a key consideration for this step in the process is the objective that the full cost determination process be as practical as possible. To satisfy this objective, it is recommended that unless a particular enterprise support program is unambiguously associated with only a subset of the line programs, it should be associated with all line programs. For example, some state DOTs have program delivery support programs that only relate to the construction and maintenance programs. Similarly, enterprise expenditures related to testing and labs, sign shops, equipment/fleet maintenance and garages, and line-program–specific administration and supervision are examples of support programs that may only support the construction and maintenance line programs.

The other key consideration for this step is selecting the basis by which expenditures in each enterprise support program are allocated to the line programs. The benchmark approach allocates support program expenditures to line programs on the basis of the line program costs identified in Step 3.

Illustrative Example

Table 5 presents a crosswalk between the enterprise line and support programs for the example. Line programs are represented by the rows, and support programs are represented by the columns. In the event that a particular line program is supported by a particular support program, an X is displayed. In this case, the program delivery support program is only related to the maintenance and construction line programs.

Table 6 illustrates the results of applying the benchmark approach to allocate support program expenditures to the line programs. The allocation calculation is performed for each valid combination of line and support programs (i.e., for each X in Table 5). The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = line cost of line program in question,
$ASLP = line cost of all supported line programs, and
$SPIQ = cost of support program in question.

For example, the allocation of the program delivery support program to maintenance is

$$(\$20{,}000{,}000/\$120{,}000{,}000) * \$3{,}000{,}000 = \$500{,}000.$$

The share of enterprise support that must be allocated to the maintenance program is therefore $1,284,314.

Step 5: Combine Cost Categories to Derive Full Cost

Objective

The objective of Step 5 is to combine the line activity cost with the appropriate allocations of both maintenance program and enterprise support expenditures to determine the full cost of the line activities.

Table 6. Example allocation of support program expenditures to line programs.

Line Programs	Allocation of Support Program Expenditure		Total Support Program Allocation
	Program Delivery Support	Administration	
Maintenance	$500,000	$784,314	**$1,284,314**
Construction	$2,500,000	$3,921,569	**$6,421,569**
Traffic operations	N/A	$98,039	**$98,039**
Public transportation	N/A	$196,078	**$196,078**
Total	**$3,000,000**	**$5,000,000**	**$8,000,000**

Table 7. Example full cost breakdown for line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Crack sealing	$500,000	$54,775	$36,076	**$590,851**
Deicing	$10,000,000	$1,345,506	$721,525	**$12,067,031**
Sign washing	$300,000	$32,865	$21,646	**$354,511**
Striping	$7,000,000	$766,854	$505,067	**$8,271,921**
Total	**$17,800,000**	**$2,200,000**	**$1,284,314**	**$21,284,314**

Sources of Information and Key Considerations

All of the information required to complete the full cost calculation is produced through Steps 1 through 4. At this point, the process has identified the line activity expenditures, an allocation of maintenance program support expenditures for each line activity, and the allocation of enterprise support expenditures that must be applied to the maintenance program. The next step, therefore, is to allocate the maintenance program share of enterprise support expenditures to the line activities themselves. Consistent with the approach for program support expenditures, the benchmark approach involves doing this on the basis of line activity cost.

The result of this calculation is the total cost for each line activity. Dividing this amount by the accomplishment recorded by the agency for each activity (where available) provides the full cost per unit of production, which now incorporates a fair share of both maintenance program and enterprise support expenditures.

Illustrative Example

Table 7 draws upon numbers from Tables 1 and 3 and the results of the enterprise support cost allocation calculations. It shows the breakdown of the full cost between the three cost categories: line, program support, and enterprise support.

The allocation of enterprise support to each line activity is

$$(\$LAIQ/\$ALA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ALA = line cost of all line activities, and
$AESM = allocation of enterprise support to the maintenance program.

For example, the allocation of the enterprise support to sign washing equals

$$(\$300{,}000/\$17{,}800{,}000) * \$1{,}284{,}314 = \$21{,}646.$$

Table 8 presents the full unit costs for production of each of the line activities in the example.

Calculation Options and Exceptions

The preceding sections describe and illustrate the benchmark approach to the full cost calculation. The benchmark approach is specifically designed for ease of use (i.e., to meet the practical requirement) and should therefore be feasible/attainable in most, if not all, state DOTs. However, depending on the data available, the knowledge of the personnel performing the calculation, and the resources/time available, there are options at each step that should be considered. These are described in the remainder of this attachment.

Simplified Benchmark Approach (All to All)

The benchmark calculation described in the previous sections accounts for two different types of maintenance program and enterprise support expenditure. The first type is general in nature and effectively supports all line activities and all line programs, respectively (for example, maintenance program and agency executive management). The second type of support expenditure is for more focused support activities and programs that only support a subset of line activities and line programs, respectively. For example, sign shop activities not

Table 8. Example full unit costs for line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Crack sealing	$590,852	75,000	Pounds	$7.88
Deicing	$12,067,030	9,000,000	Pounds	$1.34
Sign washing	$354,511	20,000	Each	$17.73
Striping	$8,271,921	18,000	Linear feet	$459.55

Table 9. Example simplified allocation of support activity expenditures to line activities.

Line Activities	Allocation of Support Activity Expenditures				Total Support Activity Allocation
	Mix Deicer	Training	Management	Stores	
Crack sealing	$7,023	$5,618	$42,135	$7,022	**$61,798**
Deicing	$140,449	$112,359	$842,697	$140,449	**$1,235,954**
Sign washing	$4,213	$3,371	$25,281	$4,214	**$37,079**
Striping	$98,315	$78,652	$589,887	$98,315	**$865,169**
Totals	**$250,000**	**$200,000**	**$1,500,000**	**$250,000**	**$2,200,000**

recouped through sign material expenditures support only sign installation and maintenance activities. The second type of support expenditure can occur at both the maintenance program and enterprise levels; however, on the basis of the full cost calculations performed in this study, it is more common within the maintenance program itself.

The number of maintenance activities and enterprise programs varies by agency and, in some cases, can be quite large. As the number increases, so does the effort required to relate line and support activities and programs. In addition, activity and program definitions tend to become closer and differences more nuanced, which further increases the knowledge, time, and effort that can be expended developing the line and support crosswalks in Steps 2 and 4. Finally, although it is recommended that the full cost calculation be undertaken by a team with representatives from the maintenance program or finance division or office, as well as people knowledgeable in agency information systems, there may be circumstances where such a team approach is not possible. In any of these situations, the simplified benchmark approach can be used to determine the full cost of maintenance activities.

As its name suggests, the simplified benchmark approach simplifies Steps 2 and 4 with the assumption that all maintenance program and enterprise support expenditures support all line activities and all line programs, respectively, essentially placing Xs in every cell of the crosswalk matrices in Steps 2 and 4.

Step 2. Table 9 illustrates the results of applying the simplified benchmark approach to allocate support activity expenditures to the line activities for the example described previously. The allocation calculation is now performed for every combination of line and support activities. The support activity allocation is equal to:

$$(\$LAIQ/\$ASLA) * \$SAIQ$$

Where
$\$LAIQ$ = line cost of line activity in question,
$\$ASLA$ = line cost of all supported line activities, and
$\$SAIQ$ = cost of support activity in question.

Using the simplified benchmark approach, now the allocation of the mix deicer support activity to deicing equals

$$(\$10{,}000{,}000/\$17{,}800{,}000) * \$250{,}000 = \$140{,}449$$

(versus $250,000 calculated previously).

Step 4. Table 10 illustrates the results of applying the simplified benchmark approach to allocate support program expenditures to the line programs. The allocation calculation is now performed for every combination of line and support programs. The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where
$\$LPIQ$ = cost of line program in question,
$\$ASLP$ = cost of all supported line programs, and
$\$SPIQ$ = cost of support program in question.

Table 10. Example simplified allocation of support program expenditures to line programs.

Line Programs	Allocation of Support Program Expenditure		Total Support Program Allocation
	Program Delivery Support	Administration	
Maintenance	$470,588	$784,314	**$1,254,902**
Construction	$2,352,941	$3,921,569	**$6,274,510**
Traffic operations	$58,824	$98,039	**$156,863**
Public transportation	$117,647	$196,078	**$313,725**
Total	**$3,000,000**	**$5,000,000**	**$8,000,000**

Using the simplified benchmark approach, now the allocation of the program delivery support program to maintenance is

$$(\$20{,}000{,}000/\$127{,}500{,}000) * \$3{,}000{,}000 = \$470{,}588$$

(versus $500,000 calculated previously).

Now the allocation of enterprise support expenditures to the maintenance program is $1,254,902 (versus $1,284,314 calculated previously).

Step 5. Table 11 draws upon numbers from Tables 1 and 9 and the results of the simplified enterprise support cost allocation calculation just completed, whereby the maintenance program share of enterprise support is now $1,254,902. It shows the breakdown of the full cost between the three cost categories of line, program support, and enterprise support that results from using the simplified benchmark approach.

The allocation of enterprise support to each line activity is

$$(\$LAIQ/\$ALA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ALA = line cost of all line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Using the simplified benchmark approach, now the allocation of the enterprise support to sign washing equals

$$(\$300{,}000/\$17{,}800{,}000) * \$1{,}254{,}902 = \$21{,}150$$

(versus $21,646 calculated previously).

Table 12 presents the full unit costs for production of each of the line activities in the example using the simplified benchmark approach.

Table 13 shows a comparison of the full unit costs for the example calculated using the benchmark and simplified benchmark approaches. The difference in this case is very modest; however, using real and complete agency data can result in much more significant differences in full unit costs.

Table 11. Example simplified full cost breakdown for line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Crack sealing	$500,000	$61,798	$35,250	**$597,048**
Deicing	$10,000,000	$1,235,955	$705,001	**$11,940,956**
Sign washing	$300,000	$37,079	$21,150	**$358,229**
Striping	$7,000,000	$865,169	$493,501	**$8,358,669**
Total	**$17,800,000**	**$2,200,000**	**$1,254,902**	**$21,254,902**

Table 12. Example simplified full unit costs for line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Crack sealing	$597,048	75,000	Pounds	$7.96
Deicing	$11,940,956	9,000,000	Pounds	$1.33
Sign washing	$358,229	20,000	Each	$17.91
Striping	$8,358,669	18,000	Linear feet	$464.37

Table 13. Example comparison of benchmark and simplified benchmark full unit cost.

Line Activity	Units	Full Unit Cost		Percent Difference
		Benchmark	Simplified Benchmark	
Crack sealing	Pounds	$7.88	$7.96	1.01%
Deicing	Pounds	$1.34	$1.33	-0.75%
Sign washing	Each	$17.73	$17.91	1.01%
Striping	Linear feet	$459.55	$464.37	1.04%

Forward-Looking or Budgetary Approximation

The sources, calculation, and tracking details for the line activity, program support, and enterprise support expenditures vary by agency. However, irrespective of these variations, the full cost calculation requires that these costs be obtained from somewhere. The prior description of Steps 1 and 3 focuses on a backward-looking, accounting approach to determining the contributions to full cost for each category of cost. If such a forensic approach is possible, combining actual expenditures, it is the most straightforward (i.e., practical) solution. However, it also is possible to make a forward-looking cost projection of the type that is done during the budget development process.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

The following steps provide an example of forward looking or budgetary approximation for determining the cost of maintenance activities.

1. Estimate the number of crew days of a particular maintenance activity that will be required during the next budget year;
2. Determine the crew profile that will be required to perform each activity (i.e., number and classes of maintenance personnel);
3. Estimate the average daily crew cost by using current average loaded rates by personnel class as well as any cost-of-living or other adjustments;
4. Multiply the results of Steps 1 and 3 to estimate the projected labor cost for the activity;
5. Review past expenditures on the activity in question and calculate the percentage of the total cost contributed by LEMO; and
6. Estimate equipment, material, and other costs using the results of Steps 4 and 5 and combine them with the labor estimate—this gives an estimate of the sum of line cost elements for the activity.

The process must be completed for all activities prior to moving on to Step 2. In addition, it is important to understand the extent to which maintenance program support is covered by the budget activities. In the event that certain support expenditures are not covered—say, for example, expenditures for the state maintenance engineer and other maintenance program support and administration—these must either be added as additional activities here and their expenditures estimated, or they must be identified as a maintenance-program–specific enterprise support expenditure in Step 3.

Step 2: Gather and Classify Enterprise Programs and Expenditures

As with Step 1, the preferred approach to obtaining this information is to extract it from agency information systems and/or financial reports for a complete fiscal year in the past (i.e., actual expenditure information). However, just as for maintenance program activities and expenditures, another option is to use forward-looking budgetary information as the principal input for this step.

Allocation Basis

Step 3: Allocate Maintenance Support Expenditures to Line Activities

In order to help ensure the practicality of the full cost determination process, both the benchmark and simplified benchmark approaches described and illustrated in this document consistently use the line cost as the basis for allocating all program support expenditures to line activities. However, an agency may choose a different basis for allocating all program support expenditures or even choose different bases for different support activities.

Beyond line activity cost, the most obvious alternative allocation basis can be found within the elements of line cost as follows:

- Workman's compensation support activity expenditures (or other support activity expenditures reasonably related to labor expended) could be allocated on the basis of labor expenditure for each line activity;
- Material stores and handling support activities expenditures could be allocated on the basis of material expenditure for each line activity;
- Unused equipment and other equipment support activity expenditures could be allocated on the basis of equipment expenditure for each activity; and
- Contractor solicitation, administration, and oversight support activities could be allocated on the basis of other expenditures for each activity (provided other expenditures are predominantly contractor payments).

In addition, labor hours and equipment hours could be used as the basis of allocating support activity expenditures.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

As with the allocation of program support expenditures, both the benchmark and simplified benchmark approaches described and illustrated in this document consistently use the

line cost as the basis for allocating all enterprise support expenditures to line programs. However, an agency may choose a different basis for allocating all enterprise support expenditures, or even choose different bases for different support programs. For example, one state DOT's indirect cost allocation plan identifies 25 different bases of allocation. Each of these bases is used for allocating one or more of its 34 indirect cost pools (support programs) to 21 direct programs (line programs). Examples of the different bases include total department expenditures, total district expenditures, consulting services expenditures, federal construction expenditures, nonlabor expenditures, total number of employees, total number of headquarters building employees, total right-of-way expenditures, total construction charges, and maintenance charges.

Step 5: Combine Cost Categories to Derive Full Cost

All allocations of enterprise support expenditures to line activities so far have been made on the basis of the line activity expenditures identified in Step 1. However, alternative approaches to allocating the maintenance program's share of enterprise support expenditures can be considered in much the same way as has been discussed for Steps 2 and 4. In addition to the various allocation bases previously discussed (some of which might similarly be candidates here), another candidate for consideration is the line activity plus program support cost basis, whereby the allocation of enterprise support to each line activity is

$$[(\$LAIQ + \$PSLAIQ)/(\$ALA + \$PSALA)] * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$PSLAIQ = program support cost of line activity in question,
$ALA = line cost of all line activities,
$PSALA = program support cost of all line activities, and
$AESM = allocation of enterprise support to maintenance program.

Applying this approach to the benchmark example, the allocation of the enterprise support to sign washing equals

$$[(\$300{,}000 + \$32{,}865)/(\$17{,}800{,}000 + \$2{,}200{,}000)]$$

$$* \$1{,}284{,}314 = \$21{,}375 \text{ (versus \$21,646 calculated previously)}.$$

Allocation Basis Considerations

Provided that the data is available for all activities and/or programs, there are clearly a number of allocation bases for an agency to choose from. However, before pursuing allocation bases other than line activity costs, agencies must consider two important issues:

1. **Calculation complexity and level of effort:** If an agency chooses to use different bases for allocation for different support activities, the complexity of the calculation will increase, as will the level of effort required and the potential for error.
2. **Potential for disagreement:** By introducing multiple bases for allocation, an agency opens the door for debate about which basis should be used for which support activities, which may ultimately weaken the perception of the validity/correctness of the full cost determination process results.

Maintenance Program Expenditure Reconciliation

Step 4 of the full cost process involves allocating a share of enterprise support expenditures to the maintenance program on the basis of maintenance program expenditure. As a result, in any case where the expenditure data for the full cost calculation is drawn from both agency maintenance and financial management systems (MMS and FMS), the total maintenance program expenditures from both sources must be compared. In the event that there is a significant discrepancy (say greater than or equal to 10%), a reasonable attempt must be undertaken to identify its source, and a fair assessment of total maintenance program expenditures is used as the basis for determining the enterprise support expenditure allocation. If the investigation reveals that the maintenance program expenditure from the FMS is low (compared with the MMS expenditure), the maintenance program share of enterprise support calculated using FMS data must be scaled up by the ratio of MMS expenditure to FMS expenditure.

Full Cost Versus Full Unit Cost of Production

The full cost calculations described in this process result in both a total full cost for each activity considered and a full unit cost, derived by dividing the full cost by reported accomplishment. Although there is value in both figures, from a practical standpoint, the full unit cost is more useful and therefore more valuable. The calculation of full unit cost relies on the agency selecting useful units of accomplishment for line activities (for example, tons, yards, square feet, linear feet, each), and then capturing and recording this data accurately. As a consequence and at a minimum, any agency undertaking the full cost calculation should consider its level of confidence in its accomplishment data and treat full unit costs accordingly. In addition, in the event that a single line activity is performed by a combi-

nation of in-house personnel and contractors, it is critical to understand whether accomplishment data is being recorded consistently in both cases. If, as it appears to sometimes be the case, contractor accomplishment data is either questionable or absent, then full unit costs calculated will be high.

Implications of Automatic Indirect Cost Allocation

Some state DOTs have implemented indirect cost allocation procedures of different types directly within their financial management systems. If expenditure data for the full cost determination process is extracted from the financial management system, it is important to understand what, if any, indirect cost allocations already have occurred. Depending on the agency, indirect cost allocation plans can be quite complex and it can take considerable effort to understand them. It is therefore recommended that, whenever possible, raw and unallocated agency expenditure data be used as the point of departure for the full cost determination process. In this way, all classification and allocation activities for both program and enterprise support expenditures occur through the full cost determination process itself, increasing the transparency of the calculation. Of course, if automatic indirect cost allocations are performed in a way that is entirely consistent with the full cost determination process described in this report, the full cost of activities can be obtained directly from the financial management system. However, it is paramount that the allocation procedures used to derive the full cost are reviewed, understood, and confirmed as being consistent with the full cost determination process.

Full Cost Calculation for Network and Geographic Subsets

The full cost determination process described here was developed in order to calculate the full unit cost of maintenance activities on a statewide basis. However, there is nothing to prevent its application to a subset of a state (e.g., a particular functional class or another geographic designation such as a district or region), provided that the requisite portion of total line expenditure and accomplishment data for a particular maintenance activity can be readily identified. The approach for allocating program and enterprise support expenditures to a subset of total line activity expenditure is no different than to the statewide line activity total (i.e., based on the line cost amount). It must be noted, however, that from a practical standpoint, there are limits to how finely the line cost data can be sliced. At some point, it is possible that a particular maintenance activity is not performed in the selected geographic subset within the timeframe for which cost and accomplishment data has been obtained. It is therefore recommended that the full cost process be applied at higher levels of aggregation—for example, by functional class or by district, and not, for example, from milepost A to milepost B on a specific highway.

Additional Considerations

The full cost determination process described here enables the calculation of an agency's full cost to perform a particular maintenance activity. However, in order to support the use of the resulting dollar amount in any other analysis or comparison, it is critical that it be placed into context. At a minimum and as previously stated, this context should include a combination of cost and units of measure for the particular activity in order to derive an agency's total (or full) unit price for the activity. In addition, it is critical to consider the impact on level of service resulting from this expenditure. In other words, what was the condition or level of service associated with the maintenance activity at the beginning and end of the analysis period? Did the level of service fall or rise (and if so by how much) or remain flat as a result of the expenditure?

In addition, if the resulting cost is going to be used as an input for a forward-looking decision and it has been derived from a backward-looking analysis (i.e., a forensic accounting exercise), inflation must be considered. Although historically inflation has been relatively modest in the area of highway construction and maintenance, more recently agencies have experienced periods of much higher inflation. This is particularly important in the area of oil and petroleum products, which are important to most maintenance activities in that they drive the price of the fuel that is used by all of the equipment. For this reason and depending on the purpose of determining the agency's full cost for performing a particular line activity, it will be important to ensure appropriate consideration for inflation and apply a factor to the resulting full unit cost.

Summary Process, Input, and Result Illustration

Figure 3 lists the process's five steps and the inputs and results of each.

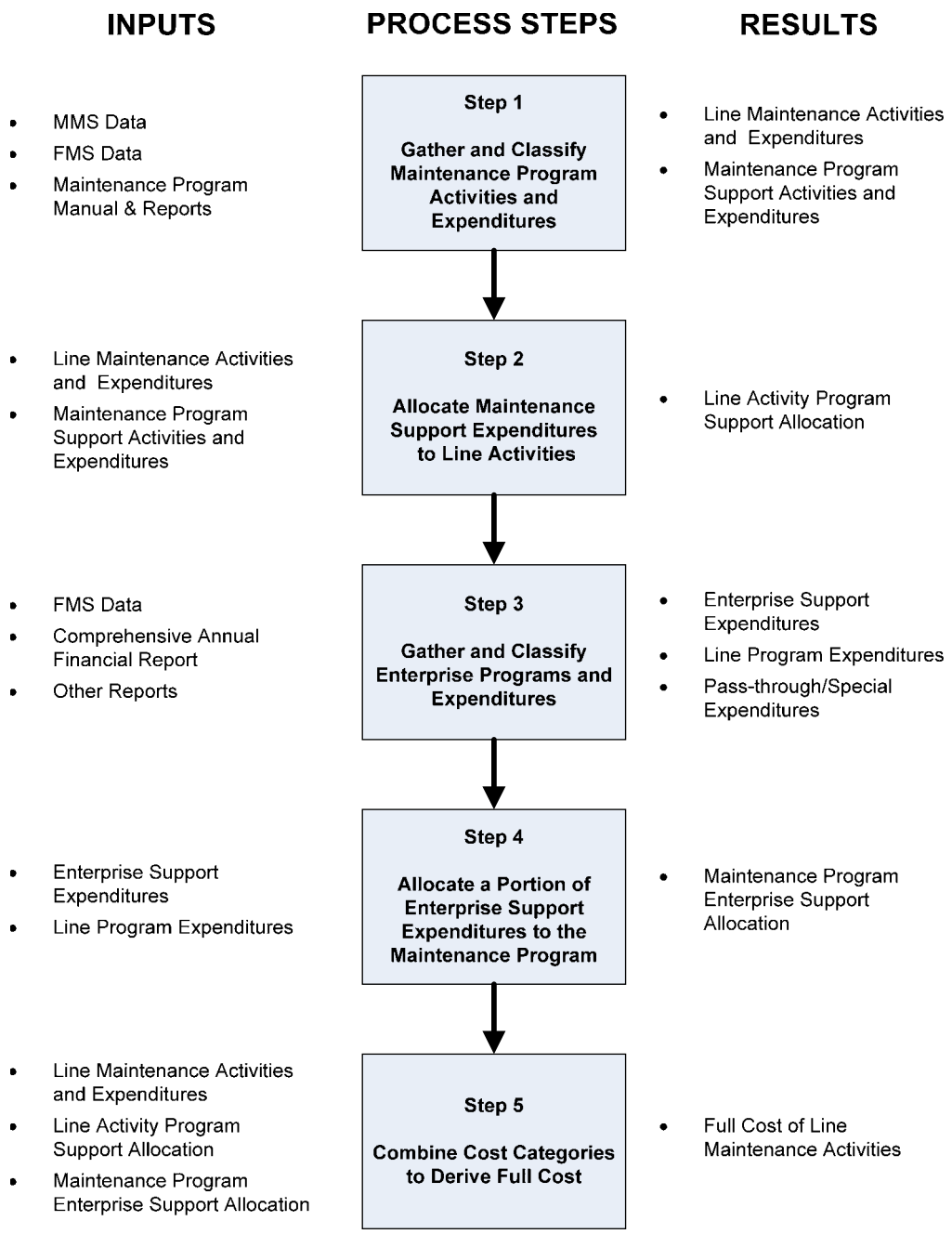

Figure 3. Summary process, input, and result illustration.

APPENDIX A

Documented Calculations for Selected State DOTs

Introduction

This appendix illustrates the application of the full cost determination process to DOTs in six states: Alabama, Arizona, Missouri, North Carolina, Texas, and Washington. In each case, a summary introduction to the agency and its maintenance program is provided, and then the five-step calculation process is documented using data provided by the agency from its management systems, annual financial and maintenance activity reports, and other documents and reports. The purposes of this appendix are to supplement the process description and provide practitioners with examples of the full cost determination process being applied in state DOTs.

Contents

Alabama DOT

Alabama Department of Transportation (ALDOT) is responsible for a highway network of approximately 11,000 centerline miles and 28,000 lane miles, as well as some 5,700 bridges with a total deck area of approximately 6.4 million square meters. ALDOT expended approximately $200 million on maintenance activities during fiscal year 2008 out of a total budget of approximately $1.3 billion.

At its lowest level, the ALDOT Bureau of Maintenance is divided into 41 geographic maintenance districts, each of which encompasses between two and four counties. Each maintenance district belongs to one of nine maintenance divisions, which comprise between four and 10 counties, with overall administration and coordination being provided by ALDOT's central office. In addition, ALDOT has a number of statewide specialty maintenance crews; for example, it has three specialty bridge inspection crews as well as statewide crews for traffic signals, signs, and underwater inspections.

ALDOT organizes its approximately 70 maintenance work activities into the following major categories:

- Roadway and shoulder maintenance,
- Drainage maintenance,
- Roadside maintenance,
- Traffic operations maintenance,
- Structure maintenance,
- Minor maintenance improvements,
- Winter and emergency maintenance,
- Service activities,
- Overhead and support activities, and
- Special maintenance.

ALDOT uses the following systems to capture and manage maintenance cost data:

- **Maintenance management system:** ALDOT currently uses a circa-1970s Jorgensen mainframe maintenance management system for both maintenance budget development and recording maintenance work accomplishments. The agency recently engaged a consultant to review ALDOT's requirements and evaluate off-the-shelf MMS products, with the goal of replacing the current mainframe system with a modern MMS over the next couple of years. ALDOT's budget development process uses the prior year's expenditures (or budget) as its starting point, to which it applies salary escalation and cost-of-living adjustments to determine a new proposed budget. The system includes a work calendar and specifies approximately 70 separate maintenance activities. Once the budget is finalized, the system produces crew-day cards for the entire year, based on the work calendar, for each activity. Bundles of crew-day cards are then distributed to the superintendent in each of the 41 districts. A single crew-day card covers one

day's work of a particular maintenance activity in one of the 41 districts.

Note: Activities in the structure maintenance area are broken down further in the Alabama Bridge Information Management System (ABIMS), where approximately 40 activities are mapped back to fewer than 10 MMS activities.

- **Financial management system:** ALDOT's comprehensive project management system (CPMS) is a custom-developed financial management system that has been in use since 1999. It was developed to replace ALDOT's prior system, both in order to address the Y2K issue and to create a tighter connection between expenditures and the agency's highway network by integrating with the agency's GIS. At its highest level CPMS reports costs by broad program (e.g., surface transportation preservation, administration, aeronautical). Beneath this, and specifically in the case of routine maintenance, all expenditures are assigned to the following hierarchy:

  Division (1 of 9)
  District (1 of 41)
  Route class [Interstate Highway System (IHS), National Highway System (NHS), other]
  Account (work activity group—listed earlier)
  Function/activity code (e.g., mowing, ditch cleaning)
  Object of expenditure (salary, equipment, materials).

The foundation of maintenance activity scheduling and cost tracking at ALDOT is the crew-day cards. All maintenance work, including certain maintenance overhead activities, is recorded on a daily basis directly on the crew-day cards produced by the MMS at the end of the budget development process. Select information on the crew-day cards is then entered into both the CPMS and MMS systems by the district clerk on a daily basis as work is performed throughout the year. Labor hours are entered into the CPMS and accomplishment data (i.e., units of production of the particular maintenance activity) and material and equipment usage are entered into the MMS.

Documented ALDOT Full Cost Calculation

The full cost determination process was applied to all ALDOT maintenance activities; however, for the purposes of this summary, two line activities have been selected in order to best demonstrate the benchmark process. The line activities selected are

- 601 – Spot premix patching, and
- 638 – Guardrail maintenance.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

ALDOT provided expenditure and accomplishment data for 69 different maintenance activities obtained from its Jorgensen maintenance management system for the year ending September 30, 2009. This data was reviewed in conjunction with the activity descriptions included in ALDOT's *Field Operations Manual* and activities classified as either line or support. Table A.1 presents the summary results of the classification process.

Pertinent observations resulting from the classification process are as follows.

For the majority of the maintenance categories identified above, ALDOT specified an "other <maintenance category> maintenance" activity, in addition to a number of specific activities. Based on the "other" activity descriptions, the fact that in a number of cases the "other" expenditure amounts are a significant fraction of the sum expenditures for the specific activities, and for the sake of consistency, the ALDOT "other" activities were classified as line.

ALDOT's support activities are all of the type that supports all line activities (i.e., there are no support activities that are related to any subset of the line activities).

Table A.2 shows the line activity expenditure and production information for the line activities selected.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Based on the nature of ALDOT's support activities observed above, the allocation of support expenditures to line activities is

Table A.1. ALDOT maintenance activity expenditure and classification.

Activity Classification	Number of Activities	Total Expenditure	Percentage of Total
Line	56	$109,443,589	93.4%
Support	13	$7,693,100	6.6%
Total	**69**	**$117,136,689**	**100.0%**

Table A.2. Selected ALDOT line activity expenditure and production.

Activity ID	Activity Name	Line Expenditure	Accomplishment	Units
601	Spot premix patching	$3,006,423	6,445	Ton mix
638	Guardrail maintenance	$2,295,593	77,217	Linear feet

accomplished using the simplified benchmark (or all-to-all) approach on the basis of line activity expenditure. In this case, the program support allocation to each line activity is calculated using the following formula:

$$(\$LAIQ/\$ALA) * \$ASA$$

Where

$LAIQ = line cost of line activity in question,
$ALA = line cost of all line activities, and
$ASA = cost of all support activities.

Therefore

The allocation of maintenance program support to spot premix patching equals

$$(\$3{,}006{,}423/\$109{,}443{,}589) * \$7{,}693{,}100 = \$211{,}330$$

and

The allocation of maintenance program support to guardrail maintenance equals

$$(\$2{,}295{,}593/\$109{,}443{,}589) * \$7{,}693{,}100 = \$161{,}364.$$

Step 3: Gather and Classify Enterprise Programs and Expenditures

Enterprise programs and expenditures were obtained from ALDOT's financial management system (CPMS) for the fiscal year ending September 30, 2008. Program descriptions and summary expenditure information were also used from ALDOT's 97th Annual Report for fiscal year 2008. Table A.3 details the set of enterprise programs, the total expenditures, and the classification of programs as line, support, or special/pass-through. The following notes are provided to further explain the table, its content, and information sources.

- The CPMS extracts provided by ALDOT excluded all debt service payments and transfers to other agencies (e.g., Public Safety).
- The Administrative Support line item represents the total expenditure in more than 20 different offices and bureaus,

Table A.3. Classification of ALDOT enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Routine Maintenance	Line	$117,613,257
Federal Construction	Line	$928,285,059
State Construction	Line	$67,313,172
Special Work Authorizations	Line	$1,007,224
Maintenance Projects	Line	$78,276,986
Subtotal		**$1,192,495,698**
Administrative Support	Support	$67,170,364
Operations and Support Services	Support	$15,022,157
Other Equipment Purchases	Support	$9,098,918
Construction Bureau Administration	Support	$1,828,936
Maintenance Bureau Administration	Support	$4,652,871
Supervision – Division (Construction)	Support	$38,932,666
Supervision – District (Maintenance)	Support	$21,930,133
Subtotal		**$158,636,045**
Total		**$1,351,131,743**

Table A.4. ALDOT line and support program crosswalk.

	Support Programs						
				Bureau Administration		Supervision – Division	
Line Programs	Administrative Support	Operations and Support Services	Other Equipment Purchases	Construction	Maintenance	Construction	Maintenance
Routine Maintenance	X	X	X		X		X
Federal Construction	X	X	X	X		X	
State Construction	X	X	X	X		X	
Special Work Authorizations	X	X	X				
Maintenance Projects	X	X	X		X		X

which have been condensed in order to keep the table to a reasonable size.

- Other Equipment Purchases are for equipment other than vehicles (e.g., engineering, lab, sign shop, traffic signal testing equipment) as well as computers and reprographic equipment.
- Operations and Support Services includes claims and damages, county engineers' salaries, insurance support services, telephone and data support services, charges by other state agencies, and freight express drayage and postage support services.
- Maintenance Bureau Administration and Supervision – District are maintenance-program–specific support programs that are not included in the routine maintenance or the maintenance project amounts (likewise for construction).

Based on the CPMS extracts, guidance from ALDOT's Finance and Audits Bureau personnel, and ALDOT's 97th Annual Report, total line program expenditure is $1,192,495,698, total support program expenditure is $158,636,045, and all special/pass-through expenditures have been excluded.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Based on the enterprise program expenditure information obtained in Step 3, ALDOT has seven support programs and five line programs. However, a number of the support programs are related to only a subset of the line programs. For example, Maintenance Bureau Administration supports only the Routine Maintenance and Maintenance Projects line programs. In order to appropriately allocate enterprise support expenditures to the Routine Maintenance program, the benchmark approach must be used. Table A.4 presents a crosswalk between ALDOT's enterprise line and support programs. The allocation calculation is performed for each valid combination of line and support programs (i.e., for each X in Table A.4). The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = line cost of line program in question,
$ASLP = line cost of all supported line programs, and
$SPIQ = cost of support program in question.

Using this calculation the allocation of Maintenance Bureau Admin to Routine Maintenance is

$$[\$117,613,257/(\$117,613,257 + \$78,276,986)] * \$4,652,871 = \$2,793,602.$$

Table A.5 shows the results of this allocation calculation for all line programs as well as the total enterprise support expenditure allocation to each line program.

Table A.5. Allocation of ALDOT support program expenditures to line programs.

	Allocation of Support Program Expenditure							Total Support Program Allocation
				Bureau Administration		Supervision – Division		
Line Programs	Administrative Support	Operations and Support Services	Other Equipment Purchases	Construction	Maintenance	Construction	Maintenance	
Routine Maintenance	$6,624,867	$1,481,603	$897,406		$2,793,602		$13,166,937	**$24,964,415**
Federal Construction	$52,288,025	$11,693,832	$7,082,952	$1,705,280		$36,300,398		**$109,070,487**
State Construction	$3,791,587	$847,960	$513,609	$123,656		$2,632,268		**$7,909,080**
Special Work Authorizations	$56,734	$12,688	$7,686					**$77,108**
Maintenance Projects	$4,409,151	$986,074	$597,265		$1,859,269		$8,763,196	**$16,614,955**
Support Program Total	**$67,170,364**	**$15,022,157**	**$9,098,918**	**$1,828,936**	**$4,652,871**	**$38,932,666**	**$21,930,133**	**$138,636,045**

Using the benchmark approach, ALDOT's Routine Maintenance program receives an enterprise support expenditure allocation of $24,964,415.

Step 5: Combine Cost Categories to Derive Full Cost

The final step in the full cost calculation pulls together the line expenditure for each activity from Step 1 and the allocation of program support expenditure to each activity from Step 2 and combines these with an allocation of the enterprise support expenditures that were allocated to the maintenance program in Step 4. The allocation of enterprise support to each line activity is calculated as follows:

$$(\$LAIQ/\$ASLA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Therefore

The allocation of the enterprise support expenditures to spot premix patching equals

$$\$3,006,423/\$109,443,589 * \$24,964,415 = \$685,774$$

and

The allocation of enterprise support expenditures to guardrail maintenance equals

$$(\$2,295,593/\$109,443,589) * \$24,964,415 = \$523,632.$$

Table A.6 shows the breakdown of full cost between the three cost categories of line, program support, and enterprise support for the two selected line activities.

Table A.7 presents the full unit costs for production of each of the line activities selected.

Arizona DOT

The Arizona Department of Transportation's (ADOT) annual maintenance budget is approximately $150 million. ADOT is responsible for maintaining roughly 7,000 centerline miles of highway, representing nearly 19,000 lane miles, as well as approximately 4,500 bridges with a total deck area approaching 3 million square meters.

ADOT's maintenance division is organized into nine geographic districts. Each district consists of several smaller units, which are referred to as maintenance orgs. ADOT also has four maintenance regions that are responsible for signing, striping, and traffic signals across the state. The region boundaries overlap with the district boundaries, with each region spanning multiple districts.

ADOT organizes its maintenance costs into the following line items for budgeting purposes:

- Paved surfaces,
- Roadside,
- Traffic,
- Landscaping,
- Vegetation,
- Rest areas,
- Winter,
- Leave,
- Training,
- Other operating costs (e.g., nonhighway utilities), and
- Central office.

ADOT uses the following three systems to capture and manage maintenance cost data:

- **Maintenance management system:** ADOT has used a maintenance management system known as PECOS for

Table A.6. Full cost breakdown for selected ALDOT line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Spot premix patching	$3,006,423	$211,330	$685,774	**$3,903,527**
Guardrail maintenance	$2,295,592	$161,364	$523,632	**$2,980,588**

Table A.7. Full unit costs for selected ADOT line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Spot premix patching	$3,903,527	6,445	Ton mix	**$605.67**
Guardrail maintenance	$2,980,588	77,217	Lin feet	**$38.60**

over 25 years to capture usage and cost information on maintenance resources by maintenance activity and organizational unit. Field crews enter labor, equipment, and material data by activity into PECOS on a daily basis. ADOT's activity structure is updated frequently, with the total number of activities being around 250. ADOT's Maintenance Office uses PECOS to support its maintenance planning and budgeting processes. ADOT currently is in the process of updating how cost information is handled in PECOS.

- **Financial management system:** Maintenance expenditures also are captured in a financial management system referred to as ADVANTAGE. This system stores department-wide information on revenues and costs of all programs and is used to support business operations throughout ADOT. For the maintenance program, ADVANTAGE is used to track and manage accounts payable and accounts receivable.
- **Maintenance budget system:** ADOT is in the final stages of implementing a maintenance budgeting system (MBS) that will enable it to develop performance-based budget requests. The MBS combines cost and accomplishment data stored in PECOS with condition data collected though ADOT's maintenance quality assurance program. With this information, ADOT can determine the current conditions of its maintained features (which are expressed in the form of maintenance levels of service) and estimate the future costs of achieving a higher or lower level of service.

For planning and budgeting purposes, PECOS is the primary source of maintenance cost data used by ADOT. While the MBS is designed to support the budgeting process, it uses cost data directly from PECOS. Also, while cost information in ADVANTAGE can be a useful QA/QC tool for evaluating PECOS results, ADOT has found that the system was not designed to handle cost data in a manner that supports the maintenance management function.

Most of the cost data captured in PECOS are manually entered by maintenance crews from around the state on a daily basis. Therefore, when determining the cost of activities, data quality is a major concern. To address this issue, ADOT is working to automate quality checks and to streamline the data-entry process so that there is less room for error. For example, when data is imported from PECOS into the MBS, the MBS compares the unit cost of each activity between all of the districts and flags activities where the variance is greater than a factor of 4. ADOT has found that when this occurs, the issue is typically erroneous accomplishment data. Also, ADOT plans to add new activity-specific drop menus in PECOS that will guide users through the process of recording vehicle, equipment, and accomplishment data.

Documented ADOT Full Cost Calculation

The full cost determination process was applied to all ADOT maintenance activities; however, for the purposes of this summary, two line activities have been selected in order to best demonstrate the benchmark process. The line activities selected are

- 422 – Guideline paint (large striper), and
- 1505 – Routine fence maintenance

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

ADOT provided expenditure and accomplishment data for 228 different maintenance activities obtained from its maintenance management system, PECOS, for the fiscal year ending June 30, 2008. This data was reviewed in conjunction with detailed activity descriptions, and activities have been classified as either line or support. Table A.8 presents the summary results of the classification process.

Pertinent observations resulting from the classification process are as follows.

A number of the maintenance budget line items have an "other <budget line item> maintenance" activity defined in addition to a number of discrete line activities. These activities, which use labor hours for the unit of accomplishment, are used to record work in the particular budget line item area that does not fit within the line activities defined. These "other maintenance" activities are classified as support activities; however, it is clear that they should only be considered to provide support to the line activities associated with the particular maintenance budget line item.

ADOT has established a number of line and support activities that are specifically intended to track contractor performance of certain line activities and the associated contract administration expenditures, respectively. This provides another example of support expenditures that are incurred for the benefit of only a subset of line activities.

Table A.8. ADOT maintenance activity expenditure and classification.

Activity Classification	Number of Activities	Total Expenditure	Percentage of Total
Line	158	$74,504,568	48.8%
Support	70	$78,112,432	51.2%
Total	**228**	**$152,617,000**	**100.0%**

Four support activities with some of the largest expenditures are related to equipment: unused monthly equipment, equipment services fuel charges, equipment parts and supplies, and equipment direct billing. These account for more than $20 million in expenditures and reflect ADOT's approach to equipment rental rates (i.e., the rates are not set in order to recoup all vehicle expenditures through productive usage charges).

Table A.9 shows the line activity expenditure and production information for the line activities selected.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Based on the observations about certain support activities in Step 1, ADOT's program structure and data are ideal for the benchmark process. On this basis and using the descriptions of activities, a crosswalk of line and support maintenance activities was developed. The number of both line and support activities (158 and 70, respectively) is such that it is not possible to present the complete crosswalk or allocation in this report. Table A.10 presents the set of support activities and support expenditure allocations to each of the line activities selected, as well as the allocations to all other line activities. Please note that only the superset of support activities that apply to the two selected line activities has been included, and in order to keep the table to a single page, the final support activity line summarizes a group of support activities. The absence of an allocation in a particular cell indicates that the line activity represented by the column is not supported by the support activity represented by the row.

Key observations about the support activities related to the two selected activities are as follows:

- Both line activities receive an allocation of the appropriate inspection activity: inspect signs/pavement markings and statewide stripe inspection in the case of guideline paint (large striper), and annual fence inspection in the case of routine fence maintenance.
- Both line activities receive an allocation of the appropriate "other" maintenance activities item: other Interstate sign/stripe maintenance in the case of guideline paint (large striper), and other roadside maintenance in the case of routine fence maintenance.
- Both line activities receive an allocation from a little over 30 broad support activities, including administrative support, training, and material handling.
- Guideline paint (large striper) also receives an allocation from the pavement preparation support activity.

Step 3: Gather and Classify Enterprise Programs and Expenditures

Enterprise programs and expenditures were obtained from ADOT's CAFR for the fiscal year ending June 30, 2008. Table A.11 details the set of enterprise programs, the total expenditures, and the classification of programs as line, support, or special/pass-through. The classifications are the result of a combination of descriptions of programs from the CAFR and other ADOT reports, as well as consultation with ADOT's finance personnel. The information in Table A.11 was obtained from Exhibit 2 – Statement of Activities, and Exhibit 4 – Statement of Revenues, Expenditures and Changes in Fund Balances - Governmental Funds. The purpose and content of the different expenditure presentations included in the ADOT CAFR are such that to obtain a picture of all expenditures, information must be drawn from a combination of sources. For example, the Statement of Activities does not include the construction program expenditures; rather, these must be obtained from the Statement of Revenues, Expenditures and Changes in Fund Balances - Governmental Funds. The point here is that if enterprise expenditures are obtained from an agency CAFR, it is critical to obtain guidance from personnel that understand what each expenditure presentation represents in order to capture the complete range of expenditures as well as avoid any double counting.

Based on ADOT's CAFR, therefore, total line program expenditure is $1,619,756,796, total support program expenditure is $54,918,357, and $1,713,208,401 is excluded from the calculation based on its classification as special/pass-through.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Based on the enterprise program expenditure information obtained in Step 3, ADOT has a single enterprise support program called Administration. This single program effectively supports all ADOT line programs. Table A.12 details the allocation of enterprise support expenditures to line programs for ADOT using the simplified benchmark approach (i.e., allocate to all line activities on the basis of line activity cost).

Table A.9. Selected ADOT line activity expenditure and production.

Activity ID	Activity Name	Line Expenditure	Accomplishment	Units
422	Guideline paint (large striper)	$814,366	77,955	Gallons
1505	Routine fence maintenance	$1,418,333	55,406	Fence panels

Table A.10. ADOT support activity expenditure allocations to selected line activities.

Support Activity	Support Activity Allocation To			Total Support Activity Expenditure
	Guideline PNT (LG STRIPER)	Routine Fence Maintenance	All Other Line Activities	
Utilities roadway	$83,605	$145,610	$4,565,437	$4,794,652
Inspection signs/pavement mark	$11,119		$86,387	$97,506
Pavement preparation	$6,116		$23,985	$30,101
Statewide stripe inspection	$2,011		$13,920	$15,931
Other I/S sign/stripe maintenance	$54,548		$423,789	$478,337
Annual fence inspection		$130,492	$32,987	$163,479
Other roadside maintenance		$270,268	$876,489	$1,146,757
Unused monthly equipment	$233,897	$407,365	$12,772,441	$13,413,703
Record keeping	$14,824	$25,818	$809,486	$850,128
Building and yard maintenance	$25,560	$44,515	$1,395,729	$1,465,804
Training	$61,603	$107,290	$3,363,933	$3,532,826
Leave	$126,139	$219,689	$6,888,081	$7,233,909
Standby	$2,033	$3,541	$111,036	$116,610
Material handling	$8,509	$14,820	$464,673	$488,002
Work for equip services	$16,675	$29,042	$910,575	$956,292
Stockpile material	$8,705	$15,161	$475,358	$499,224
Other material overhead	$5,084	$8,855	$277,628	$291,567
Administrative support	$63,636	$110,831	$3,474,959	$3,649,426
Other support activity	$42,796	$74,536	$2,336,987	$2,454,319
Supervision	$69,389	$120,851	$3,789,134	$3,979,374
Leadperson (supervision)	$34,945	$60,862	$1,908,239	$2,004,046
Transport equipment	$6,701	$11,671	$365,931	$384,303
Equipment services fuel charges	$75,357	$131,244	$4,114,996	$4,321,597
Equipment parts/supplies	$42,259	$73,598	$2,307,615	$2,423,472
Equip direct billing	$26,861	$46,783	$1,466,809	$1,540,453
All other program support	$253,515	$441,532	$21,085,567	$21,780,614
Total Program Support Allocation	**$1,275,887**	**$2,494,374**	**$74,342,171**	**$78,112,432**

Using the expenditure information from ADOT's CAFR, the highway maintenance program's allocation of enterprise support is therefore $4,598,548. However, the sum of maintenance program expenditures obtained from ADOT's MMS is $152,617,001, versus $135,629,139 reported in the CAFR. Weighing an understanding of both sources of data, and in order to ensure that the full cost calculation lives up to its name, the decision was made to scale up the allocation of enterprise support expenditures to the highway maintenance program by the same factor as the difference in total highway maintenance program expenditures from the two sources. Thus, the allocation to the highway maintenance program will be increased by 12.53% [($152,617,001 - $135,629,139)/$135,629,139] to $5,174,527. This higher enterprise support expenditure amount is allocated between line activities in Step 5.

Step 5: Combine Cost Categories to Derive Full Cost

The final step in the full cost calculation pulls together the line expenditure for each activity from Step 1 and the allocation of program support expenditure to each activity from Step 2, and combines these with an allocation of the enterprise support expenditures that were allocated to the maintenance program in Step 4. The allocation of enterprise support to each line activity is calculated as follows:

$$(\$LAIQ/\$ASLA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and

Table A.11. Classification of ADOT enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Highway Maintenance	Line	$135,629,139
Aeronautics	Line	$4,088,494
Highway	Line	$171,134,168
Motor Vehicle	Line	$110,982,343
Noncapital Including Asset Preservation	Line	$158,991,033
Capital Outlay (Construction)	Line	$989,881,588
Local Government Assistance	Line	$37,285,011
Arizona Highways Magazine	Line	$7,711,629
Highways Expansion and Extension Loan Program	Line	$4,053,391
Subtotal		**$1,619,756,796**
Distributions to Arizona counties and cities	Special/pass-through	$1,241,109,684
Distributions to other state agencies	Special/pass-through	$173,405,451
Debt-related expenditures	Special/pass-through	$298,693,266
Subtotal		**$1,713,208,401**
Administration	Support	$54,918,357
Total		**$3,387,883,554**

$AESM = allocation of enterprise support to the maintenance program.

Therefore

The allocation of the enterprise support expenditures to guideline paint (large striper) equals

$$(\$814,366/\$74,504,568) * \$5,174,527 = \$56,560$$

and

The allocation of enterprise support expenditures to routine fence maintenance equals

$$(\$1,418,333/\$74,504,568) * \$5,174,527 = \$98,507.$$

Table A.13 shows the breakdown of full cost between the three cost categories of line, program support, and enterprise support for the two selected line activities.

Table A.14 presents the full unit costs for production of each of the line activities selected.

Table A.12. ADOT support program expenditure allocation to line programs.

Line Program	Line Program Expenditure	Percent of Total Line Program Expenditure	Allocation of Support Program Expenditure
Highway Maintenance	$135,629,139	8.37%	$4,598,548
Aeronautics	$4,088,494	0.25%	$138,622
Highway	$171,134,168	10.57%	$5,802,357
Motor Vehicle	$110,982,343	6.85%	$3,762,891
Noncapital Including Asset Preservation	$158,991,033	9.82%	$5,390,640
Capital Outlay (Construction)	$989,881,588	61.11%	$33,562,243
Local Government Assistance	$37,285,011	2.30%	$1,264,160
Arizona Highways Magazine	$7,711,629	0.48%	$261,465
Highway Expansion and Extension Loan Program	$4,053,391	0.25%	$137,431
Total Line Program Expenditure	**$1,619,756,796**	**100.00%**	**$54,918,357**

Table A.13. Full cost breakdown for selected ADOT line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Guideline paint (large striper)	$814,366	$1,275,886	$56,560	**$2,146,812**
Routine fence maintenance	$1,418,333	$2,494,374	$98,507	**$4,011,214**

Table A.14. Full unit costs for selected ADOT line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Guideline paint (large striper)	$2,146,812	77,955	Gallons	**$27.54**
Routine fence maintenance	$4,011,214	55,406	Fence panels	**$72.40**

To illustrate the difference between the benchmark and simplified (all-to-all) benchmark calculations, the calculation is repeated, only this time all line activities receive an allocation of all support activities. The full unit costs for production on this basis are $22.12 and $54.22 for guideline paint (larger striper) and routine fence maintenance, respectively.

Missouri DOT

The Missouri Department of Transportation (MoDOT) is responsible for maintaining 32,000 centerline miles of road (26% of all Missouri roads), representing nearly 75,000 lane miles, and 10,000 bridges with a total deck area of approximately 7.3 million square meters. MoDOT's annual budget for FY 2007 was approximately $2.6 billion, which included $1.5 billion for construction and $450 million for maintenance. MoDOT contracts approximately 20% of its maintenance work and self-performs the remaining 80%.

MoDOT's maintenance organization is composed of a central office at its HQ, 10 district offices, and a total of 274 maintenance sheds.

MoDOT organizes its maintenance work activities into the following six categories:

1. Safer highways and intersections,
2. Maintain highways and bridges,
3. Reduce congestion,
4. Improve roadside appearance,
5. Natural event response, and
6. Emergency preparedness.

Beneath these groups are a little more than 50 discrete line activities, which MoDOT uses for the purposes of budgeting and tracking expenditures in its maintenance program. In addition, there are approximately 70 maintenance support activities.

MoDOT does not have an MMS. The key information systems used by the agency to track maintenance activities, accomplishments, and expenditures are as follows:

- **MoDOT's modified FMS:** Used to track expenditures in all programs, including maintenance, and feed information to the statewide accounting system SAM II. MoDOT's FMS and the associated Financial Datamart are the bases for tracking maintenance expenditures. Each year MoDOT produces a Maintenance and Traffic Expenditure Report which pulls expenditure information from the Financial Datamart for the maintenance program and provides detailed breakdowns of expenditures for each of the 52 discrete activities in four categories: labor and fringes, cash expenditures, equipment usage charges, and inventory usage.
- **SAM II:** The statewide accounting system. This is where all of MoDOT's timesheet information is entered, as well as material purchase for and consumption from the DOT's inventory.
- **Transportation management system (TMS):** A MoDOT Planning Department system that allows the agency to integrate data from multiple sources such as bridge, pavement, safety, and traffic, and display it graphically to facilitate analysis and decision making. The system uses a common location referencing system built with Arc/Info.
- **Fleet management system:** MoDOT tracks all expenditures associated with its fleet of vehicles in an agency-specific fleet management system and supports the calculation of vehicle rental rates.

In addition to the Maintenance and Traffic Expenditure Report and the department-wide Tracker Report, MoDOT prepares a Performance Indicators for Highway Maintenance Operations Report on an annual basis. This report presents the current level of service overall and within a number of categories for both the major and minor highways, as well as trend information.

Table A.15. MoDOT maintenance activity expenditure and classification.

Activity Classification	Number of Activities	Total Expenditure	Percentage of Total
Line	56	$324,757,064	73.2%
Support	66	$118,920,291	26.8%
Total	**122**	**$443,677,355**	**100.0%**

Documented MoDOT Full Cost Calculation

The full cost determination process was applied to all MoDOT maintenance activities; however, for the purposes of this summary, two line activities have been selected:

- R31C – Chip sealing, and
- R323 – Bridge deck repair.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

MoDOT provided expenditure data for 122 different maintenance activities from a combination of its financial management system and associated Financial Datamart for the fiscal year ending June 30, 2008. MoDOT reports accomplishment data on a regular basis, but only for a subset of the maintenance activities. Accomplishment data was extracted from MoDOT's 2008 Maintenance and Traffic FY 2008 Expenditure Report. Based on input from MoDOT personnel and activity descriptions included in the Maintenance and Traffic Expenditure Report, each activity was classified as either line or support. Table A.15 presents the summary results of the classification process.

Pertinent observations resulting from the classification process are as follows.

The majority of the support activities that MoDOT tracks are clearly general in nature and therefore provide support to all line activities—for example, R826 – training and employee development.

There are a number of support activities that focus on only a subset of line activities. For example, MoDOT has defined support activities specific to each of the six categories of maintenance identified previously—for example, R22A – support – safer highways and intersections.

Table A.16 shows the line activity expenditure and production information for the line activities selected.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Based on the nature of MoDOT's support activities observed in Step 1, the allocation of support expenditures to line activities is accomplished using the benchmark approach on the basis of line activity cost. On this basis, and using the descriptions of activities, a crosswalk of line and support activities was developed. The number of both line and support activities (56 and 66, respectively) is such that it is not possible to present the complete crosswalk or allocation in this report. Table A.17 is a summary of the complete allocation table presenting the support activity allocation for selected support activities to the selected line activities. In addition, and in order to present a complete picture, Table A.17 includes three rows that summarize expenditures and allocations to other groups of line activities (other pavement line activities, other bridge line activities, and all other line activities), and a column that details the allocation of all other support expenditures to the selected line activities and other activity groups.

Step 3: Gather and Classify Enterprise Programs and Expenditures

Summary information regarding enterprise programs and expenditures was obtained from MoDOT's modified FMS for the fiscal year ending June 30, 2008. In addition, a

Table A.16. Selected MoDOT line activity expenditure and production.

Activity ID	Activity Name	Line Expenditure	Accomplishment	Units
R31C	Chip sealing	$29,872,110	4,596	Lane mile
R323	Bridge deck repair	$4,427,277	28,345	Square yard

Table A.17. Allocation of support activity expenditure to selected MoDOT line activities.

Line Activity	Line Activity Expenditure	Support Activity Allocation				Total Program Support Allocation
		Support Maintain Highways and Bridge	Training and Employee Development	Operate Facilities	All Other Support Activities	
Chip sealing	$29,872,110	$13,008,832	$123,589	$1,395,084	$2,942,646	**$17,470,151**
All other pavement activities	$89,095,914	$38,799,863	$368,614	$4,160,948	$8,776,672	**$52,106,097**
Bridge deck repair	$4,427,277	$1,928,009	$18,317	$206,762	$433,775	**$2,586,863**
All other bridge activities	$12,020,549	$5,234,760	$49,732	$561,382	$1,123,818	**$6,969,692**
All remaining activities	$189,341,214	N/A	$783,356	$8,842,593	$30,161,539	**$39,787,488**
Totals	**$324,757,064**	**$58,971,464**	**$1,343,608**	**$15,166,770**	**$43,438,450**	**$118,920,291**

Note: Some totals rounded to the nearest dollar.

review of expenditure presentations contained in MoDOT's CAFR for the fiscal year ending June 30, 2008 was conducted. Discrepancies between the maintenance and other program expenditures were identified. However, it was discovered that this was due to highway safety and motor carrier expenditures being included in the maintenance program expenditures in the CAFR, whereas MoDOT personnel had included them with the other programs in the FMS extract. Since these other expenditures are really separate from the maintenance program, the FMS values are used for the full cost calculation.

Table A.18 summarizes MoDOT's enterprise programs, total expenditures, and the classification of programs as line, support, or special/pass-through. As a result of multiple discussions between the research team and MoDOT personnel about the full cost calculation, MoDOT personnel undertook some preprocessing of the raw data. This included eliminating any special/pass-through expenditures as well as grouping and summarizing support and other line program expenditures (other than maintenance and construction) into single line items. This preprocessing served to simplify this step of the calculation and resulted in the small number of program entries included in Table A.18.

Based on the data from MoDOT's financial management system, therefore, total line program expenditure is $2,099,076,425, and total support program expenditure is $153,868,506.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Given the enterprise program expenditure information obtained in Step 3, and recognizing that the single enterprise support program expenditure identified supports all three line program expenditure categories, there is no need to develop a crosswalk between line and support programs. The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = cost of line program in question,
$ASLP = cost of all supported line programs, and
$SPIQ = cost of support program in question.

Using this calculation the allocation of the enterprise support expenditure to maintenance is

$$(\$450,974,435/\$2,099,076,425) * \$153,868,506 = \$33,057,759.$$

Table A.18. Classification of MoDOT enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Maintenance	Line	$450,974,435
Construction	Line	$1,531,480,517
Other line programs	Line	$116,621,473
Subtotal		**$2,099,076,425**
Enterprise support	Support	$153,868,506
Total		**$2,252,944,931**

Table A.19. Full cost breakdown for selected MoDOT line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Chip sealing	$29,872,110	$17,470,151	$3,040,750	**$50,383,011**
Bridge deck repair	$4,427,277	$2,586,863	$450,663	**$7,464,803**

Step 5: Combine Cost Categories to Derive Full Cost

The final step in the cost calculation pulls together the line expenditure for each activity from Step 1 and the allocation of program support expenditure to each activity from Step 2, and combines these with an allocation of the enterprise support expenditures that were allocated to the maintenance program in Step 4. The allocation of enterprise support to each line activity is calculated as follows:

$$(\$LAIQ/\$ASLA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Therefore

The allocation of the enterprise support expenditures to R31C – chip sealing equals

$$(\$29,872,110/\$324,757,064) * \$33,057,759 = \$3,040,750$$

and

The allocation of enterprise support expenditures to bridge deck repair equals

$$(\$4,427,277/\$324,757,064) * \$33,057,759 = \$450,663.$$

Table A.19 shows the breakdown of full cost between the three cost categories: line; program support; and enterprise support, for the two selected line activities.

Table A.20 presents the full unit cost for production of each of the line activities selected.

The decision to use the benchmark approach for allocating maintenance program support expenditures to line activities is well supported by the descriptions of the activities included in the Maintenance and Traffic FY 2008 Expenditure Report. Furthermore, this approach is entirely consistent with the goal of fairly identifying and allocating support expenditures between the line activities that are supported. The calculation was repeated using the simplified (all-to-all) benchmark approach in order to demonstrate the impact of utilizing the benchmark approach over the simplified benchmark approach. Using the simplified benchmark approach the full unit costs for production for chip sealing and bridge deck repair are $9,541.23/lane mile and $229.29/yd^2, respectively.

North Carolina DOT

North Carolina Department of Transportation (NCDOT) is responsible for approximately 79,000 centerline miles of highway, representing approximately 76% of the statewide total and encompassing 169,000 lane miles. NCDOT has responsibility for 16,600 highway bridges with a total deck area of approximately 7.5 million square meters.

NCDOT's annual maintenance budget is approximately $800 million. NCDOT's overall budget is approximately $4 billion annually. NCDOT performs approximately 60% of its routine maintenance work and contracts the remaining 40%. Most of its contracting involves small contracts. In addition, NCDOT currently has one fence-to-fence contract, which is a little more than one year into the agreement.

NCDOT's maintenance organization is first organized into 14 geographic divisions and a central bridge management group. Each division covers anywhere from five to 14 counties, and is itself divided into a number of districts that encompass three to four counties. Each county is assigned a county maintenance supervisor who oversees between two and five road supervisors.

NCDOT's maintenance program currently includes approximately 120 discrete activities (each represented by its own

Table A.20. Full unit cost for selected MoDOT line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Chip sealing	$50,383,011	4,596	Lane mile	**$10,962.36**
Bridge deck repair	$7,464,803	28,345	Square yard	**$263.36**

function code—for example, 3100 – snow and ice). These activities are organized into six maintenance categories as follows:

- 2700 series – miscellaneous,
- 2800 series – pavement,
- 2900 series – roadside,
- 3100 series – maintenance,
- 3200 series – traffic, and
- 3300 series – bridge.

In an effort to improve its cost tracking and management of the maintenance function, in December 2007 NCDOT revised the set of activities and codes in the maintenance program. The number of activities was consolidated from 700 to approximately 120. As part of this consolidation effort, two of the more heavily used activities ("miscellaneous" and "payments to contractors") were eliminated. These two codes tended to collect significant dollars, in the latter case almost $40 million in one year, but did not provide any insight into the nature of the work accomplished.

NCDOT uses the following two systems to capture and manage maintenance cost data:

- **Maintenance management system –** NCDOT has used an MMS since 2003. The MMS is used primarily by first-line supervisors.
- **Financial management system –** NCDOT implemented an FMS in 2002. The central maintenance activity reporting mechanism in the FMS is the FR1101 screen/form, which captures labor, materials consumed, and equipment usage.

In contrast to the approach taken by many agencies for maintenance labor, timesheet data is entered into the FMS first, then gets transferred into the MMS. NCDOT is considering adjusting this practice, particularly given that its maintenance supervisors have PDAs that are linked directly to the MMS and could easily be used to collect and transfer maintenance timesheet data.

Documented NCDOT Full Cost Calculation

The full cost determination process was applied to all NCDOT maintenance activities; however, for the purposes of this summary, two line activities have been selected:

- 2812 – Hot mix asphalt overlay, and
- 3376 – Clean/wash bridge decks.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

NCDOT provided expenditure and accomplishment data for almost 400 different maintenance activities from its maintenance management system for the year ending June 30, 2009. Upon inspection of the data, it was evident that there were a mixture of new and old function codes (recall NCDOT recently consolidated its maintenance functions). However, using a mapping of new to old codes provided by NCDOT's maintenance organization, the data was reorganized consistent with the new codes and activity definitions to the extent possible. This involved combining labor, equipment, material, and other expenditures elements as well as accomplishments for multiple old codes into a single new code. In a small number of instances, old function codes were associated with more than one new function code. In these cases, the old function expenditures and accomplishments were divided equally between the applicable new function codes. Finally, there were approximately 80 old function codes that were not referenced in the mapping, so these were left as they were. The consolidated expenditure data was reviewed in conjunction with the detailed activity descriptions provided by NCDOT, and each activity was classified as either line or support. Table A.21 presents the summary results of the classification.

Pertinent observations resulting from the classification process are as follows.

A relatively small number of the line activities account for the majority of the line activity expenditure. For example, the line expenditure for activity 2812 – hot mix asphalt overlay, is just under 30% of the total line activity expenditure, and the top five line activities account for 50% of the total line activity expenditure.

Table A.21. NCDOT maintenance activity expenditure and classification.

Activity Classification	Number of Activities	Total Expenditure	Percentage of Total
Line	130	$649,281,065	79.3%
Support	83	$169,032,039	20.7%
Total	**213**	**$818,313,104**	**100.0%**

Table A.22. Selected NCDOT line activity expenditure and production.

Activity ID	Activity Name	Line Expenditure	Accomplishment	Units
2812	Hot mix asphalt overlay	$191,604,009	138,208	Ton
3376	Clean/wash bridge decks	$1,347,186	11,194,020	Square feet

The support activities all appear to be more general in nature, and there do not appear to be any of the "other" maintenance activities defined for the maintenance categories identified previously.

There is still a payment to contractor activity with a total expenditure amount of approximately $17,000,000. For the purposes of the full cost calculation this is classified as a line activity, although it is assumed that these expenditures ought to have been distributed between a number of line activities.

The majority of the activities with old function codes that were not referenced in the function code mapping have relatively small expenditures associated with them.

It appears as though the transition from the old function codes to the new function codes was still in progress for at least part of the timeframe that these expenditures were incurred.

There are a considerable number of support activities showing relatively small expenditures; approximately 40 support activities have expenditures of less than $10,000.

The 2700 series "miscellaneous" activities appear to be the major support activities, including various inspections, assessments, and engineering functions as well as administration and supervision.

Table A.22 shows the line activity expenditure and production information for the line activities selected.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Based on the observations about NCDOT's maintenance activities and in particular the general nature of the support activities, the allocation of support expenditures to line activities is accomplished using the simplified benchmark (or all-to-all) approach. The number of line and support activities (130 and 82) respectively is such that it is not possible to present the complete crosswalk or allocation in this report. Table A.23 presents a portion of the complete support activity expenditure allocation table for the selected activities. In order to ensure that the column totals are correct, summary rows have been added for the other line expenditures in the categories associated with the selected activities (pavement and bridge), as well as summary rows for the remaining three line categories (roadside, maintenance, and traffic). In order to ensure that the row totals are correct, columns for individual support activities, administration/supervision, and general field training are included, and catchall columns for all other miscellaneous activities (of which administration/supervision is one activity) and all other support activities are included.

Step 3: Gather and Classify Enterprise Programs and Expenditures

A summary of rounded enterprise program expenditures for the year ending June 30, 2009, was obtained from NCDOT's

Table A.23. Allocation of support activity expenditures to selected NCDOT line activities.

Line Activity	Line Activity Expenditure	Support Activity Allocation				Total Program Support Allocation
		Administration/ Supervision	Other Miscellaneous Activities	General Field Training	All Other Support Activities	
Hot mix asphalt overlay	$191,604,009	$10,730,835	$7,653,895	$950,758	$30,546,170	**$49,881,658**
Other pavement activities	$133,547,059	$7,479,340	$5,334,728	$662,673	$21,290,531	**$34,767,272**
Roadside activities	$84,727,195	$4,745,170	$3,384,548	$420,425	$13,507,501	**$22,057,644**
Maintenance activities	$133,499,392	$7,476,670	$5,332,824	$662,437	$21,282,932	**$34,754,863**
Traffic activities	$41,746,133	$2,338,004	$1,667,609	$207,148	$6,655,312	**$10,868,073**
Clean/wash bridge decks	$1,347,186	$75,450	$53,815	$6,685	$214,773	**$350,723**
Other bridge activities	$43,902,197	$2,458,755	$1,753,736	$217,847	$6,999,039	**$11,429,377**
All other (old) activities	$18,907,894	$1,058,942	$755,303	$93,822	$3,014,362	**$4,922,429**
Totals	**$649,281,065**	**$36,363,166**	**$25,936,458**	**$3,221,795**	**$103,510,620**	**$169,032,039**

Cash Management office, drawing upon data from NCDOT's financial management system. Table A.24 details the set of enterprise programs, rounded total expenditures, and the classification of programs as line, support, or special/pass-through. The classifications are the result of discussions with NCDOT personnel familiar with the objective of the full cost determination process.

Based on the data from NCDOT's financial management system, therefore, total line program expenditure is $2,723,000,000, total support program expenditure is $245,500,000, and $574,900,000 is excluded from the calculation based on its classification as special/pass-through.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Based on the enterprise program expenditure information obtained in Step 3, NCDOT has a single enterprise support program that provides support to each of the five line programs, including maintenance. A crosswalk is unnecessary in this case since it would comprise only a single column and five rows and an X in each cell. The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = cost of line program in question,
$ASLP = cost of all supported line programs, and
$SPIQ = cost of support program in question.

Using this calculation, the allocation of administration to maintenance is

$$(\$818,300,000/\$2,723,000,000) * \$245,500,000 = \$73,776,221$$

Which, in this case, is the share of enterprise support that must be allocated to the maintenance program.

Step 5: Combine Cost Categories to Derive Full Cost

The final step in the full cost calculation pulls together the line expenditure for each activity from Step 1 and the allocation of program support expenditure to each activity from Step 2 (revised in Step 4 in this case), and combines these with an allocation of the enterprise support expenditures that were allocated to the maintenance program in Step 4. The allocation of enterprise support to each activity is calculated as follows:

$$(\$LAIQ/\$ASLA) * \$AESM$$

Where

$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Therefore

The allocation of the enterprise support expenditures to hot mix asphalt overlay equals

$$(\$191,604,009/\$649,281,065) * \$73,776,221 = \$21,771,495$$

and

The allocation of enterprise support expenditures to routine fence maintenance equals

$$\$1,347,186/\$649,281,065 * \$73,776,221 = \$153,077.$$

Table A.24. Classification of NCDOT enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Maintenance	Line	$818,300,000
Construction	Line	$1,590,900,000
ARRA programs	Line	$6,200,000
Public transportation	Line	$93,400,000
Other programs	Line	$214,200,000
Subtotal		**$2,723,000,000**
Transfers to other agencies	Special/pass-through	$429,900,000
Municipal aid	Special/pass-through	$145,000,000
Subtotal		**$574,900,000**
Administration	Support	$245,500,000
Total		**$3,543,400,000**

Table A.25. Full cost breakdown for selected NCDOT line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Hot mix asphalt overlay	$191,604,009	$49,881,658	$21,771,495	**$263,257,162**
Clean/wash bridge decks	$1,347,186	$350,723	$153,077	**$1,850,986**

Table A.25 shows the breakdown of full cost between the three cost categories of line, program support, and enterprise support for the two selected line activities.

Table A.26 presents the full unit costs for production for each of the line activities selected.

Texas DOT

Texas DOT's (TxDOT) highway maintenance responsibilities extend to a statewide network of almost 80,000 centerline miles. This network comprises more than 3,200 miles of Interstate highway, 12,100 miles of U.S. highways, almost 16,300 miles of state highways, almost 41,000 miles of farm-to-market roads, and about 7,100 miles of frontage and park roads. Maintenance also has responsibility for other transportation facilities, including parking lots and facilities at parks, as well as ferries to Gulf Coast islands operating out of Galveston and Corpus Christi. With the exception of a relatively small number of miles of toll roads, toll booths, and buildings in the Austin area, the Maintenance Division does not maintain the state's toll highway system.

TxDOT has a well-developed, agency-wide approach to managing its costs as well as tracking and reporting program costs and accomplishments. The budget for routine maintenance was about $915 million for FY 2007. This total does not include additional work accomplished by contract, which is described in more detail in later sections. Routine maintenance expenditures are distributed among categories of activities as follows:

- Road surface, 33.8%;
- Bridge, 2.8%;
- Roadside, 22.9%;
- Traffic features, 32.9%;
- Winter maintenance, 2.6%; and
- Other categories, 5.0%.

Maintenance management is decentralized among 25 districts. The central office allocates the available budget to districts based on formulas for each activity that consider factors such as each district's respective share of the appropriate maintenance inventory, the condition of that inventory, total traffic or truck traffic, and other factors. District managers decide how to use those funds, including allocations among activities and between in-house versus contract forces.

The TxDOT approach is well documented in up-to-date manuals (such as its *Maintenance Management Manual* and *Maintenance Contract Manual*) and annual bound reports [e.g., *Routine Maintenance: Maintenance Division Annual Report* and the annual *Texas Condition Assessment Program (TxCAP)*]. A wide range of reports is available from the Maintenance Management Information System (MMIS) in tabular and graphical form, capturing data for individual fiscal years as well as historical trend lines.

TxDOT Maintenance Function

A brief description of how TxDOT organizes its maintenance program financially will help in understanding cost elements, methods of analysis, and cost reporting. The descriptions below have been simplified to focus on the requirements of NCHRP Project 14-18. Selective examples give an idea of what is included in an item; more complete explanations are provided in TxDOT source documents. The examples relate primarily to maintenance, recognizing that TxDOT's cost elements and accounting procedures apply across the board to all of the department's functions.

TxDOT defines three broad categories of maintenance: routine maintenance, preventive maintenance, and major

Table A.26. Full unit costs for selected NCDOT line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Hot mix asphalt overlay	$263,257,162	138,208	Ton	**$1,904.79**
Clean/wash bridge decks	$1,850,986	11,194,020	Square feet	**$0.17**

maintenance. The types of work performed in each of these categories are defined in the *Maintenance Management Manual* (2008) by examples within selected subsets of maintenance activity [e.g., the travel way (pavement), shoulder and side approaches, roadside, drainage, structures, traffic operations features, and emergency operations]. A sample of these work definitions is given below. While any category can in theory be performed either by state forces or by contract, preventive and major maintenance work is generally contracted.

- **Routine maintenance:** Routine maintenance restores an asset to its as-constructed condition. Selected examples of pavement routine maintenance include pavement repair, leveling up the pavement surface, crack sealing, and light overlays (no more than 2-in. depth) to restore rideability. Selected examples for traffic operations include installation, repair, and replacement of signs, delineators, illumination, signals, and related appurtenances; installation and replacement of pavement markings; and maintenance of traffic-control cabinets.
- **Preventive maintenance:** Preventive maintenance aims to prevent major deterioration or damage to road structures and features. Selected examples of pavement preventive maintenance include level-ups or milling to restore rideability, light overlays, seal coats, crack sealing, and microsurfacing. Selected examples for traffic operations include replacement of pavement markings, which may be performed in conjunction with pavement resurfacing.
- **Major maintenance:** Major maintenance strengthens or improves the asset to handle current and future traffic. Selected examples of major pavement maintenance include reconditioning and stabilizing the pavement base, adding base material, light overlays, level-ups, and seal coats. Selected examples for traffic operations include installing new signal systems to upgrade outdated designs.

For purposes of cost analysis, the distinction that is most important is the one between routine maintenance and preventive maintenance. Routine maintenance is managed and reported in TxDOT's MMIS. Preventive maintenance cost data are compiled from other sources and mechanisms (e.g., discussions among managers regarding current projects, and queries of management system databases).

Maintenance activities performed by state agency versus those performed by contracted forces are managed under separate budgets. The legislature has imposed a target of at least 50% of maintenance work to be contracted. TxDOT now exceeds the target when the totals of contracted routine maintenance plus contracted preventive maintenance are combined. Districts need to balance between the two methods of delivering maintenance to meet the target.

The following description of the cost determination procedure is based on interviews with several TxDOT managers in maintenance management, financial management, equipment management, and materials-and-stores management; a number of reports from the MMIS and the Financial Information Management System (FIMS); and documents, including TxDOT's *Maintenance Management Information System User Manual* (2002), *Maintenance Management Manual* (2008), *Maintenance Contract Manual* (2006), TxDOT Glossary (2010), and Indirect Cost Plan, or IDCP (Proposed Administrative Indirect Cost Rates, 2008).

Full Cost Calculation Summary

TxDOT has adopted a comprehensive, highly integrated financial accounting approach that supports all aspects of its financial management, including its indirect cost plan. Cost data associated with its MMIS is included within this department-wide financial framework. The following discussion is based on FY 2009 reports of line highway maintenance expenditures from the TxDOT MMIS, plus the considerable data on support costs in the indirect cost plan for FY 2009.

TxDOT is a large, decentralized transportation agency that processes its direct and indirect costs on a district-by-district basis in addition to producing statewide summaries. While that practice has been maintained in certain cost determination computations, it has proven more efficient to compute and display several results statewide rather than at a district level. Unit costs have been determined for all activities having a cost accomplishment unit—again, at a statewide level. Given the large amount of data involved, the following descriptions will present subsets of the total information to illustrate calculations and results, with the understanding that corresponding calculations have been applied to other maintenance activities, cost items, and districts.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

Line costs associated with maintenance activities have been obtained from MMIS reports summarizing cumulative expenditures for FY 2009. Cost data in these MMIS reports are processed through the financial system and uploaded into the MMIS, an outcome of TxDOT's integrated systems approach. Accomplishment data reside within the MMIS and are correlated with respective costs by activity. For FY 2009, statewide data are available for 121 activities, although not all districts perform all activities in any given fiscal year. All activities within the

Table A.27. TxDOT maintenance activity line expenditures.

Category of Activity Line Cost	Total Expenditure	Percent of Total
Labor costs	$138,567,983.08	17.1%
Material costs	$174,241,584.92	21.4%
Equipment costs	$77,212,618.16	9.5%
Contractor costs	$369,415,240.82	45.5%
Contract preparation costs	$11,065,528.59	1.4%
Miscellaneous costs	$41,828,735.19	5.1%
Total Activity Line Costs	**$812,331,690.76**	**100.0%**

Source: TxDOT MMIS, Statewide Maintenance Expenditures, FY 2009.

MMIS are line activities; thus, totals represent overall line costs of highway maintenance. Line costs are categorized as shown in Table A.27; most of these represent well-recognized highway maintenance line cost elements (labor, equipment, materials, etc.). Contractor costs refer to payments within the total value of the awarded contracts; contract preparation costs refer to agency expenses associated with preparing bid documents, prequalifying and communicating with contractors, advertising, letting, preparing and awarding contracts, and contract execution.

Table A.27 presents cost totals at a statewide level in each of the categories shown. Cost breakdowns in these categories also are available for each individual activity in each district and statewide.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Nomenclature

The TxDOT FMIS conducts a detailed analysis of support expenditures and their allocation to line activities. To accommodate the variances in nomenclature between TxDOT practice and the terminology used in this report, "maintenance program support costs" will refer to what TxDOT describes as its "District-Office" component of costs, and "enterprise support costs" will refer to what TxDOT describes as its "Headquarters (HQ) Divisions-Offices" component of costs (i.e., costs associated with functions located in the central office). This section addresses maintenance program support costs, or the District-Office component of TxDOT's cost computations. Enterprise support costs, or TxDOT's HQ Divisions-Offices component of costs, are covered in the following section.

Maintenance program support activities are allocated to line activities in two components: one constituting direct costs, the second constituting indirect costs.

Direct Program Support Costs

Program support costs that are sufficiently closely related to activity performance qualify as direct costs in FIMS and the IDCP. These direct program support costs include items such as laboratory testing charges, core drill costs, survey team costs, an allowance for the area engineer costs, and an allowance for roadway maintenance managerial costs. These support costs are allocated either to specific activities (i.e., those activities that benefitted from, for example, the testing, drilling, and survey team services) or, for the remainder of the support costs (i.e., the allowances for management), across line activity costs in proportion to their relative total cost that is represented in Table A.27. The result of this allocation is shown in Table A.28 at a statewide level.

Table A.28. Summary of direct maintenance program support costs allocated to line costs.

Cost Component	Total Expenditure
Total activity line costs (from Table A.27)	$812,331,690.76
Direct costs of maintenance program support	$141,883,737.51
Subtotal, maintenance program direct costs	$954,215,428.27

Source: TxDOT FIMS Report, Maintenance Direct and Indirect Expenditures by Activity, FY 2009.

Other maintenance-program support costs are subjected to a detailed analysis of indirect costs as described below.

Indirect Program Support Costs

The remaining maintenance program support costs that are regarded as indirect costs in the IDCP are organized within a number of indirect cost accounts, examples of which include the following (the grouping is only to subdivide the extensive list—each account is processed individually):

- District-Level Executive Management, Accounting, Human Resources Management, District Operations Management, and Administration Management.
- District-Level Design Management, Construction Management, Right-of-Way Management, Maintenance Management, Traffic Management, Planning and Development Management, Transportation Operations Management, and Safety Coordinator.
- District Warehouse Operations, District Partnership Management, District Headquarters Buildings and Grounds Management, Minor Repairs and Alterations to Buildings, and District Automation Operations, Region Automation, Data Center Services.
- District-Level Public Information Management, Legal Counsel, Recruiting Program, Employee Relocation, Recycling Program Coordination, Internal Review Function.
- District-Level Classroom Training (multiple categories), Educational Assistance (multiple categories).
- District-Level Transportation Management System, Transportation Management System-Maintenance, Traffic Operations, Pavement Management, Natural Resources Management.
- District-Level Administrative and Clerical Support, Switchboard and Mailroom Operations, Reproduction Services.
- District-Level Inventory Adjustments, Supplies and Miscellaneous, Adjustments to Cash, Capital Budget Items – Noncapitalized, Depreciation-Facilities, Depreciation-Minor Reportable Property.

Indirect costs are accumulated by district within each of these individual accounts; only the totals by district are given in Table A.29. Also shown in Table A.29 are the corresponding direct costs by district for all functions (not just maintenance). Indirect costs are divided by direct costs in each district to compute a district indirect cost rate for these support costs.

The indirect cost rates in Table A.29 enable one to compute the indirect costs attributable to any direct cost item in a district, including maintenance work performance. For example, assume that a maintenance job incurred a direct cost of $10,000 in District 12 (Houston). The indirect costs of program support to be allocated to this activity in this district would be 1.29% of $10,000, or $129. To take another example, assume a maintenance job incurred a direct cost of $7,500 in District 23 (Brownwood). The indirect costs of program support to be allocated to this activity would be 7.08% of $7,500, or $531. Note that at this stage, the allocation of indirect costs to a maintenance activity depends solely on the direct costs incurred by that activity. The nature of the activity (i.e., whether it is for pavement repair, roadside vegetation, winter maintenance, litter pickup, or whatever) makes no difference to the allocation methodology. By this approach, any maintenance activity may be analyzed for cost determination in this way. The full set of computations for the maintenance program would require a matrix with 25 columns (one per district) and a maximum of 121 rows (one per potential activity, realizing that a district may not record costs in all activities within a given fiscal year). In lieu of this detailed breakdown, overall results statewide are more convenient to present. Before these summarized results can be shown, however, the enterprise support costs must be addressed, since the TxDOT FIMS performs and displays program support and enterprise support calculations simultaneously.

Step 3: Gather and Classify Enterprise Programs and Expenditures

A corresponding methodology is carried out for enterprise support costs. In the context of the TxDOT methodology, "enterprise support costs" address the costs attributable to the central office functions in the capital, Austin. The indirect portion of these costs will be distributed among the direct costs of the central office functions plus the direct costs computed for all districts (the more than $7 million sum in the direct cost column in Table A.29). Several categories of enterprise support costs are listed in Table A.30, together with indirect and direct costs accumulated within the FMIS.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Allocation is again done through a percentage rate computed on the basis of total indirect costs divided by total direct costs. The computation is shown at the bottom of Table A.30. For FY 2009, the rate is 2.88%. To apply indirect costs to any type of direct cost in any district, this central-office rate is added to the district rate computed in Table A.29 (hence, the simultaneous consideration of maintenance program and enterprise support costs, or district and central-office division/office indirect costs). For example, the overall rate to allocate central office and district indirect costs (or maintenance program and enterprise

Table A.29. District indirect cost rates, FY 2009.

Code	District	Adjusted Indirect Cost for FY 2009 "IDC"	Projected Direct Cost for FY 2009 "DC"	IDC/DC, Percent = "District IDC Rate"
1	Paris	$4,391,691	$117,631,868	3.73%
2	Fort Worth	$9,734,262	$371,624,233	2.62%
3	Wichita Falls	$4,804,667	$138,995,091	3.46%
4	Amarillo	$4,518,547	$168,343,781	2.68%
5	Lubbock	$4,346,863	$182,941,267	2.38%
6	Odessa	$5,552,425	$96,093,756	5.78%
7	San Angelo	$5,356,705	$80,618,706	6.64%
8	Abilene	$5,037,145	$125,243,232	4.02%
9	Waco	$6,293,953	$440,831,461	1.43%
10	Tyler	$5,927,096	$242,483,421	2.44%
11	Lufkin	$4,472,751	$188,320,619	2.38%
12	Houston	$16,415,521	$1,276,201,011	1.29%
13	Yoakum	$4,143,842	$174,817,785	2.37%
14	Austin	$11,310,844	$362,466,180	3.12%
15	San Antonio	$7,651,070	$536,136,565	1.43%
16	Corpus Christi	$5,806,497	$206,765,049	2.81%
17	Bryan	$3,744,395	$188,272,652	1.99%
18	Dallas	$12,538,992	$854,032,214	1.47%
19	Atlanta	$4,240,546	$190,424,768	2.23%
20	Beaumont	$5,897,734	$312,346,593	1.89%
21	Pharr	$6,835,279	$329,042,269	2.08%
22	Laredo	$5,031,930	$177,869,183	2.83%
23	Brownwood	$3,571,718	$50,443,372	7.08%
24	El Paso	$7,295,125	$152,643,767	4.78%
25	Childress	$3,676,842	$88,289,853	4.16%
1-25	District Total Expenditures	$158,596,440	$7,052,878,696	

Source: TxDOT IDCP, Exhibits A and C.

support costs) to direct maintenance costs in District 12, Houston, is 1.29% + 2.88% = 4.17%. The corresponding rate to allocate indirect costs to direct maintenance costs in District 23 (Brownwood) is 7.08% + 2.88% = 9.96%.

Step 5: Combine Cost Categories to Derive Full Cost

The combined percentage distribution factors from Tables A.29 and A.30 can be applied to the direct costs of individual maintenance activities in any district to obtain total line plus support costs for that activity—or equivalently, total direct plus indirect costs. When all such district costs are aggregated to the statewide level, one obtains the sum shown at the bottom of Table A.31: the full costs of the maintenance program overall.

Let us repeat the examples discussed earlier, using the consolidated indirect cost rates resulting from data in Tables A.29 and A.30. In the first example, assume that a maintenance job incurred a direct cost of $10,000 in District 12 (Houston). The total indirect costs to be allocated to this activity in this district would be (1.29% + 2.88% =) 4.17% of $10,000, or $417. The full cost of the activity would therefore be $10,417. In the second example, assume a maintenance job incurred a direct cost of $7,500 in District 23 (Brownwood). The indirect costs of program support to be allocated to this activity would be (7.08% + 2.88% =) 9.96% of $7,500, or $747.

Full costs of individual maintenance activities have been computed at a statewide level, representing the aggregation of results from the 25 districts. Table A.32 presents these statewide costs for five sample activities.

Table A.30. Summary of enterprise support functions with indirect and direct costs.

Central Office Functions, Offices, Other Items	Adjusted Indirect Cost for FY 2009 "IDC"	Projected Direct Cost for FY 2009 "DC"	IDC/DC, Percent = "Divisions/Offices IDC Rate"
Executive Director	$2,140,681	$0	
Aviation	$1,858,440	$64,914,200	
Finance	$13,879,139	($164,574)	
General Services	$18,361,211	$0	
Audit	$4,996,665	$0	
Construction	$12,505,637	$9,692	
Maintenance	$19,622,439	$2,392,404	
Design	$4,791,852	$2,341,321	
Transportation Planning and Programming	$189,525	$81,082,742	
Public Transportation	$701,633	$207,036,793	
Vehicle Titles	$0	$77,070,949	
Human Resources	$14,156,236	$201,401	
Civil Rights	$1,267,031	$91,117	
Right-of-Way	$3,328,996	$956,026	
Travel	$3,072,359	$17,585,012	
Environmental Affairs	$26,040,441	$1,644,274	
Traffic Operations	$7,991,562	$42,915,211	
Technology System	$55,700,647	$1,976,213	
Occupational Safety	$4,160,619	$0	
Motor Vehicle	($142,908)	$6,434,730	
Comp. Claims and Refunds	($4)	$0	
Attorney General	$4,743,851	$0	
Research and Technology	$25,830	$25,342,106	
Motor Carrier	$1,484,533	$6,871,265	
Management Services	($1,414)	$0	
Public Information	$1,621,534	$0	
General Counsel	$3,036,159	$0	
Business Opportunity Program	$1,914,002	$59,994	
Bridge Division	$6,984,542	$1,113	
Allocation from Attorney General's Office	$6,044,448	$0	
Allocation from State Auditor's Office	$2,016,018	$0	
Other	$11,385,689	$539,946,264	
Subtotal divisions/offices	$233,877,393	$1,078,708,253	
District direct costs from Table A.31		$7,052,878,696	
Total direct and indirect costs	$233,877,393	$8,131,586,949	
Divisions/Offices Indirect Cost Rate	$233,877,393	$8,131,586,949	2.88%

Source: TxDOT IDCP Exhibit A.

Table A.31. Summary of maintenance program line costs plus support costs.

Cost Component	Total Expenditure
Total activity line costs (from Table A.27)	$812,331,690.76
Direct costs of maintenance program support (from Table A.28)	$141,883,737.51
Indirect costs of maintenance program support (computed by activity and district using district rates in Table A.31, aggregated program-wide and statewide) plus indirect costs of central-office divisions/offices using the divisions/offices rate in Table A.30	$52,705,669.38
Subtotal, line plus maintenance program support costs	$1,006,921,097.65

Source: TxDOT MMIS Report, FY 2009, and FIMS Report, Maintenance Direct and Indirect Expenditures by Activity, FY 2009.

Table A.32. Examples of statewide full cost calculations for five sample activities.

Activity	Line Cost	Support Cost	Full Cost	Unit Full Cost
110 Base removal/replacement	$23,644,083	$5,508,975	$29,153,059	$64.01 per CY
270 Edge repair	$14,328,973	$4,636,240	$18,965,214	$1.05 per LF
511 Mowing	$37,668,195	$9,746,181	$47,414,377	$29.58 per AC
562 Reshaping ditches	$4,129,289	$1,375,447	$5,504,736	0.25 per LF
650 Bridge decks	$1,757,129	$351,769	$2,108,897	$42.70 per SF

Source: TxDOT MMIS and FMIS Maintenance Program Reports, FY 2009.

Notes: CY=cubic yards; LF=linear feet; AC=acres; SF=square feet.
Some totals rounded to the nearest dollar.

Washington State DOT

The Washington State Department of Transportation (WSDOT) is responsible for maintaining 7,000 centerline miles of road (8.4% of all Washington State roads), representing nearly 20,000 lane miles. WSDOT also is responsible for 3,000 bridges with a total deck area of approximately 4.7 million square meters.

WSDOT's maintenance budget for the 2007 to 2009 biennium was approximately $340 million and was applied to routine maintenance activities across the state, including those related to bridges, rest areas, roadsides, signs, snow and ice control, and minor pavement treatments such as pothole patching and small chip seals. WSDOT self-performs more than 95% of this routine maintenance but does contract with a number of cities for certain landscaping and signal maintenance work. In addition WSDOT's 2007 to 2009 biennium budget included $748 million for its preservation program, of which approximately $245 million was for pavement activities, including overlays and large chip seal projects. The vast majority (in excess of 99%) of preservation work is completed by contractors. The distinction between routine maintenance and preservation activities at WSDOT is that the latter includes projects with values in excess of $60,000. WSDOT's total 2007 to 2009 biennial budget was $6.4 billion and included a construction improvement program of just over $3 billion.

WSDOT's maintenance organization comprises a central office at the department's headquarters in Olympia, as well as six regional offices located around the state that coordinate the activity in a total of 24 distinct maintenance areas. The maintenance areas cover anywhere from part of one county to three counties.

WSDOT groups its maintenance activities into nine maintenance functions as follows:

- Group 1 – Roadway maintenance and operations,
- Group 2 – Drainage maintenance and slope repair,
- Group 3 – Roadside and vegetation management,
- Group 4 – Bridge and urban tunnel maintenance and operations,
- Group 5 – Snow and ice control operations,
- Group 6 – Traffic control and maintenance operations,
- Group 7 – Rest area operations,
- Group 8 – Training and testing, and
- Group 9 – Third-party damage repair and disaster operations.

Each maintenance function is further subdivided into a number of subgroups, and each subgroup contains a number of specific maintenance activities, which are identified by unique work operation numbers. WSDOT has defined approximately 275 discrete work operation numbers. Finally, WSDOT has identified five maintenance work groups, which are used to further specify the nature of the work being conducted. These five work groups are as follows:

Group 01 – Covers time spent actually performing the core activity;
Group 90 – Covers time spent hauling materials to or from a particular maintenance activity location;
Group 91 – Covers time spent changing equipment attachments associated with paving operations and for time spent cleaning equipment after use.
Group 92 – Covers time spent in order to meet environmental requirements, such as annual meetings with the Department of Fish and Wildlife, obtaining permits to perform certain work, and maintaining/installing/removing environmental best management practices (BMP)—for example, work associated with silt fences or rock check dams;
Group 95 – Covers traffic control activities; and
Group 98 – Covers time that equipment is not in use.

WSDOT does not have a centralized MMS but instead it uses a combination of systems in order to budget, manage,

and track its maintenance activities and expenditures as follows:

- **Transportation reporting and accounting system (TRAINS):** WSDOT's mainframe financial management system and is a highly customized version of an American Management Systems (AMS) software package that has been in production since 1991. TRAINS is used to track all WSDOT revenues, expenditures, receipts, disbursements, resources, and obligations.
- **Human resource management system (HRMS):** The statewide labor system that tracks the names and hours of all Washington State employees. The information entered here feeds salary costs into the WSDOT payroll suspense file where it is combined with other employee costs such as fringe benefits.
- **Consumable inventory system:** The 30-plus-year-old mainframe system that WSDOT uses to manage its consumable inventory.
- **M4 fleet management system:** Used to track all costs associated with maintaining WSDOT's equipment fleet.
- There are a number of activity-specific maintenance management systems used to help maintain traffic signals, highway lighting, intelligent transportation systems, movable bridges, urban tunnels, and traffic signs, as well as a variety of databases that track work accomplishments for different activities.

WSDOT currently is investigating greater integration of the various maintenance management and cost-tracking activities, either through integration of the existing systems or through the implementation of an integrated maintenance management product. In addition, WSDOT's ongoing critical applications effort is a project to explore the replacement of 11 critical systems, including the current financial management system (TRAINS) and the labor collection and distribution system.

Currently, WSDOT tries to reconcile work accomplishments in the maintenance program from a variety of systems, including the automated data collection systems on certain vehicles and handheld PDAs. WSDOT is starting to compare the amounts recorded by these data collection devices to the consumable inventory, but it can be very challenging due to the multiple sources of data and lack of integration.

Documented WSDOT Full Cost Calculation

The full cost determination process was applied to all WSDOT maintenance activities; however, for the purposes of this summary, two line activities have been selected:

- 2113 – Snow plowing truck, and
- 2152 – Anti-icing/deicing app liquid.

Step 1: Gather and Classify Maintenance Program Activities and Expenditures

WSDOT provided expenditure and accomplishment data for 266 different maintenance activities (or work operations, as they are referred to within the agency) that make up its M2 subprogram, as well as total expenditure information for two relevant maintenance support subprograms: M1 – Maintenance Management and Support, and M5 – Inventory and Stores Administration. The two support subprograms were added as line items to the 266 other maintenance activities. The expenditure data was reviewed in conjunction with detailed activity descriptions provided by WSDOT, and each activity was classified as either line or support. Table A.33 presents the summary results of the classification process.

Pertinent observations resulting from the classification process are as follows.

In addition to a number of specific activities, each WSDOT work function (or group of related activities) includes a general activity—for example, 1199 – Other Roadway Maintenance as Approved by Superintendent. WSDOT has created other maintenance activities in order to 1) capture expenditures that, although related to work function, cannot be classified as any of the specific activities, and/or 2) track cost for a specific activity, which will ultimately be transferred to the appropriate specific activity. It therefore seems reasonable to identify the other expenditures as a support activity and allocate it between the specific line activities of the work function. In a number of cases, however, the expenditure amounts for the "other" activity are a more significant fraction (i.e., greater than 30%) of the sum of specific activity expenditures. In these cases, the "other" activity has been classified as line in order to prevent potentially skewing the full cost of the other specific activities. The "other" activities for the following work functions are therefore classified as line:

Table A.33. WSDOT maintenance activity expenditure and classification.

Activity Classification	Number of Activities	Total Expenditure	Percentage of Total
Line	227	$144,962,680	78.9%
Support	41	$38,878,654	21.1%
Total	**268**	**$183,841,334**	**100.0%**

Table A.34. Selected WSDOT line activity expenditure and production.

Activity ID	Activity Name	Line Expenditure	Accomplishment	Units
2113	Snow plowing truck	$7,095,338	1,763,663	Equipment mile
2152	Anti-icing/deicing app liquid	$6,445,140	1,020,128	Gallon

- Electrical equipment and ITS systems,
- Signal systems,
- Electrical services and highway lighting systems, and
- Disasters.

One of the activities identified in the roadway maintenance and operations work function is section safety and debris patrol. Based on the description of this activity, which indicates that this is a means of identifying locations where specific line activities should be conducted, it is classified as a support activity. By contrast, since the description of the winter safety patrol includes the application of sand, anti-icing, and/or deicing material, as well as minor amounts of snow removal (i.e., line activity coupled with patrol/survey), it is classified as a line activity.

There are a number of activities in the snow and ice control operations work function that clearly provide support to the snow and ice control line activities alone. For example, dormitory and dining room operations, radio operation specifically for snow and ice operations, mixing anti-icing and deicing liquids, and winter field supervision.

WSDOT identifies a series of program-wide support activities in the training and testing work activities work function. For example, administrative support, instructor training, drug and alcohol testing, maintenance of stockpile sites, and yard and shop clean up.

Table A.34 shows the line activity expenditure and production information for the line activities selected.

Step 2: Allocate Maintenance Support Expenditures to Line Activities

Based on the nature of WSDOT's support activities observed previously, the allocation of support expenditures to line activities is accomplished using the benchmark approach on the basis of line activity cost. On this basis, and using the descriptions of activities, a crosswalk of line and support maintenance activities was developed. The number of both line and support activities (227 and 41, respectively) is such that it is not possible to present the complete crosswalk or allocation in this report. Table A.35 presents a support activity allocation table detailing a portion of the support activity allocation to the

Table A.35. Allocation of support activity expenditure to selected WSDOT line activities.

		Winter Operations Support Activities				General Support Activities			
						Excluding Winter			
Line Activity	Line Activity Expenditure	Radio Operations	Mixing Deicing Fluids	Winter Field Supervision	All Other Winter Support Activities	Field Supervision	Radio Operator	All Other General Support Activities	Total Program Support Allocation
Snow blower	$790,466	$5,023	N/A	$27,934	$47,912	N/A	N/A	$141,266	**$222,136**
Snow plowing truck	$7,095,338	$45,089	N/A	$250,744	$430,069	N/A	N/A	$1,268,024	**$1,993,926**
Snow plowing – motor grader	$447,444	$2,843	N/A	$15,812	$27,121	N/A	N/A	$79,964	**$125,740**
Snow drift removal	$543,863	$3,456	N/A	$19,220	$32,965	N/A	N/A	$97,195	**$152,836**
Opening seasonal passes	$613,934	$3,901	N/A	$21,696	$37,212	N/A	N/A	$109,718	**$172,527**
Winter sand cleanup	$1,203,747	$7,649	N/A	$42,539	$72,963	N/A	N/A	$215,124	**$338,276**
Sanding	$4,838,534	$30,747	N/A	$170,990	$293,278	N/A	N/A	$864,706	**$1,359,721**
Anti-icing/deicing app liquid	$6,445,140	$40,957	$147,118	$227,766	$390,659	N/A	N/A	$1,151,826	**$1,958,326**
Anti-icing/deicing app solid	$13,736,933	$87,294	N/A	$485,452	$832,636	N/A	N/A	$2,454,959	**$3,860,341**
Guide stakes/posts/signs	$320,996	$2,040	N/A	$11,344	$19,457	N/A	N/A	$57,366	**$90,206**
Winter drainage maintenance	$373,416	$2,373	N/A	$13,196	$22,634	N/A	N/A	$66,734	**$104,937**
Winter safety patrol	$5,453,602	$34,656	$124,485	$192,726	$330,559	N/A	N/A	$974,626	**$1,657,052**
Avalanche control	$911,866	$5,795	N/A	$32,225	$55,271	N/A	N/A	$162,962	**$256,252**
All other line activities	$102,187,401	N/A	N/A	N/A	N/A	$48,925	$4,546	$26,532,907	**$26,586,378**
Total	**$144,962,680**	**$271,823**	**$271,603**	**$1,511,644**	**$2,592,736**	**$48,925**	**$4,546**	**$34,177,377**	**$38,878,654**

selected line activities. Two catchall columns and a catchall row are included to enhance understanding and ensure that the column and row totals represent the total support activity expenditure and the total support activity allocation to each line activity, respectively.

Key observations about the support activities related to the two selected line activities are as follows:

- All winter operations line activities, including the two selected, receive an allocation of winter radio operations and winter field supervision.
- Only anti-icing/deicing app liquid and winter safety patrol receive an allocation of mixing deicing fluids since these are the only line activities that consume deicing fluid.
- WSDOT has segregated radio operations and field supervision between winter operations activities and all other activities. Winter activities do not receive an allocation of the general field supervisions, nor do the general activities receive an allocation of the winter field supervision.

Step 3: Gather and Classify Enterprise Programs and Expenditures

Summary information regarding enterprise programs and expenditures was obtained from WSDOT's financial management system, TRAINS, for fiscal year 2008. Table A.36 details the set of enterprise programs, the total expenditures, and the classification of programs as line, support, or special/pass-through. The classifications are a result of a combination of prior knowledge of WSDOT's program structure and consultation with WSDOT's Office of Budget and Financial Analysis.

The rationale for classifying three programs as special/pass-through is as follows:

- Program B is for expenditures associated with operating specific facilities, including the Tacoma Narrows Bridge, SR 520, and others that are funded by toll revenues.
- Program E is a revolving fund for the purchase and maintenance of vehicles and other equipment. Its expenditures

Table A.36. Classification of WSDOT enterprise programs and expenditures.

Program Name	Type	Total Expenditure
Maintenance	Line	$185,637,078
Aviation	Line	$3,036,081
Improvements	Line	$1,130,398,293
Preservation	Line	$366,074,984
Traffic Operations	Line	$30,995,241
Public Transportation	Line	$43,370,820
Ferries Construction	Line	$62,786,853
Ferries Maintenance and Operations	Line	$227,058,867
Rail	Line	$39,978,457
Local Programs	Line	$254,425,326
Subtotal		**$2,343,762,001**
Toll Operations and Maintenance (Tacoma)	Special/pass-through	$15,374,998
Operations Transportation Equipment Fund	Special/pass-through	$62,249,570
Public–Private Partnerships	Special/pass-through	$416,282
Subtotal		**$78,040,851**
Information Technology	Support	$36,969,127
Capital Facilities	Support	$17,875,122
Program Delivery Management and Support	Support	$26,141,408
Transportation Management and Support	Support	$15,748,643
Transportation Planning, Data, and Research	Support	$34,605,283
Charges from other agencies	Support	$31,538,183
Subtotal		**$162,877,765**
Total		**$2,584,680,617**

Note: Some totals rounded to nearest dollar.

are reimbursed through equipment rental charges to the other programs, including maintenance. To consider it in the full cost calculation would effectively be double counting equipment expenditures.
- Program K is such a small portion of WSDOT's expenditures (<0.02%) that WSDOT's Office of Budget and Financial Analysis recommended it be excluded.

Based on the data from WSDOT's financial management system, therefore, total line program expenditure is $2,343,762,001, total support program expenditure is $162,877,765, and $78,040,851 is excluded from the calculation based on its classification as special/pass-through.

Step 4: Allocate a Portion of Enterprise Support Expenditures to the Maintenance Program

Based on the enterprise program expenditure information obtained in Step 3, WSDOT has six support programs and 10 line programs. Five of the support programs effectively support all 10 of the line programs, but one support program, H – Program Delivery Management and Support, is focused on WSDOT's regions and highways and thus cannot be considered to support all line programs. Table A.37 presents a crosswalk between WSDOT's enterprise line and support programs. The allocation calculation is performed for each valid combination of line and support programs (i.e., for each X in Table A.37). The support program allocation is equal to:

$$(\$LPIQ/\$ASLP) * \$SPIQ$$

Where

$LPIQ = cost of line program in question,
$ASLP = cost of all supported line programs, and
$SPIQ = cost of support program in question.

Using this calculation, the allocation of Program Delivery Management and Support to Maintenance is

$$\left[\$185,637,078 \Big/ \left(\begin{array}{c}\$185,637,078 + \$1,130,398,293 \\ + \$366,074,984\end{array}\right)\right] * \$26,141,408 = \$2,884,956.$$

Table A.38 shows the results of this allocation calculation for all line programs as well as the total enterprise support expenditure allocation to each line program.

Using the benchmark approach, WSDOT's maintenance program receives an enterprise support expenditure allocation of $13,715,125.

Step 5: Combine Cost Categories to Derive Full Cost

The final step in the cost calculation pulls together the line expenditure for each activity from Step 1 and the allocation of program support expenditure to each activity from Step 2, and combines these with an allocation of the enterprise support expenditures that were allocated to the maintenance program in Step 4. The allocation of enterprise support to each line activity is calculated as follows:

$$(\$LAIQ/\$ASLA) * \$AESM$$

Table A.37. WSDOT line and support program crosswalk.

	Support Programs					
			Management and Support			
Line Programs	Information Technology	Capital Facilities	Program Delivery	Transportation	Transportation Planning, Data and Research	Charges from Other Agencies
Maintenance	X	X	X	X	X	X
Aviation	X	X		X	X	X
Improvements	X	X	X	X	X	X
Preservation	X	X	X	X	X	X
Traffic Operations	X	X		X	X	X
Public Transportation	X	X		X	X	X
Ferries Construction	X	X		X	X	X
Ferries Maintenance and Operations	X	X		X	X	X
Rail	X	X		X	X	X
Local Programs	X	X		X	X	X

Table A.38. Allocation of WSDOT support program expenditures to line programs.

Line Programs	Allocation of Support Program Expenditure						Total Support Program Allocation
	Information Technology	Capital Facilities	Management and Support		Transportation Planning, Data and Research	Charges from Other Agencies	
			Program Delivery	Transportation			
Maintenance	$2,928,130	$1,415,794	$2,884,956	$1,247,367	$2,740,903	$2,497,974	**$13,715,125**
Aviation	$47,889	$23,155	N/A	$20,401	$44,827	$40,854	**$177,127**
Improvements	$17,830,239	$8,621,185	$17,567,339	$7,595,583	$16,690,156	$15,210,891	**$83,515,394**
Preservation	$5,774,252	$2,791,937	$5,689,113	$2,459,799	$5,405,040	$4,925,986	**$27,046,128**
Traffic Operations	$488,901	$236,391	N/A	$208,269	$457,640	$417,079	**$1,808,279**
Public Transportation	$684,106	$330,775	N/A	$291,425	$640,363	$583,607	**$2,530,277**
Ferries Construction	$990,363	$478,855	N/A	$421,889	$927,038	$844,874	**$3,663,019**
Ferries Maintenance and Operations	$3,581,493	$1,731,705	N/A	$1,525,696	$3,352,489	$3,055,355	**$13,246,738**
Rail	$630,597	$304,903	N/A	$268,631	$590,276	$537,959	**$2,332,365**
Local Programs	$4,013,156	$1,940,420	N/A	$1,709,582	$3,756,550	$3,423,604	**$14,843,313**
Support Program Total	**$36,969,127**	**$17,875,122**	**$26,141,408**	**$15,748,643**	**$34,605,283**	**$31,538,183**	**$162,877,765**

Note: Some totals rounded to the nearest dollar.

Table A.39. Full cost breakdown for selected WSDOT line activities.

Line Activity	Cost Categories			Full Cost
	Line	Program Support	Enterprise Support	
Snow plowing truck	$7,095,338	$1,993,926	$671,304	**$9,760,568**
Anti-icing/deicing app liquid	$6,445,140	$1,958,326	$609,788	**$9,013,254**

Table A.40. Full unit costs for selected WSDOT line activities.

Line Activity	Full Cost	Accomplishment	Units	Full Unit Cost
Snow plowing truck	$9,760,568	1,763,663	Equipment mile	**$5.53**
Anti-icing/deicing app liquid	$9,013,254	1,020,128	Gallon	**$8.84**

Where

$LAIQ = line cost of line activity in question,
$ASLA = line cost of all supported line activities, and
$AESM = allocation of enterprise support to the maintenance program.

Therefore

The allocation of the enterprise support expenditures to snow plowing truck equals

$$(\$7,095,338/\$144,962,680) * \$13,715,215 = \$671,304$$

and

The allocation of enterprise support expenditures to anti-icing/deicing app liquid equals

$$(\$6,445,140/\$144,962,680) * \$13,715,215 = \$609,788.$$

Table A.39 shows the breakdown of full cost between the three cost categories of line, program support, and enterprise support for the two selected line activities.

Table A.40 presents the full unit costs for production of each of the line activities selected.

APPENDIX B

Maintenance Cost Tracking Activities for Selected State DOTs

Introduction

This appendix summarizes the maintenance cost tracking activities at DOTs in three states: California, Minnesota, and Vermont. In each case, a summary introduction to the agency and its maintenance program is provided, followed by a description of the management systems and processes used to track the various categories of cost that compose the full cost of any particular maintenance activity. The purpose of this appendix is to supplement both the process description and the documented calculations and to provide practitioners with additional insight into maintenance cost tracking practices at state DOTs collected during this project. Full cost calculations were not performed for these agencies because it was determined that the full cost process does not vary between agencies; the only differences relate to the systems and other sources of input data, as illustrated by the six calculations documented in Appendix A.

Contents

California Department of Transportation

Introduction

The California Department of Transportation (Caltrans) is responsible for approximately 15,000 centerline miles of highway, representing approximately 9% of the statewide total and encompassing 50,000 lane miles. Caltrans has responsibility for approximately 12,000 highway bridges with a total deck area of 21 million square meters.

Caltrans' annual maintenance budget for the year 2007/2008 was approximately $1.1 billion, representing an increase of approximately $162M from 2006/2007. The total agency budget was $13.9 billion in 2007/2008. In addition to Caltrans' maintenance budget, which is directed primarily toward preventative maintenance activities, Caltrans' 2007/2008 budget included $2.5 billion for its State Highway Operations and Protection Program (SHOPP). The SHOPP program is composed of more major projects, above and beyond preventive maintenance activities. Caltrans coordinates the activities conducted under its maintenance and SHOPP programs since it must avoid expenditure of maintenance dollars in areas that are scheduled to be addressed by SHOPP projects.

Caltrans uses a combination of in-house maintenance crews and contractors. In 2007/2008, approximately $420 million of the $1.1 billion maintenance budget was paid to contractors, or 38%.

The Caltrans maintenance program is composed of just over 500 discrete activities organized into 16 families, which are in turn grouped into seven broader groups. The groups and families are as follows:

- HM 1 – Road Bed:
  - A. Flexible Pavement; and
  - B. Rigid Pavement.
- HM 2 – Roadside:
  - C. Slopes, Drainage, Vegetation;
  - D. Litter, Debris;
  - E. Landscaping;
  - F. Environmental; and
  - G. Public Facilities.
- HM 3 – Structure:
  - H. Bridges; and
  - J. Other Structure.
- HM 4 – Traffic Control and Service Facilities:
  - K. Electrical; and
  - M. Traffic Control.
- HM 5 – MTCE Auxiliary:
  - T. Support; and
  - W. Training, Field Auxiliary Services.
- HM 6 – Snow and Major Damage:
  - R. Snow/Ice Control; and
  - S. Storm Maintenance.

- HM 7 – Radio:
  - U. Radio Support.

At its highest level, Caltrans is organized into 12 district offices and the headquarters. Each of the districts covers one or more counties and oversees activities at multiple geographically dispersed maintenance stations. The majority of maintenance activities are run by the districts, although there are some activities that are coordinated on a statewide basis—for example, structures inspection.

Caltrans uses the following three systems to capture and manage maintenance cost data (one integrated maintenance management system and two financial accounting systems):

- **Integrated maintenance management system (IMMS):** Caltrans operates an integrated maintenance management system, the initial implementation of which was completed in 2003. The system is a Hanson product; however, it is now maintained and supported by another vendor. The primary users of the system are the districts. The IMMS is a work-tracking system that is used to track field maintenance staff time, activities accomplished and scheduled for maintenance crews, and the statewide road inventory. All charges in the IMMS must be assigned to an expenditure authority (EA), which are represented by the 16 letter codes, or families, identified previously.
- **Financial accounting systems:** Caltrans uses two financial accounting systems: CLASS, which is a California state government accounting system, and TRAMS, which is a Caltrans accounting system used for tracking expenditures. Caltrans is working to replace TRAMS with a new integrated financial management system (IFMS), which is an off-the-shelf system.

The IMMS is not reconciled to the TRAMS/IFMS because of the different uses of each system, although some data is transferred from IMMS to TRAMS, specifically labor and material usage.

Labor Costs

Field maintenance employees fill out a daily time sheet on the IMMS and assign their time to the appropriate EA and activity along with equipment and material usage. (For example, the A series is flexible pavement and the B series is concrete pavements.) The maintenance supervisor's time is recorded in Staff Central (another Caltrans timesheet system) and is then automatically charged to maintenance EA. Caltrans also has special maintenance forces—for example, structures inspection personnel—who report to and are managed by the headquarters. Although their organization and reporting structure is different from the rest of the maintenance organization, their costs are still reported in the same way as all other maintenance activities.

Travel time (i.e., time spent traveling between yard and site or between sites) is not tracked separately but gets charged to whatever activity is being undertaken.

There are circumstances in which Caltrans maintenance personnel perform work that is outside of the agency's maintenance program, although this is very limited. When such "day labor" activity occurs—for example, where maintenance personnel perform work on selected capital projects/activities—the maintenance personnel involved charge time against the appropriate capital EA, which is available within the IMMS. In other instances, nonmaintenance employees (other than contractors) effectively perform maintenance work for the agency—for example, when construction personnel perform certain oversight functions for maintenance activities. In these cases, a portion of the maintenance budget is transferred to the appropriate construction EA(s). The production rates are also tracked, so Caltrans can estimate the benefit and the equivalent internal cost.

Caltrans also has instances where its maintenance crews are paid for certain work by other agencies—for example, The Bay Area Toll Authority.

Equipment Costs

Caltrans used to calculate and utilize equivalent equipment rental rates to allocate equipment usage costs to maintenance activities. When they are tracked/utilized, Caltrans equipment charges are based on the time of possession for a particular activity and therefore include travel time as well as any down/idle time. The features and functionality of the current accounting system (TRAMS) are such that this calculation was deemed too time consuming, and as result, Caltrans stopped performing it two to three years ago. One of the anticipated benefits of the new accounting system (IFMS) will be to better support the calculation of equivalent vehicle rental rates, and Caltrans expects to return to this approach for tracking equipment costs as and when IFMS is implemented.

At the present time, and since the suspension of the rental rate calculation, Caltrans allocates a portion of total equipment costs to each program that includes a line item for equipment costs. The percent allocation was set based on the relative magnitude of equipment line item budgets at the time the internal rental rate calculation was suspended. Although the equipment budget can vary from year to year, the program allocation continues to be based on the original budget split.

Material Costs

Caltrans' IMMS calculates and maintains average unit prices for materials on a district-by-district basis. Maintenance per-

sonnel record material consumption on a daily basis in IMMS associated with the appropriate EA and maintenance activity, just as they do labor hours and equipment usage.

Overhead Costs

California's full cost recovery policy requires state agencies to "recover full costs when goods or services are provided to others" (California Department of Finance, 2002). The policy defines "full costs" as the sum of direct and indirect costs.

- Direct costs are easily identifiable with a specific objective, such as the implementation of a project or the delivery of a specific service. Examples include the cost of personnel directly responsible for the objective, material costs, and equipment expenses.
- Indirect costs are not directly related to a specific objective. Examples include the cost of management staff, IT staff, and accounting staff.

In order to comply with this policy, Caltrans calculates two types of indirect cost rates:

1. **Program functional rates:** This rate covers the indirect costs associated with an individual program and subprogram. Programs include highways, aeronautics, mass transportation, planning, and administration. Subprograms within the highway program include capital outlay support, local assistance, maintenance, and operations. Each subprogram has its own program functional rate.
2. **Administration rates:** This rate covers the costs of activities accrued centrally that benefit all programs. Examples include the department's legal services, building depreciation, and bond expenses. Administration rates are determined first by calculating the total administration costs, and then by allocating a portion of this total to each program. These calculations are done at the program level, so each subprogram within a program has the same administration rate.

The combination of these two rates represents each program's indirect cost rate. Table B.1 shows these rates for fiscal year 2008/2009.

Details on how these rates are determined are provided on page 84.

Table B.1. Caltrans indirect cost rates, fiscal year 2008/2009.

Reimbursed Work

Program		Program Functional	Administration	Billing Rate
10:	AERONAUTICS	37.90%	33.59%	71.49%
20:	HIGHWAYS			
20.10	Capital Outlay Support	33.12%	28.11%	61.23%
20.30	Local Assistance	18.30%	28.11%	46.41%
20.40	Program Development	18.30%	28.11%	46.41%
20.65	Legal	n/a	28.11%	28.11%
20.70	Toll Collection	n/a	28.11%	28.11%
20.70	Operations	17.23%	28.11%	45.34%
20.80	Maintenance	36.15%	28.11%	64.26%
30:	MASS TRANSPORTATION	29.02%	18.43%	47.45%
40:	TRANSPORTATION PLANNING	0.68%	14.08%	14.76%
50:	ADMINISTRATION	n/a	28.11%	28.11%

Capital Outlay Support Projects - SB45

Program		Program Functional	Administration	Billing Rate
20.10	CAPITAL OUTLAY SUPPORT	33.12%	n/a	33.12%

NOTE: Rates are applied to the *Direct Labor* cost of work performed.

Program Functional Rate

The program functional rate is the ratio of the total indirect cost to the direct labor, as expression (1) shows:

$$FR = \frac{PFIC}{DL} \tag{1}$$

Where
FR is the functional rate,
PFIC is the total program functional indirect cost, and
DL is the direct labor.

The total program functional indirect cost is the sum of the total functional indirect cost and of the carryforward, as expression (2) shows:

$$PFIC = TFI + carryforward \tag{2}$$

Where *TFI* is the total functional indirect cost.

The total functional indirect cost is the sum of the indirect labor and the indirect operating expenses, as expression (3) shows:

$$TFI = PS + OE \tag{3}$$

Where
PS is the indirect labor, and
OE is the indirect operating expenses.

The indirect labor is computed as expression (4) shows:

$$PS = \frac{IL_{PY}}{TL_{PY}} * BL \tag{4}$$

Where
IL_{PY} is the prior year's indirect labor,
TL_{PY} is the prior year's total labor, and
BL is the budgeted labor for the current year.

The indirect operating expenses are calculated the same way:

$$OE = \frac{IOE_{PY}}{TOE_{PY}} * BOE \tag{5}$$

Where
IOE_{PY} is the prior year's indirect operating expenses,
TOE_{PY} is the prior year's total operating expenses, and
BOE is the budgeted operating expenses for the current year.

The carryforward is intended to take into account the sum of money or debts from the previous year. It is the difference between the prior year's recovery of indirect costs and the prior year's total functional indirect costs, as expression (6) shows:

$$carryforward = RIC_{PY} - TFI_{PY} \tag{6}$$

Where RIC_{PY} is the prior year's recovery of indirect cost.

The prior year's total functional indirect cost is computed the same way as the current year's total functional indirect cost. It is the sum of the prior year's indirect labor and the previous year's operating expenses.

The prior year's recovery of indirect cost is the product of the prior year's program functional rate and the difference between the prior year's total labor and the prior year's indirect labor, as expression (7) shows:

$$RIC_{PY} = FR_{PY} * \left(TL_{PY} - IL_{PY}\right). \tag{7}$$

The direct labor cost is the difference between the total budgeted labor and the indirect labor, as expression (8) shows:

$$DL = BL - PS \tag{8}$$

Where *BL* is the total budgeted labor.

Administration Rate

The administration rate, like the program functional rate, is the ratio of the total indirect cost to the direct labor, as expression (9) shows:

$$AR = \frac{AIC}{DL} \tag{9}$$

Where
AR is the administration rate,
AIC is the total administration indirect cost, and
DL is the direct labor.

The direct labor remains unchanged and is calculated as expression (8) showed. However, since the administration rate is calculated for each major program (i.e., not for the subprograms), the direct labor should be calculated for each major program, summing the subprogram's direct labor.

The administration indirect cost for each program is the sum for each program of the total administration cost, legal cost, equipment depreciation cost, building depreciation cost, bond interest, and carryforward, as expression (10) shows:

$$AIC = TAC + LC + EDC + BDC + BI + carryforward \tag{10}$$

Where
TAC is the total administration cost,
LC is the legal cost,
EDC is the equipment depreciation cost,
BDC is the building depreciation cost, and
BI is the bond interest.

The total administration cost for a program (*i*) is the sum of the general administration cost (50.10) for a program (*i*), central and services cost (50.20) for a program (*i*), and pro-

fessional and technical services cost (50.60) for a program (i), as expression (11) shows:

$$TAC_i = GAC_i + CSC_i + PTSC_i \quad (11)$$

Where

GAC is the general administration cost,
CSC is the central and services cost, and
$PTSC$ is the professional and technical services cost.

The central and services cost is the budgeted amount on the governor's budget.

The general administration cost and professional and technical services cost are computed, as expression (12) shows:

$$GAC = \frac{AOE_{PY}}{TOE_{PY}} * BOE + BL \quad (12)$$

Where

AOE_{PY} is the prior year's allowable operating expenses for general administration cost,
TOE_{PY} is the prior year's total operating expenses for general administration cost,
BOE is the budgeted operating expenses for the current year for general administration cost, and
BL is the budgeted labor for the current year for general administration cost.

To calculate the general administration cost and professional and technical services cost for each program (i), the costs are prorated to the department's major programs, as shown in expression (13):

$$GAC_i = \frac{BPYH_i}{TBPY} * GAC \quad (13)$$

Where

$BPYH_i$ is the budgeted PY hours for program i, and
$TBPY$ is the total budgeted PY hours.

The legal support cost for programs 10, 30, and 40 is the budgeted amount on the governor's budget. The legal support cost for program 20.65 is the total budgeted legal support less tort expenditures.

The equipment depreciation cost for programs 10 and 20 is the balance amount of the equipment multiplied by the equipment depreciation rate (6.67%). For programs 30 and 40, the equipment depreciation cost is shown in expression (14):

$$EDC = BAE * 6.67\% * \frac{BPYH_i}{BPYH_{30} + BPYH_{40}} \quad (14)$$

Where BAE is the balance amount of the equipment.

The building depreciation cost is the balance amount on the building multiplied by the building depreciation rate (2%).

The bond interest is the sum of the budgeted bonds less the rental income.

The carryforward is intended to take into account the sum of money or debts from the previous year. It is the difference between the prior year's recovery of indirect costs and the prior year's administration indirect costs, as expression (15) shows:

$$carryforward = RIC_{PY} - AIC_{PY} \quad (15)$$

Where RIC_{PY} is the prior year's recovery of indirect cost.

The prior year's administration indirect cost is computed the same way as the current year's administration indirect cost [refer to expression (10)].

The prior year's recovery of indirect cost is the product of the prior year's administration rate and the difference between the prior year's total labor and the prior year's indirect labor, as expression (16) shows:

$$RIC_{PY} = AR_{PY} * \left(TL_{PY} - IL_{PY}\right). \quad (16)$$

Contracts

The costs of work performed by maintenance contractors are calculated with a contract management system. However, since a lot of this work is responding to a particular incident, it can be difficult to determine exactly what work was done, and it is more challenging than with in-house personnel to track units of production. Maintenance contract expenditures can be and are rolled into the other in-house expenditures.

Strict standards have been established by Caltrans for the use of personnel service contracts. For example, the contracting agency should clearly demonstrate that the proposed contract will result in actual overall cost savings to the state, but the contractor's wages should be at the industry's level and should not significantly undercut state pay rates.

Minnesota DOT

Introduction

The Minnesota Department of Transportation (Mn/DOT) accomplishes most of its maintenance in-house with state maintenance employees. Mn/DOT is responsible for maintaining approximately 11,382 centerline miles (21,191 lane miles) of Interstate roadways and state trunk highways. Mn/DOT's maintenance operations budget for fiscal year 2007 was $233,000,000. Minnesota counties are responsible for road maintenance on the approximate 45,000 lane miles of county road systems. Some counties will also maintain township roads under contracts with selected townships.

Mn/DOT's maintenance function is organized into eight geographic districts and a central office providing management and financial oversight, support for contract administration, and coordination of state road maintenance activities. Central office field support includes the fleet management unit, sign shop, and coordination of regional striping crews. Maintenance functions for each of the eight districts are organized into either one or two maintenance areas, which are then subdivided into truck stations sufficient to cover the road miles for winter and summer maintenance in each area.

Mn/DOT organizes its maintenance costs into the following products and services for budgeting purposes:

- Clear roads:
  - Clear obstructions (debris removal); and
  - Snow and ice control.
- Roadsides:
  - Mowing and planting;
  - Spraying;
  - Brush and tree removal; and
  - Rest area and property management.
- Smooth roads:
  - Pavement and shoulder repair;
  - Paving; and
  - Drainage repair.
- Traffic management:
  - Signals, signs, and striping;
  - Guardrail repair;
  - Lighting; and
  - Traffic operations and systems maintenance.
- Fleet management.
- Bridges:
  - Bridge inspection; and
  - Bridge repair/maintenance.
- Facilities management.
- Regulation:
  - Issue permits.
- Information traveler services.
- Inventory control.
- Infrastructure operations and maintenance administration.

Maintenance Costing Systems

Mn/DOT uses the following financial and maintenance management systems for collecting, integrating, and managing maintenance operations cost data. These systems are described briefly in the following paragraphs.

- **Resource Consumption Application (RCA):** RCA is a department-wide system used by all Mn/DOT maintenance and other employees to capture on a daily basis time, equipment, and materials used in state work activities. This information is shared with and used by several other maintenance management systems (discussed below), including the Work Management System (WMS), Equipment Management System (EMS-M5), Building Maintenance System, the Automated Facilities Management System, and Bridge Maintenance System. RCA data, including labor hours worked, vacation hours, sick time, and holiday pay, are shared with statewide systems, including the Statewide Automated Materials Management System (SAMMS), Statewide Employee Management Application (SEMA4), Minnesota Accounting and Purchasing System (MAPS), and the statewide information access warehouse. All data entries include job number, activity code, organization code, and funding code. The RCA system also collects equipment (hours or miles of use) and materials usage data for interface with SEMA4. All data is inputted into RCA electronically with no paper forms used.
- **Statewide Employee Management Application:** SEMA4, Mn/DOT's human resources and payroll system, is a personnel and payroll system common to most state of Minnesota departments that tracks labor costs and related human resources administrative costs. RCA labor inputs are fed into SEMA4. SEMA4 also captures employee compensation data not inputted into RCA such as state-paid insurance benefits and retirement and Social Security contributions. It shares this data with RCA and the statewide MAPS system.
- **Minnesota Accounting and Purchasing System:** MAPS is a statewide accounting and purchase system that gathers payroll information, equipment usage and depreciation data (from EMS-M5), materials usage, and other data. Equipment rates are used by MAPS to assign costs to jobs and activities based on the usage reported by job and activity. System data is distributed to the information access warehouse and ongoing Mn/DOT financial application initiatives such as activity-based costing and activity-based budgeting and management.
- **Work Management System:** WMS utilizes RCA, SAMMS, and other system inputs for work planning, preparation of field work orders, development of work plans, and creation of post-project reports (mostly for snow and ice control at present). No overhead costs are included in the labor costs reported by WMS. Thus, a comparison of MAPS and WMS costs may not give equal results since labor overhead costs are applied in the MAPS system. WMS data is used to develop Mn/DOT "dashboard" performance measures. Note that Mn/DOT Maintenance and Office of Human Resources are just beginning to develop a system or model for identifying production units or measures. Expert input from field maintenance forces is being used to establish the production unit or measurement parameters, collect the necessary data, and monitor selected projects to compare model performance with actual experience.

- **Equipment Management System:** EMS-M5, which employs the FleetFocus™ web-based fleet management system, is used to collect fleet management resource information, including labor, equipment, and materials used by fleet mechanics and managers. Equipment status codes are maintained for major equipment items to track current status. EMS-M5 only tracks miles driven by each unit. Other costs for operation of mobile equipment (depreciation, fuel use, etc.) are captured in the MAPS directly or through SAMMS and SEMA4 interfaces.
- **Statewide Automated Materials Management System:** SAMMS collects and manages material (salt, sand, etc.) usage employed in Mn/DOT's field maintenance operations, including related inventory control costs, fuel usage (from EMS), stockpile usage (from RCA) and materials usage from numerous other maintenance activities. Standard English units of measure are used. Material purchases tracked through SAMMS are recorded by location code and local rates used and include a material handling cost to arrive at total costs.
- **Other systems/cost management initiatives:** Other maintenance management systems for collecting data for the management of building maintenance include the Maximo Building Maintenance System to manage Mn/DOT's central office and district buildings, and the Automated Facilities Management System for maintenance area and rest area facilities. The bridge maintenance system is used by the central bridge office and district bridge maintenance staffs to collect bridge maintenance data. Another system used for Mn/DOT pavement maintenance projects is the Bridge and Road Construction (BARC) system, project funding for which comes from the State Transportation Improvement Program (STIP). Work under the BARC program is done under contract. Costs for projects completed under this program are charged to the affected road segment, job code, and maintenance activity code.

Additional cost management systems presently under development within Mn/DOT include Activity-Based Costing, Activity-Based Budgeting, and Activity-Based Management. These programs still await the development of discrete production or performance measurement units for comparative measures of project performance. Pilot programs have been run in a few Mn/DOT offices to assess measurement parameters developed to date, but these hierarchal systems await further development of the measurement units.

Contract Maintenance

Only a small portion of Mn/DOT's routine and preventive road maintenance work is accomplished under contract with others. It should be noted that depending on the size and complexity of the maintenance activity (and the availability of funds in the appropriate account), some activities often considered as preservation or rehabilitation maintenance are usually done by contract. As an example, some joint repair, considered by some as preventive maintenance, is sometimes done by contract. For winter maintenance, Mn/DOT Maintenance may contract on a seasonal or ad hoc basis with small local equipment operators to maintain a relatively short segment of state trunk highway in a small rural community. Mn/DOT may also enter into agreement with local farmers in some areas for mowing of hay on roadsides. For debris cleanup, Mn/DOT enters into agreements with interested counties (mostly in the Minneapolis–St. Paul metro area) for "sentence to serve" assistance with litter pickup on roadsides. Similarly, Mn/DOT consummates agreements with local Adopt-a-Highway groups for litter pickup on state trunk highway roadsides.

Mn/DOT also enters into annual contract agreements with the Greenview Organization for janitorial services and minor maintenance of Mn/DOT rest areas on state trunk and Interstate highways and selected building sites. Staffing under these contracts is accomplished mainly by retired persons who interface with the public and perform cleaning, minor maintenance, and some mowing of rest area facilities and grounds.

Vermont Agency of Transportation

Introduction

The highway maintenance responsibilities of the Vermont Agency of Transportation (VTrans) extend to a statewide network of more than 2,600 centerline miles (6,500 lane miles) of state highway, of which about 700 miles are designated on the NHS. The breakout of this mileage by functional class is: Interstate, 320 miles; principal arterial, 382 miles; major collector, 1,145 miles; urban collector, 5 miles; and minor collector or local, 10 miles. The system is largely rural: only 22% of Interstate highways and 15% of NHS mileage is classified as urban. There are also Class 1 town highways that form an extension of a state highway route and that carry a state highway route number. These roads are maintained by the respective towns, however, and are not part of the state highway network.

Highway maintenance in Vermont is defined as work covered by the legislative highway and bridge maintenance appropriation. The highway routine maintenance program excludes, for example, bridge reconstruction and rehabilitation, as well as separate funding for maintenance work in other modes (rail, public transit, and aviation/aeronautics). The budget for highway routine maintenance is about $65 million annually (FY 2008). VTrans' maintenance program expenditures are displayed in two levels of reports:

- The allotment report tracks total expenditures for maintenance, covering all monies appropriated by the legislature. This total includes the cost to accomplish maintenance,

plus administrative costs and support costs for items such as utilities, building rental and maintenance, and insurance. This total corresponds to the $65 million budget number above.
- The activity cost report tracks the basic maintenance work costs (i.e., the labor, equipment, and material costs to actually perform maintenance work, plus some indirect and support activities by maintenance personnel). It excludes some administrative costs and the support costs for utilities, rent, and so forth. The activity costs constitute about $60 million within the $65 million budget discussed above.

Routine maintenance expenditures are distributed among categories of activities as follows:

- Road surface, 7.2%;
- Bridge, 2.4%;
- Roadside, 14.2%;
- Traffic features, 5.9%;
- Winter maintenance, 30.6%;
- Overhead activities, 36.1%; and
- Other categories, 3.6%.

Maintenance of the state highway network is performed through nine districts.

General Information

MATS Development and Philosophy

The Maintenance Activity Tracking System (MATS) represents a tri-state collaboration among Vermont, New Hampshire, and Maine. Each state works on system advances that are shared with the other partnering states, with technical assistance provided by a consulting firm under retainer. MATS' capabilities thus continue to evolve, and the level of system development varies slightly among the states. The descriptions below represent the current implementation in Vermont. There is as yet no formal system documentation for general use. MATS information has been gained through interviews and review of an internal paper on MATS' development and operating philosophy (Spaulding, 2008).

The three agencies involved credit the development of MATS with helping their staff to think about maintenance business processes anew. There is now an understanding that maintenance management has as a first priority the accomplishment of work to improve the transportation system. It is not solely a tabulation of expenditures that "pay the bills." Maintenance management is seen as a three-legged model encompassing:

- **Transportation assets:** Their group, type, and location, and what specific asset is affected by maintenance.
- **Maintenance work:** Its group, type, and scope; what resources are used; and what work and improvements are accomplished.
- **Money:** Its source (e.g., fund, appropriation, account, line item) and use in transactions to enable maintenance work.

MATS' development has been accomplished with key philosophies in mind (e.g., the importance of current information and the interpretation of cost as the representation of the value of something accomplished rather than the more purely financial concept of payment for an item received). The idea of information currency is embodied in operations that are performed daily [e.g., the daily updates performed between MATS and the financial system, the input of the daily work report (DWR), and the daily input of contract estimated costs and accomplishments]. These operations will be discussed further in the sections that follow. The idea of cost as representing value rather than a strictly financial transaction is embodied in operations such as stockpile calculations and treatment of agency and contracted equipment rental charges. Monthly quality checks of MATS information are conducted to identify and correct human errors.

MATS interacts with several systems, either directly or through uploads and downloads to a data warehouse. For example, it interacts directly with the agency's financial system and indirectly with its payroll system and equipment management system. (Direct electronic interaction with the payroll system is forthcoming.) It downloads information on pavements and bridges from the data warehouse, such information having been generated and uploaded by the agency's pavement and bridge management systems.

VTrans continues to improve MATS, in conjunction with the tri-state team and its system development framework, to provide a comprehensive agency-wide approach to managing, tracking, and reporting maintenance program costs and accomplishments. MATS has evolved as a Web-based product, and VTrans is considering loading it onto personal handheld devices such as PDAs. While application of MATS is now focused in the central office and district maintenance functions, MATS is sufficiently general in its approach and system capabilities to apply to other agency functions as well. VTrans is beginning to migrate the system horizontally to other divisions (e.g., Construction, Planning, Finance and Administration, Motor Vehicles). [It has been suggested that, when MATS is migrated to other divisions, its name may need to be generalized beyond maintenance (e.g., Managing Assets on Transportation Systems.)] MATS is also being migrated vertically to go deeper within the maintenance organization (to the garage level). In the future MATS may also be offered to towns.

Work Performance

Highway maintenance in Vermont is performed largely by state agency forces. Contract work is primarily for rental of individual pieces of private equipment as well as services such as mowing, pavement leveling, certain bridge maintenance, Interstate paint striping, and emergency response. The reporting of contract work in maintenance cost varies. For example, pavement leveling [which is funded through the state's Pavement Management System (PMS) program] does appear in the actual cost reports for maintenance, and encompasses work beyond traditional pavement maintenance such as patching. Emergency services work, which for system purposes is designated as a type of special event, can also be tracked by MATS for purposes of billing towns for emergency assistance and reimbursement from the Federal Emergency Management Agency (FEMA). Certain contracted bridge maintenance work, however, is not tracked in MATS, but does appear in other cost reports for bridges.

Daily Work Report

Work performed by maintenance crews is reported on activity work reports. These reports summarize the labor, equipment, and materials used for an activity. An activity report is completed for each individual activity performed during the day. The multiple activity reports for a given day are compiled within the MATS DWR to compute both costs and accomplishments of maintenance activities. Accomplishments are expressed in physical units (e.g., square yards, cubic yards, acres, lineal feet, each) as identified in the MATS activity table. The labor hours in the DWR cover the total daily work hours (eight hours) plus any overtime. Additional information is presented below for each of the component resources of labor, equipment, and materials, respectively. DWRs also establish linkages between work performed and location on the highway system. Administratively, they enable the process of opening and closing work requests and budget requests to function properly, and their cost and accomplishment data can be compared to the work plan to evaluate progress in meeting plan targets.

Labor Costs

Labor cost reporting and processing is straightforward. Key points are as follows:

- Crews fill out daily activity reports. One report is completed for each individual activity, showing the hours worked on that activity. These activity reports for each crew are combined within a DWR and entered into MATS. The cumulative total hours in the DWR should equal the full eight-hour regular workday plus any overtime.
- Travel and supporting activities (e.g., flagging) are included in the time charged to an activity.
- All daily work time is covered, including time spent on indirect activities (e.g., training, leave).
- From the information in the daily work reports, MATS generates a labor time sheet entry for each employee in real time. When the payroll time period is completed, the time sheet is submitted in paper form to the payroll system. Within the tri-state MATS compact, Maine has already effected this transfer of time sheet information to the payroll system electronically. Vermont is now working on a similar electronic connection.
- The labor cost rate is a loaded or built-up rate that includes the employee's actual hourly wage plus benefits (e.g., allowance for vacation, leave, sick time, holidays, military service) and applicable taxes (Social Security, Medicare). Data on rate burdens are contained in a MATS fringe factor table.
- Nonmaintenance labor does perform maintenance. Prison labor is tallied at $200 per crew per day. Volunteer labor for litter pick-up is recorded in labor hours; no cost is attributed. However, VTrans could report an equivalent cost if needed.

Equipment Costs

VTrans has two ways of accounting for equipment costs: the rental costs of agency equipment as managed through the central garage, and the contracted costs of private equipment.

Agency Equipment

The central garage manages VTrans' fleet of vehicles and heavy equipment. As capital assets exceeding $5,000 in value and with a life of at least two years, maintenance equipment is managed according to VTrans' policy on assets capitalization. This policy calls for:

- Capital equipment assets to be recorded at purchase price plus any incidental cost (e.g., insurance during transit, freight, duties, title registration, and breaking-in costs);
- Straight-line depreciation;
- Physical inventories to be taken every year, with any inventory adjustments signed and approved by the division director; and
- Maintenance of records on equipment inventory through a capital asset management system maintained by the Finance and Administration division, with the appropriate business managers providing information on new assets, retired assets, adjustments, and depreciation.

The central garage uses a Maintenance Control and Management System (MCMS) to help manage the maintenance

equipment fleet and provide the data needed for Finance and Administration's capital asset management system. The MCMS tallies the purchase cost and annual maintenance and operating costs and statistics for each piece of equipment. It computes depreciation and has an algorithm to help managers identify whether it is more economical to overhaul or replace an aging piece of equipment. The cost profiles developed through MCMS for the equipment, plus current costs of fuel and other operating items, are used to quantify equivalent rental rates (hourly or per mile) for equipment use.

Private Equipment

Determining the performance-based cost of using private equipment under contract may be complicated by different ways in which contract payment is structured. In this context, "performance-based" refers to understanding the extent to which equipment is used (i.e., its hours of operation). If the equipment is charged on an hourly basis, there is no issue—the hourly charge is equivalent to a rental rate, and the equipment use can be charged according to the hours worked by the crew as recorded on the DWR. If the equipment is charged on a flat daily, weekly, or monthly basis, however, reflecting its performance-based cost correctly requires additional steps and MATS features.

- The additional steps needed are to estimate the hours that the equipment will be used and then to compute an equivalent rental rate. As an example: assume an excavator will be contracted for $3,000/month for two months. Its contract cost will be $6,000. It is estimated that during the two months, it will be used on some number of jobs by some number of crews for a total of 60 hours. The effective rental rate (or hourly charge) will be $6,000/60 hours or $100 per hour.
- The relevant MATS' features involve two options for submitted private equipment cost data on the "Rental Setup" screen, based on the method of payment in the rental agreement. If hourly charges are the basis of payment for the private equipment, the MATS "Rental Type" is specified to use the DWR hours for the appropriate activity as the basis of payment. If another charge structure is used (e.g., daily, weekly, monthly), the MATS "Rental Type" is specified to use the vendor's invoice as the basis of payment (e.g., $3,000 per month in the contract example above). The MATS computation of activity charges, however, would be based on the estimated hourly rate ($100 per hour in the example above) as the equivalent rental charge.
- The MATS "Rental Setup" screen also includes a field labeled "Actual" that allows post-contract adjustment in the MATS data to reflect actual, rather than estimated, usage. It permits back-calculating the actual effective rate based on this actual usage. For example, if the crews actually spent 65 hours on activities using the private excavator, the correct equipment rate would be $92.31 per hour. This adjustment maintains the integrity of the unit cost and total cost data from both a performance-based and an invoice-paid perspective.

Material Costs

Material costs are handled by MATS either in stockpile calculations or as over-the-counter purchases. The MATS DWR thus has two separate tabs for processing material costs. The "Stockpile" tab is used to report use of materials that are kept in stockpiles (i.e., they have a known and continually tracked quantity). The "Materials" tab is used to report use of other materials that are consumed on an activity but whose overall quantities are otherwise not tracked. Calculations involved in the "Materials" tab are straightforward: quantity multiplied by unit price (price to be discussed below). The discussion in this section therefore focuses on the handling of "Stockpile" materials.

The stockpile calculations help to track quantity and cost of materials over time, recognizing that use of materials may occur at some time after their purchase. When a DWR identifies use of a material, that quantity will be charged at the appropriate unit price, and the quantity will be deducted from the stockpile. Additional adjustments are also managed for deliveries, distributions, and corrections to or from the stockpile.

- A crew inserts a "Delivery" when material from a vendor is added to the stockpile.
- A crew specifies a "Distribution" when material is transferred from one stockpile to another. (The business rule is that the sending crew always does the distribution, to avoid missed or double counts.) The sender's stockpile quantity is reduced and the receiver's stockpile is increased by the amount distributed.
- A correction allows recalibration of the stockpile quantity to account for inaccuracies inherent in usage reporting, particularly with bulk materials such as salt or brine. (Corrections should rarely if ever be required for countable items such as pipe.) Piles of bulk materials should be periodically measured and adjusted. For example, with reasonably accurate usage reporting, stockpiles of winter bulk materials will show several small corrections throughout the winter.

Pricing of materials may be done through a statewide or regional average price, which is provided to MATS in a crew material rate table. While usage of most materials reflects a straightforward cost calculation, some issues have been identified but not yet resolved:

- Reuse of materials (e.g., framing lumber and plywood on bridge maintenance); and

- Consumable materials (cleaners, etc.) used in cleaning rest areas, which currently are not reported. (The recommendation is to treat these costs as expenditures that are not reported on the DWR.)

Indirect or Overhead Costs

Some indirect costs are tracked directly in MATS (e.g., fringe benefits on maintenance labor, and labor time reported in overhead-type maintenance activities); for example:

- 0001-4110: Training, meetings, and conferences; leave time; general administration; working with towns; and patrol and inspection.
- 5720-5760: Controlling stock and inventory, and manufacturing and stockpiling materials.
- 5860-5870: Maintaining buildings, grounds, and equipment.

Other indirect costs are factored in through nightly updates between the financial system and MATS. In these operations the VTrans administrative costs, including executives' salaries and administrative-position salaries, and the support costs (for utilities, building rental, building maintenance and janitorial services, etc.) are spread on a pro-rata basis among the maintenance activity and other program costs. This operation enables the agency to provide total dollar-per-lane-mile costs for summer and winter periods to answer the question, "How much does it cost . . . ?"

Contracts

VTrans does not contract a significant amount of its maintenance work. Approximately 5% of its work is contracted (Cambridge Systematics, Inc., 2002), and about 70% of this contract volume is for mowing. Most of the analytic issues associated with contract costs were discussed under the Equipment Costs section. One other item of import is that information on contract accomplishment as well as cost is input daily to MATS, providing up-to-date estimates of contractor billing.

Level of Service and Relationship to Costs

VTrans does not use a level of service approach such as that, for example, applied by Washington State. Rather, the concept is more one of the relationship of proposed work to total inventory and network condition, and—for a given activity—the amount of work to be accomplished for given dollars spent.

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation