Minnesota Statewide
Highway Systems Operation Plan

HSOP

MINNESOTA DEPARTMENT OF TRANSPORTATION

April 2005

Minnesota Statewide Highway Systems Operation Plan

Minnesota Department of Transportation

April 2005

Minnesota Department of Transportation
395 John Ireland Boulevard
Saint Paul, Minnesota 55155
General Phone: 651-296-3000
Toll Free: 1-800-657-3774
TTY: 1-800-657-3994
Web Site: www.dot.state.mn

Table of Contents

Page

Chapter I – Introduction 1-1

1.0 OBJECTIVES FOR THE PLAN 1-1

2.0 PLANNING CONTEXT 1-2

3.0 PLANNING HORIZON 1-3

4.0 PLAN DEVELOPMENT PROCESS 1-3

Chapter II – Major Trends and Influencing Factors 2-1

1.0 SYSTEM USAGE TRENDS 2-1

2.0 SYSTEM GROWTH TRENDS 2-3

3.0 ECONOMIC TRENDS 2-3

4.0 CUSTOMER/USER TRENDS 2-5

Chapter III – Target Setting Framework and Maintenance Performance Measures 3-1

1.0 INTRODUCTION 3-1

2.0 TARGET SETTING FRAMEWORK 3-2

3.0 MAINTENANCE PERFORMANCE MEASURES 3-2

3.1 INFRASTRUCTURE MAINTENANCE AND PRESERVATION 3-3

3.1.1 BRIDGE PREVENTIVE MAINTENANCE 3-3

3.1.2 PAVEMENT MAINTENANCE 3-10

3.1.3 TRAFFIC SIGNAL AND LIGHTING MAINTENANCE 3-14

3.2 SUPPORTING INFRASTRUCTURE MANAGEMENT 3-18

3.2.1 BUILDING (FACILITY) MAINTENANCE 3-18

3.2.2 FLEET MANAGEMENT 3-22

3.2.3 ELECTRONIC COMMUNICATIONS 3-27

3.2.4 INFORMATION TECHNOLOGY INFRASTRUCTURE PRESERVATION 3-36

Table of Contents (continued)

Page

3.3 USER MOBILITY AND TRAVEL RELIABILITY 3-39
3.3.1 FREEWAY MANAGEMENT 3-40
3.3.2 LANE CLOSURES 3-49
3.3.3 SIGNAL PERFORMANCE ON ARTERIALS 3-54
3.4 SNOW AND ICE MANAGEMENT 3-57
3.5 SAFETY 3-64
3.5.1 PAVEMENT STRIPING 3-65
3.5.2 SIGNING 3-68
3.5.3 GUARDRAIL 3-71

Chapter IV – Summary of Performance and Funding Gaps 4-1
1.0 MAINTENANCE-OPERATIONS INVESTMENT-DECISION FRAMEWORK 4-1
2.0 SUMMARY OF MAINTENANCE PERFORMANCE MEASURES 4-4

Chapter V – Future Direction, Findings and Recommendations 5-1

List of Appendices

Appendix A Acronyms and Definitions
Appendix B Minnesota Statewide Transportation Plan Policies and Outcomes
Appendix C HSOP Management Structure

List of Figures

		Page
Figure 2-1	Growth Trends in Minnesota (1996-2003)	2-2
Figure 2-2	Percent of Congested Miles of the Twin Cities Metropolitan Urban Freeway System	2-2
Figure 2-3	Mn/DOT Financial and Employment Trends	2-3
Figure 2-4	Salt Cost Trends	2-4
Figure 2-5	Labor Trends – Transportation Generalist Class	2-5
Figure 3-1	Percentage of Bridges in the Good Condition Category	3-3
Figure 3-2	Percentage of Bridges in the Poor Condition Category	3-4
Figure 3-3	Customer Ride Quality – Present Serviceability Rating	3-11
Figure 3-4	Recommended Pavement Spending – 2008 to 2022	3-12
Figure 3-5	Reported Annual Signal and Lighting Work Requests Metro District (1995 – 2004)	3-15
Figure 3-6	Facilities Assessment	3-19
Figure 3-7	Equipment Achieving Minimum Utilization	3-24
Figure 3-8	Units within Life-Cycle	3-25
Figure 3-9	Statewide ARMER Implementation Areas	3-29
Figure 3-10	Historic and Projected System Coverage (Percent)	3-33
Figure 3-11	Historic and Projected System Reliability/Maintenance (Percent)	3-34
Figure 3-12	Percentage of Servers within Recommended Service Life (2005-2012)	3-37
Figure 3-13	Percentage of Routers within Recommended Service Life (2005-2012)	3-38
Figure 3-14	Annual Statewide VMT Trends (1983-2003)	3-39
Figure 3-15	Metropolitan Urban Freeway System (MUFS)–Existing and Future	3-41
Figure 3-16	Percent of Congested Miles on the Twin Cities Urban Freeway System	3-42
Figure 3-17	Instrumented Miles – Metropolitan Urban Freeway System	3-43
Figure 3-18	FIRST Unit Activities (1993 to 2002)	3-44
Figure 3-19	Implementation of FIRST Route Coverage	3-47
Figure 3-20	Highly Restricted Facilities (Planned Lane Closures) – 2004	3-49
Figure 3-21	Location of Truck Stations and Night Crews	3-50
Figure 3-22	Location of Incident Response Trailers	3-53
Figure 3-23	Signal Retiming Frequency – Existing and Target	3-55
Figure 3-24	Statewide Average Regain Time – By Commuter Classification	3-59
Figure 3-25	Statewide Average Regain Time – By Collector Classification	3-59
Figure 3-26	Annual Snow and Ice Cost Trends (Normalized)	3-60
Figure 3-27	Average Plow Truck Costs (1997-2009)	3-61
Figure 3-28	Labor Trends – Transportation Generalist Class	3-62
Figure 3-29	Salt Cost Trends	3-62
Figure 3-30	Total Striping Miles and Cost per Foot	3-65

Figure 3-31 Percent of Line Miles within Life-Cycle 3-66
Figure 3-32 2003 Signing Replacement by District – Percent of Total 3-69

List of Tables

		Page
Table 1-1	Linkage between HSOP Performance Categories and Measures and Statewide Transportation Plan Policies	1-4
Table 3-1	Current Bridge Preventive Maintenance Activities	3-5
Table 3-2	Annual Bridge Preventive Maintenance Activities and Needs	3-8
Table 3-3	Present Serviceability Rating (PRS) Targets	3-10
Table 3-4	Signal and Lighting System Needs	3-17
Table 3-5	Electronic Communications System Coverage (Percent)	3-32
Table 3-6	Electronic Communications System Reliability/Maintenance (Percent)	3-33
Table 3-7	Cost for Additional Staff	3-35
Table 3-8	Priority and Cost for Instrumentation Projects	3-44
Table 3-9	Estimated Operational Cost of Adding Staff	3-45
Table 3-10	Estimated Cost of FIRST Routes to be Added	3-48
Table 3-11	Estimated Annual Additional Staff Costs (per crew)	3-51
Table 3-12	Estimated Initial (one time) Equipment Costs (per crew)	3-51
Table 3-13	Target Clearance Times for Snow and Ice Removal	3-58
Table 3-14	Calculation of Snow and Ice Gap (in Millions)	3-63
Table 3-15	Guardrail Material Cost History – 1999 to 2004	3-72
Table 4-1	Relationship between Maintenance Activities and Relevant Statewide Transportation Plan Policy Areas	4-3
Table 4-2	Summary of HSOP Performance Measures	4-5
Table 5-1	HSOP Performance Measures Implementation Strategies	5-5

SRF.DATA:DATA:Trans:5089 HSOP:Report:FINAL REPORT:Final Report 042805.doc

Chapter I
Introduction

Welcome to the first Minnesota Statewide *Highway Systems Operation Plan* (HSOP). This plan has been prepared by the Minnesota Department of Transportation (Mn/DOT) to support the Department's Strategic Directions and Transportation Polices and to provide a framework for managing key maintenance activities throughout Minnesota.

This operations plan is a significant first step to assessing the challenges of preserving and maintaining the State's transportation infrastructure at a time when the competition for resources is intense and the need for services is increasing in parallel with population and economic growth. This operation's planning effort is intended to complement Mn/DOT's Statewide Transportation Plan from a maintenance-operations perspective. It is also intended to compliment other strategic planning efforts such as the Mn/DOT District Plans, which focus more on capital infrastructure needs.

1.0 OBJECTIVES FOR THE PLAN

Mn/DOT has six main objectives for this ***Highway Systems Operation Plan***:

1. Document major trends and key factors that directly affect and/or influence maintenance operations work activities.

2. Identify linkages between maintenance operations activities and Minnesota's Statewide Transportation Plan and District 20-year Plans.

3. Identify performance measures in the operations maintenance area, and gather supporting data for tracking Mn/DOT's progress toward achieving the performance measures.

4. Based on identified trends and present performance levels, identify funding gaps and/or changes in maintenance operations activities to meet performance measures.

5. Based on different levels of investment, identify, if possible, level of service changes and/or priorities for various maintenance operations work activities.

6. Provide guidance and strategies to Mn/DOT Districts and Offices for implementation of the plan.

2.0 PLANNING CONTEXT – RELATIONSHIP TO STRATEGIC DIRECTIONS AND STATEWIDE TRANSPORTATION PLAN

The Highway System Operations Plan (HSOP) is statewide in scope, and further defines Mn/DOT's Strategic Directions for operations-related decisions at the District, Modal, Business and Operation Plan levels. In short, this plan is intended to define strategies that will help make decision-making on work plans and budgets at the maintenance-operations level easier.

Five performance categories have been identified for the HSOP based on user expectations and policy direction. These performance measure categories are:

I. Infrastructure Maintenance and Preservation

This area covers many of the typical maintenance activities including maintenance of bridges, pavements, signals, and lighting.

II. Supporting Infrastructure Management

This area focuses on maintenance of infrastructure and equipment that is needed to support other core Mn/DOT work activities. For example, equipment and buildings need to be maintained and repaired so that they can serve their intended function. Also, electronic communications services are needed to conduct daily operations for many state agencies.

III. User Mobility and Travel Time Reliability

Activities in this area focus on maintaining user mobility and travel reliability on the Twin Cities' 320-mile Metropolitan Urban Freeway System (MUFS). User mobility and travel reliability is enhanced by managing peak freeway traffic flows, responding to and clearing incidents quickly, and by minimizing lane closures or other capacity restrictions. In addition, this area also includes management and operations of 630 signalized intersections within the Twin Cities Metropolitan Area.

IV. Snow and Ice Management

Mn/DOT market research has shown that snow and ice is one of the highest priority services. Minnesota receives significant snow, freezing rain, and ice during a seven-month period between October and April each year. This activity involves the work associated with clearing snow and ice on over 12,000 miles of state highways throughout Minnesota.

V. Safety

Maintaining striping and signing is important to user safety throughout the transportation system, and guardrail and barrier repair protects motorists should their vehicle leave the roadway in a hazardous location.

These performance measure categories are tied to Mn/DOT's Strategic Directions and Statewide Transportation Plan policies (Table 1-1). The table shows that the relationship between the two plans is direct. It should be noted that HSOP Category III – User Mobility/Travel Reliability, and HSOP Category IV – Snow and Ice Management are tied together, because snow and ice

management affects user mobility and reliability of travel. Similarly, there is a connection between HSOP Category V – Safety and most of the other performance measure categories. For example, snow and ice removal affects safety just as well as pavement maintenance and signal operations affect safety. In subsequent sections of the plan, Chapter 2 provides background information on key trends and factors that influence maintenance activities. Identification and documentation of performance measure methodologies and establishment of a target setting framework for key maintenance activities, discussion of specific maintenance activities, their performance measures, policy direction and financial implications, as well as strategies for achieving performance targets is provided in Chapter 3. Chapter 4 provides a summary of performance measures and a discussion of the financial resources and potential impacts of different levels of investment on performance levels and/or trade-offs. And lastly, Chapter 5 identifies key findings and recommendations for and beyond the 2006 to 2009 timeframe.

3.0 PLANNING HORIZON

The planning horizon for this plan covers the next two biennia (2006-07 and 2008-09). The performance objectives and financial information contained within the plan focus on this time period. However, many of the operations strategies identified do suggest a longer term direction for specific work activities.

4.0 PLAN DEVELOPMENT PROCESS

The HSOP plan was developed in a year long process that included a significant amount of participation from Mn/DOT's District Operations Staff, Office of Investment Management (OIM), and specialized groups such as bridge, pavement management, pavement marking, fleet management, building management, Metro Electrical Services Unit and the Regional Traffic Management Center.

The plan development was led by a Project Management Team[1]. Six committees were formed to investigate and develop maintenance performance measures, service levels, best management practices, benchmarks and/or performance standards for areas listed below.

1. Safety
2. Mobility
3. Snow and Ice
4. Bridge Maintenance
5. Supporting Infrastructure
6. Pavement Maintenance

Individual committees met numerous times to review and discuss information. Information was funneled through a consultant who was responsible for reviewing, organizing and writing the plan. The overall process, findings and recommendations were reviewed and approved by the study's Steering Committee and the Commissioner of Transportation.

[1] See Appendix C for the complete HSOP management structure.

Table 1-1
Linkage between HSOP Performance Categories and Measures and Statewide Transportation Plan Policies

	Statewide Plan Policies	HSOP Performance Categories and Measures
Strategic Direction 1 "Safeguard What Exists"	**Policy 1** Preserve Essential Elements of Existing Transportation Systems[1]	I. Infrastructure Maintenance and Preservation 1. Preventive Bridge Maintenance 2. Pavement Preventive Maintenance 3. Pavement Patching 4. Signal and Lighting Maintenance
		II. Supporting Infrastructure Management 1. Building Maintenance 2. Building Functional Adequacy 3. Fleet Management Life-Cycle/Utilization 4. Electronic Communications Coverage 5. Electronic Communications Management 6. IT Infrastructure Preservation
	Policy 3 Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers[1]	III. User Mobility and Travel Time Reliability 1. Regional Transportation Management Center - Coverage 2. Incident Removal 3. Planned Lane closures 4. Unplanned Lane Closures 5. Signal Performance on Arterials IV. Snow and Ice Management 1. Time to Bare Pavement by Road Type
Strategic Direction 2 "Make Network Work Better"	**Policy 7** Increase the Safety and Security of Transportation Systems and their Users[1]	V. Safety 1. Striping 2. Signing 3. Guardrail

[1] Outcomes for these policies are provided in Appendix B.

Chapter II
Major Trends and Influencing Factors

The 2003 Minnesota Statewide Transportation Plan identified historic demographic and economic trends that have influenced transportation in Minnesota[2]. These include aging population; the changing roles of women; strong regional economies; competition in global markets; and advances in computer technology and telecommunications. Maintenance activities are influenced by numerous factors, from costs of raw materials, traffic levels, to weather, regulatory and customer expectations. This chapter provides background information on key trends and factors that influence maintenance activities. These were categorized into four main areas.

- System Usage
- System Growth
- Economic Factors
- Customer/User Expectations

1.0 SYSTEM USAGE TRENDS

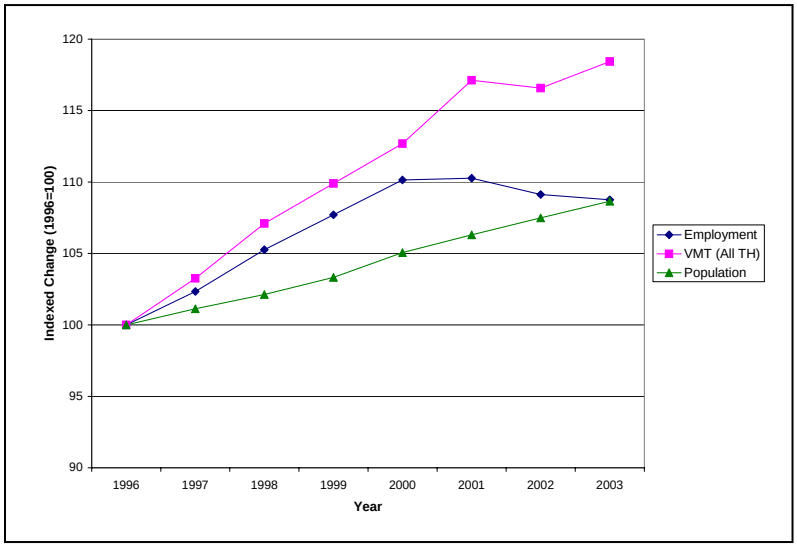
Trend: *Due to demographic and economic trends, the use of Minnesota's transportation system is increasing – this has resulted in greater maintenance needs and also changes in the way maintenance work activities are planned, designed and accomplished.*

According to the 2000 Census, Minnesota was the fastest growing state in the Midwest with a population increase of 544,380 people or 12.4 percent from 1990 to 2000. Population growth is anticipated to continue; population projections estimate that Minnesota will add over a million more people by 2030. As population increases, so do transportation usage and the "wear and tear" on the system. Pavement deteriorates faster, and more signs, poles, and other infrastructure are damaged due to crashes.

System usage is represented by vehicle-miles-traveled (VMT). Figure 2-1 shows trends in population, employment, and VMT (on all Trunk Highways) in Minnesota from 1996 to 2003; 1996 was the base year and indexed at 100 percent. System usage has increased at a rate substantially above population and employment growth (population and employment grew by nine percent while VMT increased by 18 percent). While all types of roadways have experienced growth, major highways (state routes) have experienced the largest share. From 1990 to 2000, VMT increased by 54 percent on the Interstate System. Interstate routes and other principal arterials carry close to 50 percent of all VMT in the state.

[2] Minnesota Statewide Transportation Plan: Moving People and Freight from 2003 to 2023 (Minnesota Department of Transportation, 2003), p. 4-1.

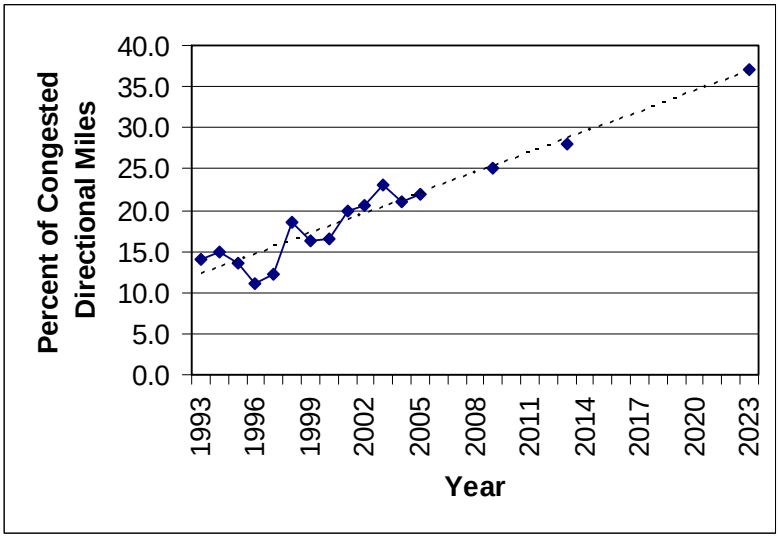
Figure 2-1
Growth Trends in Minnesota (1996-2003)



Source: Minnesota Statewide Transportation Plan 2003

System usage is concentrated on interstates and other arterials. This has resulted in more congestion on these facilities, especially on Interregional Corridors (IRC) and the Metropolitan Urban Freeway System (MUFS). Based on data collected on the MUFS, the percent of congested miles on the system increased from 14 percent in 1993 to 23 percent in 2003. When this data is projected to 2023, based on anticipated growth in traffic volumes, the percent of congested miles on the system increased to 37 percent (Figure 2-2). As volumes increase and facilities are congested for more hours of the day, maintenance activities have to be curtailed to minimize traffic problems. This has translated to a need for more night maintenance work and work in off-peak hours to avoid significant backups, secondary crashes and angry motorists.

Figure 2-2
Percent of Congested Miles of the Twin Cities Metropolitan Urban Freeway System



Source: Congestion and Incident Clearance Report, October 2004

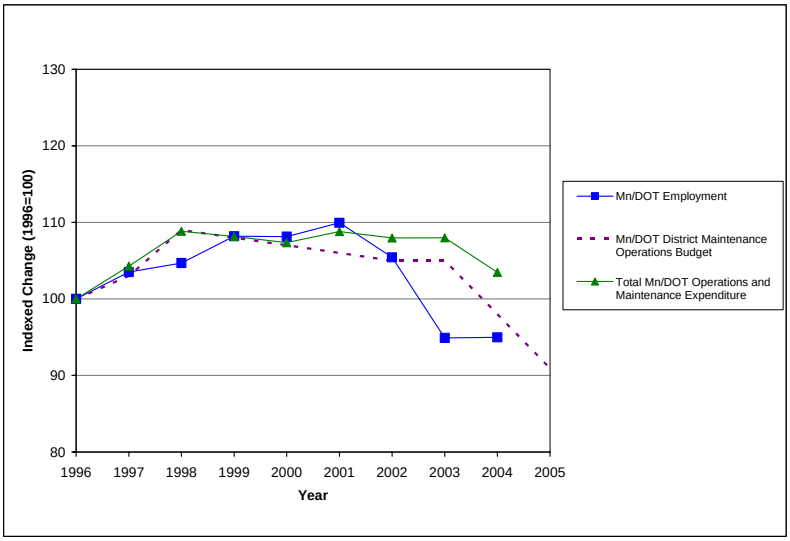
Minnesota is a key freight production state that exports more than it imports. It ranks ninth nationally in outbound domestic freight tons[3]. Between 1993 and 1997 shipments originating in Minnesota increased by 52 percent in total ton-miles. Nationally during this same period, a 10 percent increase was seen in ton-miles. The majority of heavy trucks carrying these loads use the state's highway system. This truck use results in greater damage to the system thereby increasing maintenance needs.

[3] Commodity Flow Survey Report, (1997)

2.0 SYSTEM GROWTH TRENDS

Trend: *Minnesota's transportation system is increasing: more travel lanes, bridges, interchanges, signals, signs and street lights are constructed or placed – this requires additional resources to maintain them.*

Figure 2-3
Mn/DOT Financial and Employment Trends



Source: Mn/DOT Office of Investment Management

The transportation system is being expanded to try to keep up with increasing traffic demands as well as address safety and preservation issues. As new or expanded facilities are brought on line, these facilities need to be maintained. While the number of lane miles constructed has not been increasing as fast as the need for them, new lanes are being added to the Twin Cities Beltway and other key routes throughout the state such as TH 371, TH 23 and TH 14. In addition, many new interchanges have been added as part of Interregional Corridor (IRC) funding, new signals are being added to address safety and congestion problems, and new and larger signs are placed to provide guidance and safety to users. These changes result in increased maintenance demands and higher long-term operational costs.

3.0 ECONOMIC TRENDS

Trend: *Costs of labor, equipment and materials is increasing while financial resources have been decreasing in terms of real purchasing power.*

At a maintenance-operations level, the economic trends that affect Mn/DOT's ability to conduct and prosecute work are primarily related to growth in labor, equipment and material costs. This is especially true due to limited growth in real dollars of the maintenance and operations budget (Figure 2-3).

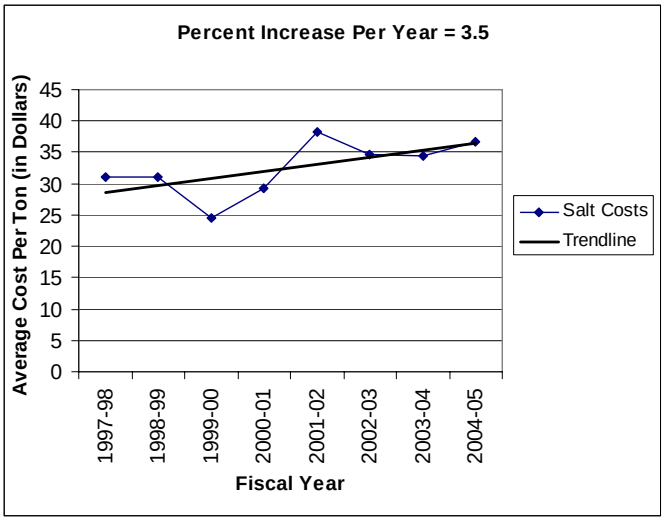
Figure 2-3 shows that, in real terms, total Mn/DOT operations expenditures have grown by only three percent since 1996. Most of this growth can be attributed to growth in construction operations (those activities that support highway and bridge capital construction projects). Dollars targeted for conducting maintenance operations during this same time period declined by

nine percent. Contributing to this reduction was a $36 million shift in funds from operations and administrative activities to support debt service on bonding for construction projects. Budgetary pressures such as these have contributed to a five percent decrease in total Mn/DOT employment. These declining trends along with a decline in real purchasing power have forced the Department to focus on delivering services in a more efficient manner and to refine, and sometimes reduce, the level of services provided. Budgetary constraints have also compelled the Department to rely more heavily on capital funding such as Bridge and Road Construction (BARC) funds to purchase materials for signing, striping and other activities.

Over the same timeframe, costs have increased for labor, equipment and materials. Material costs have risen significantly over the past number of years, even though Mn/DOT has moved to larger statewide contracts. Many of the increases have been due to market forces beyond Mn/DOT's control. For example, Mn/DOT uses a significant amount of steel in many of its maintenance activities; from cutting edges for snowplows, to culverts, guardrail, sign posts and bridge materials. World demand for steel has increased significantly, (i.e., China has increased steel usage) which has resulted in significant increase in steel prices. The market is changing so fast, Mn/DOT can no longer get long-term pricing on snow plow cutting edges for the winter season. This has increased the cost of replacing equipment and doing routine maintenance and/or repair activities.

Another example is energy costs. The cost for oil has increased significantly which has driven up fuel costs. This has not only caused dramatic increases to fuel intensive activities such as snowplowing, but also increased shipping costs for raw materials such as salt. Figure 2-4 shows the average increase in salt cost over the last eight years at 3.5 percent annually. Salt costs make up approximately 25 percent ($11.5 million) of snow and ice maintenance operations cost. This rate of increase over four years would result in $1.7 million increase in salt costs.

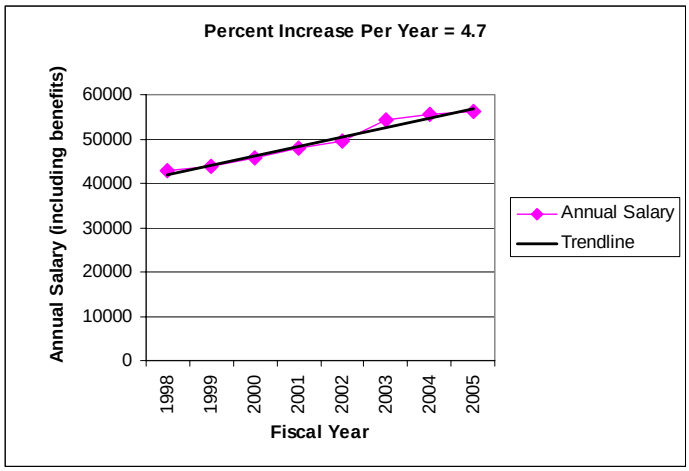
Figure 2-4
Salt Cost Trends



Source: Mn/DOT Snow and Ice Management Committee – 2004

Another major contributor to budget pressures is labor costs. Maintenance activities are inherently labor intensive due to the large transportation system, the need to work under traffic, and the need to deal with a variety of weather and other conditions. Labor costs make up 21 percent of the snow and ice operations cost and a significant portion of all other maintenance operations work. Even though direct salary rate increases have been minimal over the last number of years, overall labor costs have increased an average of 4.7 percent due to insurance and other employee costs (Figure 2-5).

Figure 2-5
Labor Trends – Transportation Generalist Class



Source: Mn/DOT Snow and Ice Management Committee – 2004

To minimize rising costs, Mn/DOT has left more positions unfilled, instituted a flexible workforce program to minimize number of employees and better equip Mn/DOT for handling of peak labor demands (i.e., construction activities and snow and ice management). This has provided more flexibility to shift staff to cover peak demands and therefore reduce overall staff needs. This added "flexibility" has come as a result of training higher-level technical staff to perform snow and ice functions. This has resulted in higher paid employees being needed for snow and ice work.

4.0 CUSTOMER/USER TRENDS

Trend: *Users of the system have consistently expressed their desire for safe and efficient transportation facilities, and prompt snow and ice removal. There is an increased emphasis on minimizing impacts of work activities on road users, establishing performance measures and targets, to ensure resources are used effectively and reducing impacts to environment.*

Mn/DOT regularly conducts market research to help define what products and services are important and how well it is delivering them. Highway maintenance consistently ranks as one of the most important services provided by Mn/DOT according to these surveys[4]. Users surveyed in 2000 indicated that safety was most important followed by roadway conditions. The most important individual services were "maintaining stop lights in working order" and "keeping roads clear of snow and ice." In contrast, maintenance of roadsides has been low on the publics' priority list. As a result Mn/DOT has placed less emphasis on roadside maintenance activities.

In terms of national trends, there has been an increased effort to minimize the impact of maintenance and construction activities on the public. This is especially true in large metropolitan areas where congestion is occurring for many hours of the day. This has resulted in greater scrutiny of lane closures, more effort placed on increasing efficiency of work, and reducing timeframes for construction work. In addition, it has resulted in more nighttime or off-peak maintenance work, and increased efforts to respond and clear incidents quickly.

[4] Minnesota Statewide Transportation Plan: Moving People and Freight from 2003 to 2023 (Minnesota Department of Transportation, 2003)

Another national trend deals with environmental stewardship. This focuses on following through on National Pollution Discharge Elimination System (NPDES) rules and regulations, which includes maintenance of sediment traps and drainage ponds. Other environmental goals include complying with energy efficient building regulations, minimizing salt usage through anti-icing and natural snow fences. While these activities have all contributed to reduced pollution and greater energy savings they also have increased upfront costs.

There has been a national trend for more performance-based measures that can easily correlate the cost for delivering specified levels-of-service or a specific outcome. Mn/DOT has been a national leader in this area, particularly in the maintenance operations area[5]. This effort has lead to better information on costs, levels of performance achieved for the cost, and ability to compare or benchmark programs in terms of best practices and/or performance levels.

[5] Booz Allen Hamilton, Research for Customer-Driven Benchmarking of Maintenance Activities, (NCHRP Web Document 58 – Project 14-13, 2003)

Chapter III
Target Setting Framework and Maintenance Performance Measures

1.0 INTRODUCTION

Defining performance measures and establishing performance targets has allowed Mn/DOT to track performance and to evaluate whether it is achieving the targets. Mn/DOT has made a significant effort to develop performance measures and track performance of key activities. The HSOP provides an opportunity to formally document and improve existing measures, identify new measures, and assess data and reporting issues. This chapter discusses the methodology for setting performance targets as well as discussing specific performance measures in the maintenance area.

2.0 TARGET SETTING FRAMEWORK

In setting performance targets, both trend-based and policy-based targets are used. Trend-based projections are used, if data is available, to estimate levels of performance based on extrapolation of historic trends. Policy-based targets are set to achieve desired performance levels, based on policy or user expectations. In addition, national benchmarks, accepted or standards of practice, and/or benefit-cost comparisons were used to evaluate current practices and effectiveness of activities. Targets should be realistic. Setting targets too high can lead to over-investment and inefficient use of scarce resources while setting targets too low can lead to under-investment and a failure to meet user expectations and provide safety. In addition, they may also lead to unintended increases in long-term costs (i.e., failure to do preventive maintenance can result in higher reconstruction and/or rehabilitation costs).

The methodology for setting performance targets consisted of the following steps:

1. Existing performance measures were reviewed and revised as needed. In addition, potential performance measures were identified for key maintenance-operations activities where no measures exist today. Measures focused on quantifying level of work, level of response, and/or measured activity with respect to national benchmark and/or other established level if available. Measures were classified in one of three categories:

    - **Mature Measures:** These are measures for which baseline data exists and policy targets have been in use previously.
    - **Emerging Measures:** These are measures for which data exists, but targets have not been set previously.
    - **Developmental Measures:** These are measures for which neither data nor targets were previously developed.

2. Whenever possible, historical data was collected to better understand levels of performance and investment in the recent past. In most cases, limited financial information was available due to previous changes to accounting systems and/or changing practices. Some reconciliation was done between costing systems and financial information obtained from other management systems such as Work Management System (WMS) and Mn/DOT's Fleet Management System (M4).

3. Work teams identified factors affecting their ability to perform maintenance activities (i.e., weather, traffic increases, inflation pressures, changing expectations, regulatory issues).

4. Teams also identified how the scope of their services is changing due to system changes. For example, they identified whether the service needs to expand to cover more miles, more signals, and more guardrails, or whether higher volumes require more service or repair or changes in the way service and/or repair operations are done. Where possible, information was documented to substantiate these trends.

5. Where possible, service implications were identified based on maintaining current levels of funding. In addition, financial implications were identified for meeting identified performance targets (i.e., targets based on national benchmarks, b/c information, and/or best management practices). It should be noted that the performance measures identified in this plan focus on conducting maintenance operations such that user costs are minimized (i.e., lane blockages – increased night maintenance).

There are two important cautions with respect to the target-setting methodology. First, when only a limited number of historical baseline points are available (limited data), trend-based projections are used as more of a reference than a predictive tool. Over time, as more data is collected and as more experience is gained with specific measures, better predictive tools should be developed. Second, there is a significant correlation between level of capital investments for roadway and bridge reconstruction and rehabilitation, and maintenance levels. The newer the system, the fewer maintenance needs there are. If the system is allowed to age without capital investments for rehabilitation, preventive maintenance or replacements, more maintenance will be needed to keep the system functioning.

3.0 MAINTENANCE PERFORMANCE MEASURES

Performance measures were developed for the five maintenance performance areas. As part of developing these measures and targets, benefit-cost, industry standards and/or benchmarks were utilized where possible. Work activities were categorized into five main performance measure areas.

3.1 Infrastructure Maintenance and Preservation
3.2 Supporting Infrastructure Management
3.3 User Mobility and Travel Reliability
3.4 Snow and Ice Management
3.5 Safety

These categories and many of the individual work activities parallel those in the Statewide Transportation Plan. Discussion of each individual work activity includes A. Introduction and Background; B. Performance Measure Definition; C. Policy Direction – Financial Implications; D. Implementation Strategies.

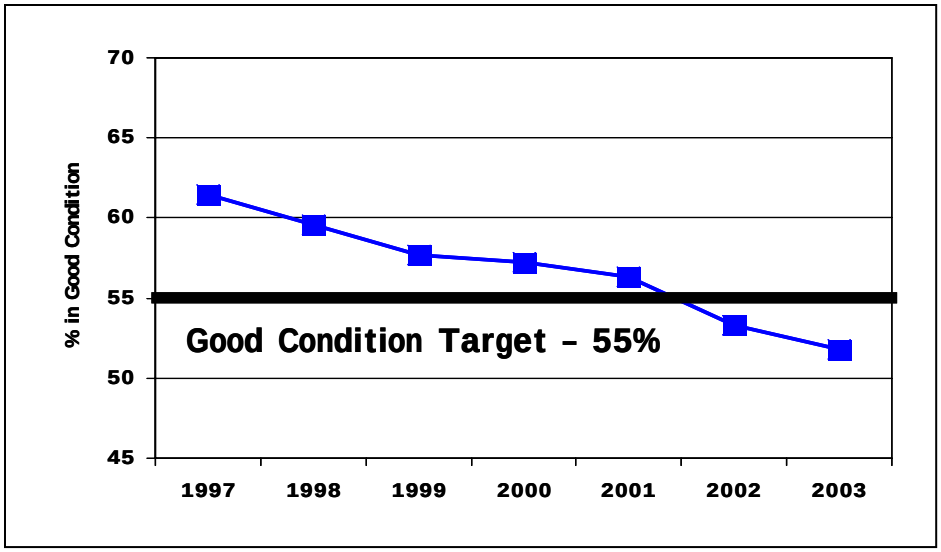
3.1 INFRASTRUCTURE MAINTENANCE AND PRESERVATION

3.1.1 BRIDGE PREVENTIVE MAINTENANCE

A. Introduction and Background

Mn/DOT regularly inspects and tracks the conditions of all of the bridge structures on a statewide basis through PONTIS[6]. Using federal bridge inspection guidelines, all bridge components are evaluated and documented. Based on this evaluation, the percentage of bridges in the "good" structural condition category has been declining for the past seven years and is below the Statewide Transportation Plan target of 55 percent (Figure 3-1). In addition, the percentage of bridges in the "poor" condition category is over the 2 percent Statewide Transportation Plan target, holding steady at approximately 4 percent (Figure 3-2). Part of the reason for the declining number of good bridges and the higher number of bridges in "poor" condition is the large number of aging bridges constructed in the interstate era, and the limited dollars that are being spent to rehabilitate or replace these structures.

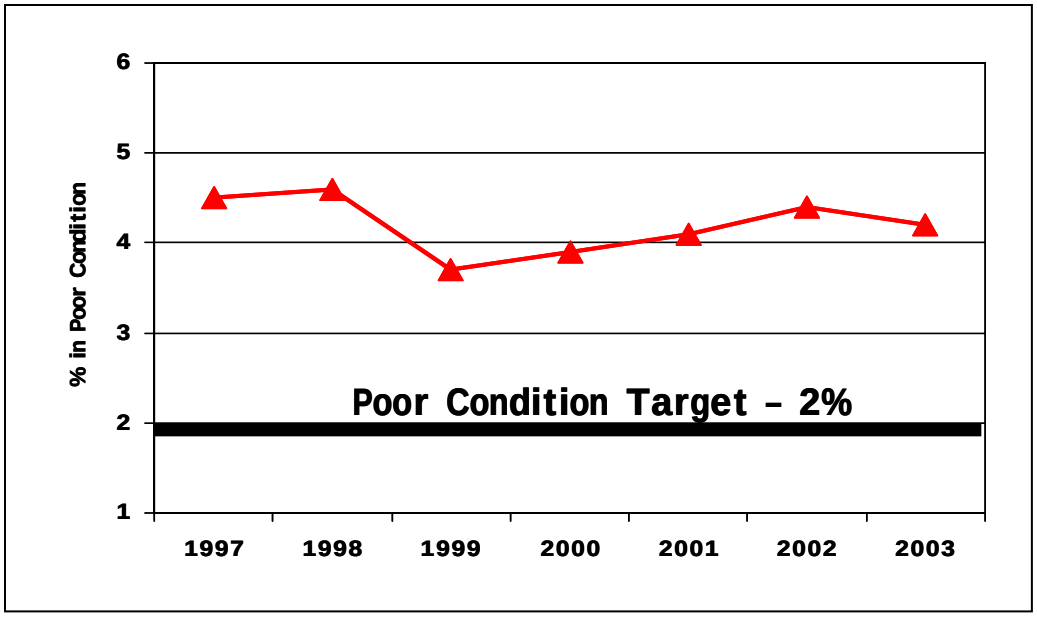
Figure 3-1
Percentage of Bridges in the Good Condition Category



Source: Mn/DOT District Operations Performance Data Summary Report, 2004

[6] PONTIS is a federal bridge inventory/inspection program that tracks the conditions of individual bridge elements. It is also used to report the overall condition of bridges.

Figure 3-2
Percentage of Bridges in the Poor Condition Category



Source: Mn/DOT District Operations Performance Data Summary Report, 2004

Given the number of bridges on Mn/DOT's system[7] and the average bridge life-cycle, Mn/DOT should be replacing or conducting major rehabilitation work on approximately 74 bridges per year. Mn/DOT is currently spending $30.3 million on bridge replacements and bridge improvements when the identified annual needs are over $76 million for the years 2007 to 2030[8]. Rehabilitation and reconstruction timeframes could be prolonged with a consistent, life-cycle bridge preventive maintenance program.

Bridge preventive maintenance work can be equated to regularly washing one's car to minimize the potential rusting or damage due to salt, sand, and other abrasive materials. Regular washing extends life and maintains value. Bridges have similar needs[9]. For example, frequent use of deicing salts and sand to remove snow and ice can lead to corrosion of metal components like bearings, rebar and steel floor beams or girders. In addition, sand and other materials can also clog rubber expansion joints and drains.

In 2004, Mn/DOT spent approximately $1.0 million on a system that has a value of $4.3 billion to conduct bridge preventive maintenance activities including joint repairs, deck flushing, crack sealing, spot-painting, and concrete sealing. Based on a survey of bridge maintenance staff, these activities were prioritized and evaluated to identify standards of practice and cost-effectiveness (Table 3-1)[10].

[7] Mn/DOT has a total of 4,429 bridge structures of 10 feet and over (includes large culverts)
[8] Based on information presented in District Operations Performance Data Summary Report, June 2004.
[9] Preventive bridge maintenance applies to bridges with decks (2,735 bridges), not to large culverts
[10] Based on survey of all Mn/DOT Districts in January 2004.

Table 3-1
Current Bridge Preventive Maintenance Activities[1]

Maintenance Priority Order		Preventive Maintenance Activities	D1	D2	D3	D4	D6	D7	D8	Metro
1	Joint Repairs	Strip Seal		Y	Y	Y	Y	Y	Y	Y
		Poured Seal		Y		Y	Y	Y	Y	
2	Flushing	Drain	Y	Y	Y	Y	Y	Y	Y	Y
		Deck, Joints, Truss	Y	Y	Y	Y	Y	Y	Y	
		Bridge Seats		Y	Y	Y	Y	Y	Y	Y
		Steel Beam Ends			Y	Y	Y	Y	Y	
		Concrete Beam Ends		Y	Y	Y	Y	Y	Y	
3		Crack Sealing		Y	Y	Y	Y	Y	Y	
4	Concrete Seals	Deck Seal								
		Bridge Seat Seal					Y			
		Bridge Rail Seal					Y	Y		
		Concrete Beam Ends			Y					

[1] Based on survey of bridge maintenance staff in each District January 2004. Blank boxes indicate that activity is either not performed at all (most cases) or is only done in certain circumstances.

Based on this, the first priority is to maintain bridge joints, followed by flushing activities, crack sealing, spot painting and finally concrete sealing. Repairs to beam ends and bridge seats were less of a concern for many, since maintaining the bridge joints, which are a higher priority, should minimize the negative impacts to these elements. If traffic control concerns prevent joints from being maintained a more expensive preventive maintenance program for spot painting and sealing beam ends and substructures located under joints should be implemented.

B. Performance Measure

This measure is considered a developmental measure[11]. Recommended bridge preventive maintenance activities are grouped into four categories. Performance targets developed for these bridge maintenance categories are shown below. These preventive maintenance activities are intended to cover bridges with decks that are in "good" condition.

[11] The estimates of preventive work needed in all categories except for Strip Seal Joints, were reduced by 13 percent to account for ridges in "fair" and "poor" condition. Bridges with these condition ratings require major rehabilitation or reconstruction, not preventive maintenance. Strip seals function to preserve the bearings and structural elements below the bridge deck, so except for total replacement of the structure, they should continue to receive preventive maintenance.

Joint Repairs – Joint repair is a high priority for bridge preventive maintenance activities. There are two types of joint repairs – strip seal joints and poured seal joints. Strip seal joints should be replaced every 25 years or on four percent of bridges each year while poured joints should be replaced every 8 years or on 12 percent of bridges each year (i.e., based on maintenance experience and average life-cycle of seals). The repair needs are based on inspections that occur every one or two years and are documented in PONTIS[12] elements #300 and #301. The performance measure for strip seal joints is as follows:

$$Strip\ Seal\ Joints = \frac{Total\ Lin.\ Ft.\ of\ Strip\ Seals\ (C.S.1)}{Total\ Lin.\ Ft.\ of\ Strip\ Seals}$$

The performance measure for poured seal joints is as follows:

$$Poured\ Seal\ Joints = \frac{Total\ Lin.\ Ft.\ of\ Poured\ Seals\ (C.S.1)}{Total\ Lin.\ Ft.\ of\ Poured\ Seals}$$

The target for these measures is to have 96 percent of all strip seals and 77 percent of all poured seals in condition state one.

Deck Crack Sealing – Crack-sealing needs are based on bridge inspections and are documented in PONTIS element #358 Deck Cracking. Deck cracking condition states two and three are considered deficient and should be sealed[13]. Crack seals last approximately five years, so 20 percent should be replaced annually. The proposed performance measure is as follows:

$$Deck\ Crack\ Sealing = \frac{Total\ Sq.\ Ft.\ of\ Deck\ Cracking\ (C.S.1\ and\ C.S.2)}{Total\ Bridge\ Deck\ Area}$$

The target for this measure is to have 80 percent of all deck cracking in condition states one or two.

Concrete Sealing – Bridge concrete sealing includes – deck seals and railing seals. These should be done in conjunction with crack sealing. Bridge deck surfaces (except ones with overlays) and railings should be re-sealed every 7 years.

[12] PONTIS is a federal bridge inventory/inspection program.

[13] Condition State (C.S.) one, will be revised in FY 2006. At this time C.S. 1 will be split and C.S. 2 will include sealed cracks. The current C.S. 2 and C.S. 3 will become C.S. 3 and C.S. 4, respectively during the three year transition period. PONTIS data for this measure will require scrutiny to prevent data errors.

The performance measures for these activities are as follows:

$$Deck\ Seals = \frac{Deck\ Seals\ Completed\ within\ 7\ years\ (Sq.\ Ft.)}{Total\ Deck\ Area\ (Sq.\ Ft.)}$$

$$Railing\ Seals = \frac{Rail\ Seals\ Completed\ within\ 7\ years\ (Lin.\ Ft.)}{Total\ Bridge\ Rail\ (Lin.\ Ft.)}$$

The target for these measures is to have 74 percent decks and rails sealed within a 7-year life-cycle.

Flushing – Flushing is to remove chemicals and material build-up from bridge trusses, joints, drains, bridge seats and beam ends. This is carried out under Activity 2837 – Bridge Flush. The target for this measure is to flush annually 87 percent of bridges with decks. The performance measure calculation is shown below:

$$Flushing = \frac{Total\ Bridges\ with\ Decks\ Flushed\ (Sq.\ Ft.)}{Total\ Deck\ Area\ (Sq.\ Ft.)}$$

Based on a cost effectiveness analysis, the above shown package of preventive maintenance activities is anticipated to have a benefit-cost ratio of approximately four to one[14]. In addition, bridge preventive maintenance activities may need to be done differently in metropolitan areas where traffic volumes are much higher; these areas are likely to require more substantial traffic control and/or night work

C. Policy Directions – Financial Implications

While Mn/DOT performs many of the bridge preventive maintenance activities, these maintenance activities are not done consistently on the full system. Table 3-2 shows a comparison of the dollars spent in 2004 for these activities as compared to the life-cycle preventive treatments. These preventive treatments are expected to yield a benefit-cost ratio of approximately 4:1 over reactive maintenance treatments.

For example, PONTIS shows 28.1 percent of joints needing poured seal as compared to the 12 percent annual life-cycle replacement need. Therefore, there is more than a two-year backlog for this work. Another example shows six percent of the Strip Seals needing replacement as compared to the annual life-cycle replacement of four percent per year. This shows a backlog of one and one-half years.

[14] Treatment frequency and cost effectiveness is based on January 2004 survey of Mn/DOT bridge staff.

Table 3-2
Annual Bridge Preventive Maintenance Activities and Needs

Maintenance Priority Order		Preventive Maintenance Activities	2004 Activity Level Dollars	Annual Performance Target[1] (Percent)	Total Performance Quantity[2]	Current Need[3] (Percent)	Total Annual Need[4]	Performance (Percent)
1	Joint Repairs	Strip Seal	$300,000	4	10,858 LFT	6	$855,000	94
		Poured Seal	–	16	49,338 LFT	28.1	$79,500	72
2	Flushing	Drain	$520,000	100	2,379 bridges	2,379 bridges	$1,386,000	–[5]
		Deck, Joints, Truss						
		Bridge Seats						
		Steel Beam Ends						
		Concrete Beam Ends						
3	Crack Sealing	Crack Sealing	$170,000	20	4,892,319 SFT	11	$ 1,326,500	86
4	Concrete Seals	Deck Seal	–	20	1,819,554 SFT	92	$45,700	–[5]
		Bridge Rail Seal	–	20	158,286 LFT	98	$439,000	–[5]
			$990,000			**Total =**	**$4,131,700**	

[1] Percent of applicable bridges to receive maintenance activity on annual basis.

[2] Annual quantity of work needed to meet performance target.

[3] Current identified need; if greater than performance target, there is more than one-year backlog of work.

[4] Annual bridge preventive maintenance needs identified to meet stated performance targets.

[5] Due to limited data, current needs for these measures have not been established.

Based on the bridge preventive maintenance schedules, best practices, and the number of bridges, it is estimated that the need for bridge preventive maintenance is approximately $4.1 million per year. In addition to this $4.1 million in annual needs, it is estimated that an additional $134,000 is needed per year to "catch-up" on structures not receiving joint repairs in the past. This equates to a total funding level of $8.6 million per biennium or $4.3 million per year less the 2004 level of spending ($990,000) which equates to a gap of approximately $3.3 million per year or $6.6 million per biennium.

It is anticipated that the return on investment through extending the life of the bridge or delaying the time before major maintenance is required is approximately four to one. While there will be short-term savings of not doing bridge preventive maintenance, there will come a time when preventive maintenance is no longer a viable option and reconstruction or rehabilitation is the only remedy.

D. Implementation Strategies

The implementation strategy for this area should focus on continuing to document the need for this preventive work, to focus the preventive dollars according to need and to activities that provide the highest benefit-cost with respect to extending bridge life, and to develop an economical way to track and report bridge preventive work. It is suggested that a simple spreadsheet or database be developed to track measures by district to provide better information to crews and supervisors[15]. Other implementation issues and strategies are listed as follows:

- Best practices should continue to be investigated, defined and implemented throughout the state where common problems and work elements are similar.

- Significant discussion will need to occur with respect to doing preventive work in the Twin Cities area. This area has high traffic volumes that limit lane closures. As a result, a significant amount of these activities will likely need to occur at night.

- Inconsistencies due to traffic or other considerations should be documented and/or explained so that program is fundamentally consistent between Districts.

- Work should be done to improve the linkage between work repairs and condition reporting programs (i.e., potential link between WMS and PONTIS). This would reduce reporting lag and result in better information to supervisors.

- Continue to investigate potential enhancements to bridge management systems to link different investment strategies and life-cycle cost elements.

- As more information is collected and better data becomes available, performance measures will need to be re-assessed.

Continue to explore the use of FHWA funds for preventive bridge maintenance activities. The Federal Highway Administration (FHWA) recently tried to make it easier to fund preventive maintenance activities by issuing a memorandum (October 8, 2004 Preventive Maintenance Eligibility Memorandum). This funding would include bridge preventive maintenance activities.

The most significant challenge is to retain long-term funding for bridge preventive maintenance activities. Bridge preventive maintenance does not affect a structures short-term serviceability, but focuses on extending its overall life. Therefore, when funding is limited, it tends to as be allocated to address immediate maintenance needs, not preventing larger costs that are far into the future. These short-term needs are often not related to bridge maintenance. This leaves many of the preventive strategies without resources over time. In addition, separate funding mechanisms and management structures between construction and maintenance often lead to management of the asset with insufficient regard to overall life-cycle costs.

[15] One could also explore use of PONTIS as a tool; however, this may be too complicated and costly.

3.1.2 PAVEMENT MAINTENANCE

Pavements are one of the most visible transportation elements to the public. They not only can observe the surface condition, but also more importantly feel the condition of the roadway through its ride. Mn/DOT evaluates all pavements statewide to identify problem areas and to determine cost-effective solutions. From a maintenance standpoint, treatments generally fall into two categories; pavement preventive maintenance and pavement patching. Pavement preventive maintenance is generally performed on "good" pavements to prevent or slow further deterioration. Pavement patching is reactive maintenance to temporarily fix isolated pavement areas that may have a significant problem. These two maintenance activities are described in more detail below.

3.1.2.1 Pavement Preventive Maintenance

A. Introduction and Background

Pavement Preventive Maintenance (PPM) activities (i.e., seal coats, joint seals, micro-surfacing, thin overlays) are done to cost-effectively extend pavement life. Pavements are exposed to weather (i.e., rain, snow, cold, heat) and various traffic loads. These external forces can cause significant deterioration over time. Many of the preventive treatments focus on sealing the roadway surface to prevent water from seeping into pavement joints and subgrade materials. Water can cause loss of roadway strength, stripping and raveling of the pavement surface, and significant joint deterioration. Other preventive treatments focus on correcting rutting and/or isolated structural problems to improve ride and drivability.

Pavements throughout the state are rated to assess their vehicle ride quality. These ratings are correlated with public expectations. The smoothness of ride is based on a scale of 0 to 5. "Good" ratings are based on values between 3.1 and 5.0. "Poor" values are represented by ratings of 2.0 or less. Normally, only pavements with a Present Serviceability Rating (PSR) above 3.0 are considered for preventive maintenance activities because once pavements deteriorate beyond this point they tend to have too many structural defects to cost-effectively be addressed by pavement preventive activities. A rating of 3.0 is considered just below the "good" category and the beginning of the "fair" category.

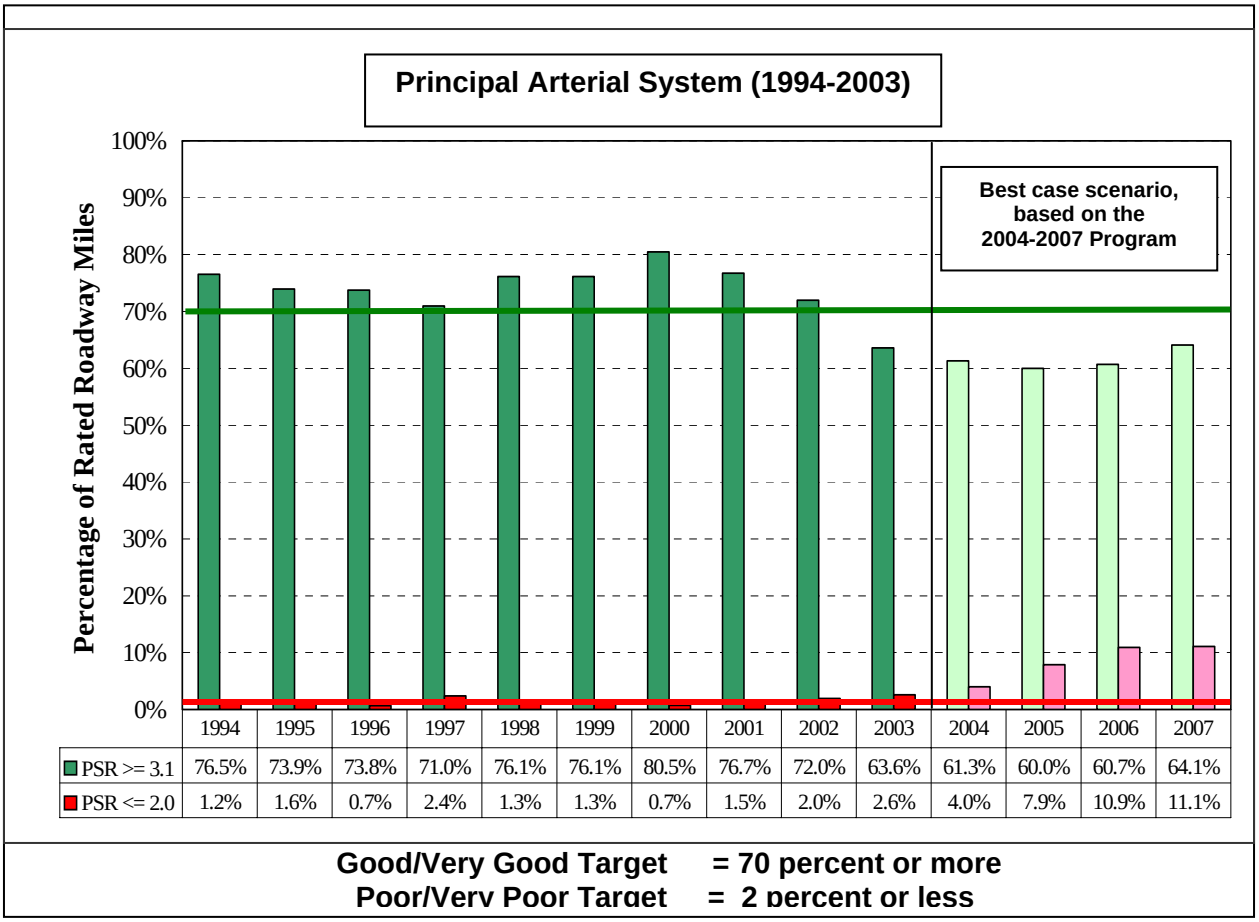
Mn/DOT uses its pavement management system to assess the best combination of preventive treatments and rehabilitation strategies on a segment-by-segment basis. Pavement serviceability rating targets by roadway class are shown in Table 3-3.

Table 3-3
Present Serviceability Rating (PSR) Targets

Roadway Class	Target (in percent)	
	Good/Very Good	Poor/Very Poor
Principal Arterials	70 or more	2 or less
Minor Arterials	65 or more	3 or less

For principal arterials, the overall goal is to achieve 70 percent of the system in the "good" PSR category and only two percent in the "poor" PSR category (Figure 3-3). There are two components to achieving the statewide pavement targets identified above. One is to effectively slow or prevent pavement deterioration through preventive maintenance and the other is to fix and/or preserve pavements that are in poor condition through rehabilitation and/or reconstruction.

Figure 3-3
Customer Ride Quality – Present Serviceability Rating



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
PSR >= 3.1	76.5%	73.9%	73.8%	71.0%	76.1%	76.1%	80.5%	76.7%	72.0%	63.6%	61.3%	60.0%	60.7%	64.1%
PSR <= 2.0	1.2%	1.6%	0.7%	2.4%	1.3%	1.3%	0.7%	1.5%	2.0%	2.6%	4.0%	7.9%	10.9%	11.1%

Source: Mn/DOT District Operations Performance Data Summary, June 2004

B. Performance Measure

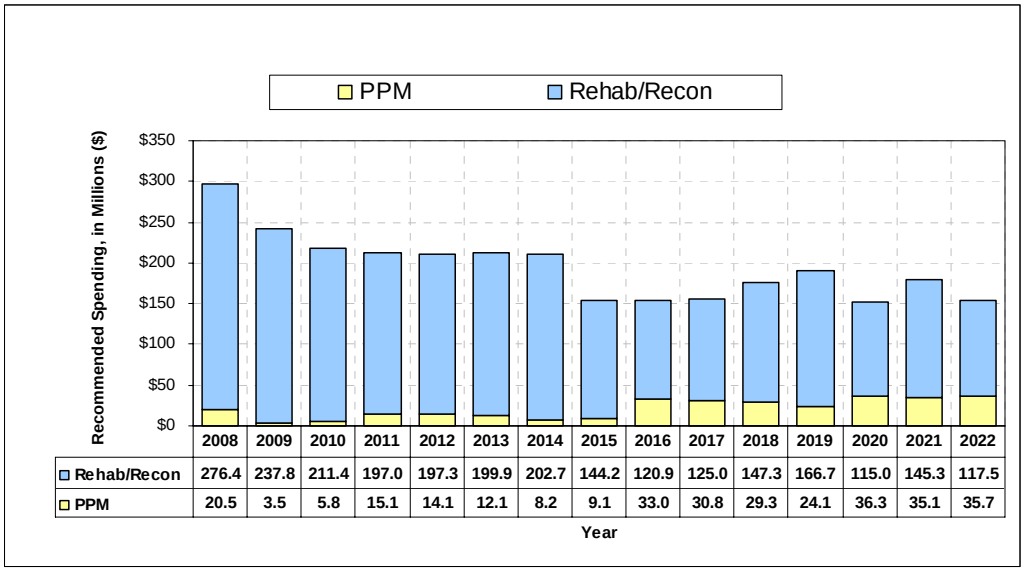
During the first biennium of the HSOP (FY 06-07) Mn/DOT will continue to use a spending level target of $40 million per year. This target was established in 2001 based on estimated historical statewide PPM spending. Beginning in 2008 Mn/DOT will move to a variable PPM spending target based on pavement modeling done to achieve the 20-year District Plan pavement targets adopted for pavement Present Serviceability Ratings (PSR). This performance measure is a spending or input measure. The outcome to be achieved is a smooth pavement measured by the Present Serviceability Rating (see Figure 3-3). Pavement preventive maintenance is one strategy to achieve and maintain PSR at the lowest life-cycle cost.

C. Policy Directions – Financial Implications

Statewide programmed PPM spending for FY 2006 is approximately $27 million, spending in FY 2007 is estimated to be $16.7 million. When these totals are subtracted from the $40 million target, Mn/DOT is faced with a FY 2006-07 funding gap totaling $36.3 million. For fiscal years 2008 and 2009 Mn/DOT's pavement management model recommends PPM spending of $20.5, and $3.5 million respectively. The lower recommended spending level in 2009 is due primarily to worsening pavement conditions. Over the past three years, the condition of many pavement sections has fallen below the level at which preventive maintenance strategies are cost-effective.

Figure 3-4 shows recommended pavement spending from 2008 through 2022 broken down by Pavement Preventive Maintenance (PPM) and Rehabilitation and Reconstruction (Rehab/Recon). This figure shows that a much higher funding effort is needed over the next 10 years to get pavements back to desired conditions. The recommended pavement spending of $229 million (on average) during the initial period (2008 to 2014) is higher when compared to the $169 million recommended for the later period (2015 to 2022). This is because more expensive treatments are needed in replacement and rehabilitation areas to restore pavements to meet target condition levels. Once PSR targets are met in 2014, an equilibrium level of preventive maintenance spending needed to maintain trunk highway pavements at District Plan targets is estimated to average $32 million per year.

Figure 3-4
Recommended Pavement Spending – 2008 to 2022



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rehab/Recon	276.4	237.8	211.4	197.0	197.3	199.9	202.7	144.2	120.9	125.0	147.3	166.7	115.0	145.3	117.5
PPM	20.5	3.5	5.8	15.1	14.1	12.1	8.2	9.1	33.0	30.8	29.3	24.1	36.3	35.1	35.7

Source: Mn/DOT, Office of Materials

Mn/DOT made a policy decision during the 20-year District planning process to fully fund pavement needs in order to meet PSR performance targets by 2014. This funding will come from the State Road Construction Budget and will cover pavement preventive maintenance needs. Therefore a funding gap for fiscal years 2008 and 2009 will not be identified in this HSOP.

D. Implementation Strategies

The implementation strategy is to set the preventive pavement maintenance target on year-to-year pavement conditions and the best mix of maintenance and rehabilitation choices. In addition, Mn/DOT will continue to monitor pavement conditions, document preventive treatments and their effectiveness, continue application of new materials and research to extend pavement life-cycle and increase cost-effectiveness, and continue investigation into internal best management practices to employ effective practices across the state. The overall objective is to get the pavements back to an optimal condition so that less expensive preventive maintenance treatments can maximize pavement life at the lowest possible cost.

3.1.2.2 Pavement Patching

A. Introduction and Background

Pavement patching is a reactive maintenance treatment that is performed by Mn/DOT maintenance crews to hold pavements together until major rehabilitation and/or reconstruction activities can be done. Pavement patching is needed to address severe pavement distresses such as severe transverse cracking, severe longitudinal cracking, alligator cracking and rutting. These distresses are most often associated with a poor ride and limited roadway strength. Roadways with severe distresses are most likely to be ones in "poor" condition. In theory, if roadway conditions worsen, then more of these severe distresses will be present and the need for patching will rise. If patching does not occur, potholes and more significant pavement ride issues usually develop.

Source: Mn/DOT Office of Maintenance
Pavement Patching

It is Mn/DOT's policy to repair all potholes and severe distresses. However, the level of repairs or "fixes" is dependent upon the amount of patching dollars available, weather conditions, and the timing for future rehabilitation and/or upgrades. There are different levels of patching fixes from placing cold mix directly in pot-holes to cutting out bad areas, correcting the poor sub-soils and patching with hot mix. The level of fix does affect the ride of the roadway and how long the fix will last. Pavement patching expenditures (type and longevity of fixes) have historically fluctuated with the type of winter (availability of funds due to snow and ice activities). For example, if there is a light winter, monies left in snow and ice would be used to do better and more permanent fixes to pavements so that ride is improved and potholes don't occur the following year. If it is a severe winter and more money is needed for snow and ice, there is typically less money available for patching and other maintenance activities; therefore less extensive fixes are made.

B. Performance Measure

This is a developmental measure. The performance measure for pavement patching is *the amount (investment dollars) spent on pavement patching as compared to a recommended amount (investment dollars) that should have been spent*. The present gap was estimated based on patching expenditures in 2004 as compared to the dollars that needed to be spent to address severe pavement distress issues. The patching need was determined by professional judgment of maintenance staff. This amounted to an additional 50 percent of 2004 budget or $5.5 million.

C. Policy Directions – Financial Implications

Based on input from maintenance staff, the level of patching is inversely-related to winter severity and snow and ice removal costs. However, there is little information for tracking fluctuations in dollars spent on patching and why they have occurred over time. The direction of this measure is to try and better track the changes in expenditures in this area and link them to performance and to overall system need. Patching expenditures should be based on whether the condition of the system is getting worse, particularly the bottom tier of roadways in "poor" condition.

D. Implementation Strategies

This is a difficult performance measure because it's reactive, it is subject to other capital investments in pavement preservation and reconstruction, it is somewhat dependent on weather conditions, and historically it has been dependent on the availability of funds left over from snow and ice removal. Additional work should be done to try and correlate the need for patching with severe distresses and/or other aspects of the pavements that are collected and analyzed. For example, one method would be to track conditions of roadways that receive patching and then search the statewide pavement database for similar conditions to better assess statewide need. This analysis would also have to account for all short-term construction or major pavement rehabilitation programs.

3.1.3 Traffic Signal and Lighting Maintenance

A. Introduction and Background

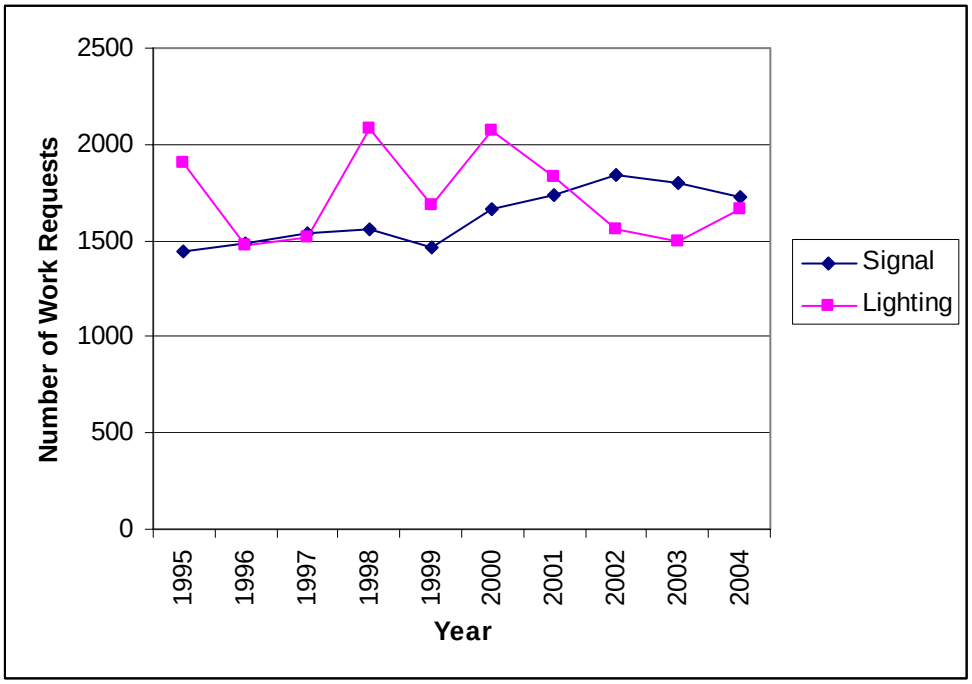
Traffic signal and overhead lighting maintenance crews are responsible for ensuring that signals and lights are functioning and that this infrastructure system (i.e., connections, poles, hardware, and software) is in good condition.

Signals control mainline and cross-street traffic flow movements on key arterial routes, while overhead lighting improves nighttime visibility of roadways and intersection areas. On state highways, Mn/DOT's Metro Electrical Services Unit (MESU) maintains 663 signals and over 18,000 lights, while in greater Minnesota Mn/DOT's Regional Electrical Service Unit (RESU) maintains over 600 signals and 7,000 lights. The MESU operates out of a central location at Fort Snelling, while greater Minnesota operations are run out of five locations – Duluth, Rochester, Mankato, St. Cloud and Detroit Lakes. The Central Electrical Service Unit (CESU) provides technical support to operations in Greater Minnesota and physical support of signals to the MESU in the metro area.

Maintenance activities are divided into two categories–reactive type maintenance where technicians respond to reports of problems, and preventive maintenance where systems are inspected on a regular basis and updates/repairs are made before they lead to a future malfunction. The majority of work done on these systems is reactive type maintenance. If problems are reported after normal business hours, they go to a 24-hour on-call service for emergency dispatch. On average, MESU and CESU workers respond to over 3,000 reports of signal problems annually. MESU also responds to over 1,700 reports of lighting problems and/or knockdowns each year.

Reported annual signal work requests in the Twin Cities metropolitan area have increased by 18 percent over the last 10 years from 1,448 in 1995 to 1,721 in 2004. The reported annual lighting work requests range from a low of approximately 1,500 to high of 2,085 (Figure 3-5).

Figure 3-5
Reported Annual Signal and Lighting Work Requests – Metro District (1995-2004)



Source: Metro Electrical Services Unit

B. Performance Measure

This is an emerging measure. Data for work on these systems has been tracked for a number of years, but no formal measure has been developed. Signal and lighting maintenance activities have established guidelines for prioritizing repair activities[16]. For signals and lighting problems, malfunctions are prioritized on a scale from one to five. Signal and lighting priorities and performance targets are outlined below:

Priority 1 Pole knockdowns, signals on flash, signal heads out and/or outages that have a direct impact on traffic flow and/or safety "repair immediately." Performance target is to begin repair within 20 minutes of notification of problem.

Priority 2 – 3 Individual signal lamp outages, reports of malfunctioning loops or detector cards; lighting knockdowns that don't affect traffic. Repair within one to three days (signals); one to three weeks (lighting)

Priority 4 – 5 Signal and lighting work that does not affect traffic or safety (i.e., background signal head shields, relamping signal or overhead street light in low priority area, preventive checks/maintenance). Repair as time permits (four months).

Maintenance activities are scheduled and tracked using the Automated Facilities Management System (AFMS)[17]. The information in the AFMS is available to plan and prioritize scheduled maintenance as well as identify historical trends. The system tracks the types of malfunctions, where malfunctions occur, and materials, labor and equipment costs that were needed to make repairs.

While the signal and lighting work priorities have been in place for a number of years, the proposed targets are new. The initial performance measures identified should be tested and evaluated over time to see if they properly represent the appropriate performance levels. Because repair time has not been previously reported against these new performance targets, the current level of performance is unknown.

C. Policy Directions – Financial Implications

The Electrical Service Unit's materials budget was reduced by $770,000 in 2003 and by an additional $193,000 in 2004 (a total reduction of 61 percent) to $597,000. The 2003 reduction resulted in some significant shortages of materials including an eight-week period where only essential lighting poles were replaced. The materials budget is split between the Metro Electrical Service Unit (MESU), the Regional Electrical Services Unit (RESU), the Central Electrical Service Unit (CESU), and Regional Transportation Management Center (RTMC). Each of these groups has responsibilities for repairing different components of signal, lighting, and information data collection systems.

[16] Priority system established by Metro Electrical Services Unit (MESU).
[17] Computer database system which tracks work activities (i.e., labor, materials, and equipment) used to complete work orders.

In addition to materials reductions, the Metro Electrical Services Unit is also down five staff positions from previous levels. These reductions in staff and budget have limited work to primarily emergency repairs. While the electronics in the signal cabinets are inspected every other year, no life-cycle maintenance and limited preventive maintenance activities are being done on the other components outside the cabinet.

The present budget is sufficient to conduct emergency repairs; however, it does not address any life-cycle replacements or ongoing maintenance trouble-spots. Table 3-4 identifies the status of the unmet needs for the major components of signal and lighting systems, and traffic management systems. The preservation needs (life-cycle) for these systems are addressed in the District Plans and are not included in the table below.

Table 3-4
Signal and Lighting System Needs

Maintenance Element	2006-07	2008-09
Signal Poles and Equipment[1]	$100,000	$100,000
Signal Cabinets[2]	$390,000	$390,000
Lighting Poles[3]	$200,000	$0
Lighting Cabinets[4]	$0	$0
Greater Minnesota ITS Maintenance[5]	$320,000	$320,000
Total	**$1,100,000**	**$810,000**

[1] Annual replacement cycle of 20 years is not included in this table but is accounted for in 20-year District Plans. The $100,000 is for correcting chronic maintenance problems – moving heads to back of poles for top 20 signals (signals where heads are hit frequently – $10,000 per intersection).

[2] Most signal cabinets in metro have been replaced recently. Greater Minnesota area needs upgrade (75 cabinets per year over next 10 years)

[3] On average 400+ poles knocked down each year. Current restitution budget covers $500,000 of $600,000 annual material costs for knockdowns (restitution fund should be monitored; if collection percentage drops revenue would not be there for replacement). Damage to facilities can be collected from drivers and/or insurance companies. Monies are directed into account and used to purchase replacement materials. District 20-year plans are covering life-cycle replacement costs (e.g., TSP has $3 million for lighting). In the first biennium, the District Plans do not account for lighting pole needs.

[4] Lighting cabinets are to be replaced at rate of 75 per year for next 10 years ($750,000). Costs are included in District plans for lighting life-cycle costs.

[5] Greater Minnesota ITS infrastructure maintenance is estimated at 3.7 percent of capital costs

D. Implementation Strategies

Ensuring timely repairs to signal, lighting, and Intelligent Transportation System (ITS) infrastructure minimizes user delays and safety problems. The present budget and staffing level does not allow for preventive maintenance work to be done outside the signal cabinets. In addition, it requires that work be prioritized by level of importance (1 = most important to 5 = least important). Life-cycle replacements of signals, light poles and other infrastructure have not been given a significant priority in past work. The majority of these life-cycle costs have now been addressed through District Plans.

Implementation strategies include the following:

- Continue to evaluate overhead re-lamping work to identify electrical and re-lamping work that can be done in large group contracts to maximize efficiency and minimize staff.

- Consider using better overhead lamps to reduce frequency of re-lamping, thereby minimizing exposure to traffic and safety issues. In addition, continue discussion with design staff to locate lights in areas that are less likely to by hit, and consider large light towers in interchange areas to minimize number of lights and simplify re-lamping work.

- Continue to identify chronic maintenance problems for use of preservation funds to minimize number of ongoing maintenance calls to same locations (e.g., move heads to back of signal poles).

- Continue to monitor number of work orders, type of work orders, work order backlogs, performance levels, and materials cost. Develop internal benchmarks to identify performance standards for different work activities.

- Consider logging preventive work activities (outside cabinet inspections) as priority five work orders to track ability to complete work with present staff complement.

- Work with Districts to identify priority list for preservation (life-cycle) replacement projects. Work on identifying different levels of life-cycle treatments from full-replacement, to poles and wiring, to wiring and re-lamping.

- Consider pooling work forces with larger cities and counties for signal preventive maintenance activities

- Continue to monitor restitution reimbursements and work with state patrol, FIRST units and RTMC to identify higher percentage of knockdowns for reimbursement.

3.2 SUPPORTING INFRASTRUCTURE MANAGEMENT

3.2.1 BUILDING (FACILITY) MAINTENANCE

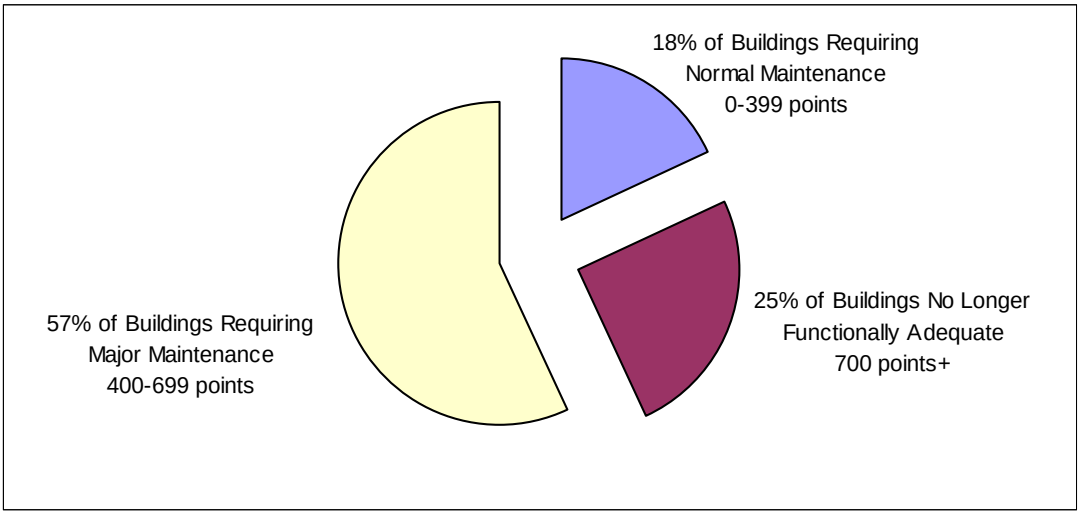
A. Introduction and Background

Mn/DOT is one of the largest caretakers of buildings in State government with 1,050 facilities at 380 locations. These facilities vary from headquarter buildings (17), to truck stations (132), to rest areas (84), to radio communication facilities (88), to salt/sand storage facilities. The structural area of all of these buildings is in excess of 5.5 million square-feet with an estimated replacement cost in 2004 dollars of over $498 million.

Management of these facilities is divided into three areas – Capital Construction, Capital Operations, and Facilities Maintenance. Capital construction of facilities is generally large projects (over one million dollars) that range from total replacement, to additions or alterations on existing structures. Target funding for these large projects is approximately $20 – 25 million every two years (state bonding appropriation). Capital Operations projects are similar to capital construction projects; however, the projects are much smaller, less than one million dollars per project. These projects are in the operating budget, which allocates approximately $7 million towards replacement/rehabilitation of smaller buildings (no funding was allocated in 2004). Finally, the Facility Maintenance Program (FMP) is an annual appropriation to cover work that preserves the facilities capital value such as roof replacement, mechanical and electrical systems, and other building components (approximately $7 million annually).

Building maintenance needs are generated based on a comprehensive review of all facilities every two years. The review uses a detailed assessment of all functional areas of a facility ranging from safety standards and energy conservation to barrier-free access and environmental compliance[18]. Out of this assessment comes a well-documented priority list of capital and maintenance needs. Based on the recent 2004 assessment, 18 percent of Mn/DOT facilities require normal maintenance, 57 percent require major maintenance, and 25 percent were found to be functionally inadequate (Figure 3-6). A facility is considered functionally inadequate when it has such severe problems that it really can't adequately serve its intended function.

Figure 3-6
Facilities Assessment[1]



Source: Mn/DOT Commissioner's Staff Facilities Presentation, June 2003.

[1] A comprehensive rating system evaluates a building's function elements every two years. Rating process is documented in Mn/DOT's Facility Condition Assessment information.

[18] Assessment follows standards developed by Statewide Facilities Management Group. This group represents 15 agencies that manage and maintain the state's capital assets.

The Minnesota Legislature has acknowledged that a significant problem exists with deteriorating public buildings and the lack of adequate funds for building maintenance and replacement. In 1996 it amended Minnesota State Statutes, Section 16A.11 by adding a subdivision which specifically addressed building maintenance. That amendment stated… "Unless otherwise provided by the commissioner of finance, the amount to be budgeted each year for building maintenance is two percent of the cost of the building, adjusted up or down depending on the age and condition of the building." This statute was later revised in 2002 to reduce building maintenance to **one** percent of building value.

B. Performance Measure

The performance measures for this area are considered mature measures. There has been significant effort put into evaluating and prioritizing buildings throughout all state agencies. As a result, there is a sound basis for identifying the scope and magnitude of the problems. The two measures developed for this area are described below.

- **Building Annual Maintenance**

  The first measure *is percent of building replacement cost that is expended for annual maintenance.* There are well documented guidelines and procedures for calculating this measure, and it is consistent with measures used in the private sector[19]. In 1996, the Statewide Facilities Management Group (SFMG) identified maintenance needs based on standard private industry practices and benchmarks. This group recommended that Mn/DOT's annual building maintenance needs be set at 2.0 percent of the replacement value (the private sector's target established by Building Owners Management Association (BOMA) is 2.7 percent).

- **Building Functional Adequacy**

  The second measure *is the percentage of buildings that meet the functional needs.* This measure also has well documented guidelines and procedures based on SFMG[20]. These guidelines are consistent statewide and are based on a comprehensive assessment that is done every two years. This assessment looks at all functional elements of the building including site, primary systems, secondary systems, service systems, safety standards, functional standards, energy conservation, barrier free access, and environmental issues[21]. Buildings that score over 500 points are deemed functionally inadequate. The identified target for this measure is to have 80 percent of Mn/DOT facilities functionally adequate at any one time. The remaining 20 percent are replaced by priority during a six-year construction schedule. As buildings are replaced on the schedule, others are no longer functionally adequate and are added to the construction schedule.

---

[19] State of Minnesota Building and Maintenance Guidelines, (Statewide Facilities Management Group (SFMG), (1999).

[20] State Facilities Management Group represents building/facility managers for all state agencies; developed set of building maintenance guidelines in May 1999.

[21] Rest areas were not included in this measure.

C. Policy Directions – Financial Implications

Mn/DOT currently spends 1.26 percent of the replacement value or $6.3 million on building maintenance. Based on the SFMG recommended minimum guidelines (i.e., 2.0 percent), the financial gap is 0.74 percent of the total replacement building value. This translates to a financial shortfall of $3.6 million annually. This means that as each year goes by more and more deficiencies are mounting that will cost more to fix in the future, or require additional capital funding to replace the facility prior to meeting its intended design life.

This will likely increase the number of functionally inadequate facilities over time. This is consistent with a report titled *The Capital Iceberg*[22]. This report was developed to assess the potential problem of deferred maintenance and deferred renewal of capital assets. The report concluded that the state faces a critical and expensive problem that needs resolution. The problem was equated to an iceberg, of which the size is increasing as the assets continue to depreciate and deteriorate faster than rehabilitation can occur and/or new buildings are commissioned. Budget estimates were developed based on facilities that can be replaced using current staff. A total need of $25 million ($10 million for capital operating and $15 million for capital construction) for each biennium was identified. Because there are insufficient monies to replace functionally inadequate facilities (cost prohibitive), some maintenance funds are going to these facilities to keep them operational.

D. Implementation Strategies

There are good measurement tools in place to measure the size and scope of the facility problems and track these problems over time. As facilities have aged Mn/DOT has attempted to partner with local communities to either build common facilities and/or transfer the old facility to the local entity as a way to reduce overall taxpayer costs. The following are some strategies to consider for this area:

- Consider incorporating the Capital Operations Bonding Program into the biennial base amount provided for facilities operations and maintenance. These funds are to be used to construct those facilities identified as functionally inadequate and below the $1 million threshold.

- Consider establishing revolving "loan" fund for buildings. Many local partnership projects have been held up or lost because the state could not move forward on projects to meet the schedule of cities and/or counties.

- Security at buildings is a significant issue since September 11, 2001. There is no funding allocated or identified as part of this plan to address future security needs for buildings and/or other infrastructure (i.e., fencing, security gates or card systems). Mn/DOT has formed a Department of Homeland Security. They are investigating security issues and the need to make additional investments.

[22] The Capital Iceberg, (Division of State Building Construction, Department of Administration – State of Minnesota, 1994), p. 6.

- Continue to review building maintenance practices and strategies to ensure that most cost-effective practices are being employed. Continue to partner with local officials and other state agencies where it makes sense to coordinate facilities and operations. Hutchinson Area Transportation facility (HATS) is looked at as a model for this type of cooperation.

- Environmental issues are also a major concern. Environmental regulations will impact Mn/DOT's operations life storm water management, highway maintenance, and a number of building maintenance issues such as water re-use in wash bays.

3.2.2 FLEET MANAGEMENT

A. Introduction and Background

Mn/DOT currently has an investment of nearly $215 million in approximately 11,700 pieces of equipment (units in the fleet). Of this number, roughly 3500 are licensed on road vehicles. Annual repair and maintenance of the fleet is over $16 million. The current annual budget to purchase replacement equipment is $13.0 million. In 1986, the equipment budget was $11.7 million. It was held at that level for sixteen years until 2002 when it was raised to $14.7 million as part of a new initiative funding program. In FY 2003, budgets were reduced to $13.0 million, where it remains through 2005. In 1985, the fleet size was 11,700 units, indicating that there has been a 200 unit fleet reduction since that time.

Funding levels is only one of the factors that typically make managing governmental fleets challenging. Equipment needs vary from year-to-year and season-to-season. Weather and construction program levels are often unpredictable. Fleet managers scramble to find enough vehicles when the construction season is in full swing, and then deal with excess vehicles when the program drops back down. The fleet has to be prepared for a heavy winter season, a bad-pothole spring and a summer when roadsides continuously grow; yet the fleet manager is scrutinized during light winters and dry summers when the equipment is sitting idle. At the same time, it is expected that Mn/DOT be equipped so it can quickly respond to floods, tornados, and other disasters or events.

Low utilization problems and keeping equipment beyond economic life are common deficiencies in governmental fleets. In a U.S. General Accounting Office (GAO) report dated May 2004[23], it was cited that *"Because of lack of attention to key vehicle fleet management practices, the agencies GAO reviewed cannot insure their fleets are the right size or composition to meet their missions."* The GAO report examined the Departments of Agriculture, Army, Homeland Security, Navy and Veterans Affairs and focused their attention on agencies' justifications for acquiring and retaining vehicles. The report goes on to say, *"Industry practices of cost-efficient fleets include developing utilization criteria related to the mission of a vehicle and conducting periodic fleet assessments to determine whether fleets are the right size and composition."*

[23] Federal Acquisition – Increased Attention to Vehicle Fleets Could Result in Savings, (United States General Accounting Office, GAO-04-664, 2004).

Likewise, in a document dated January 2004[24], the Minnesota Department of Administration *"has decided to pursue a comprehensive long-term solution for addressing fleet management…"* including many of the same issues including fleet size, acquisition criteria, leasing versus owning, utilization, etc.

B. Performance Measure

The following performance measures are considered emerging measures. Mn/DOT has aggressively pursued fleet management changes. In July 2002, two years before the GAO Report was written, Mn/DOT formally initiated key performance measures to better manage its equipment fleet[25]. These performance measures included targets for equipment utilization, units out-of-life-cycle, fleet size, and scheduled vs. unscheduled maintenance. At the same time, Mn/DOT continued to pursue enhancement of fleet management and data collection systems, expansion of internal leasing programs and challenged District/offices to implement changes in organizational structure. This was all aimed at enhancing the ability to manage its fleet.

The following focuses on two of the measures, namely *equipment utilization* and *out-of-life-cycle*. (Note that *reduction in fleet size* is a result of achieving targets of the other two and therefore does not have specific targets set for it.)

- **Equipment Utilization Rate Goals (Targets)**

  Equipment is procured to produce work; equipment that is idle produces no work. While idle equipment is not consuming fuel and generating maintenance repair costs, it is still incurring costs such as depreciation, obsolescence, storage costs, cost of tied up money in asset and parts, etc. And the cost really goes up if age alone is used to justify replacement and much needed equipment dedicated funds are used to purchase new units to replace low usage equipment.

  For these and other reasons, it is essential that Mn/DOT size its fleet properly for meeting its mission, and that it establishes performance measures to monitor and justify the number of units permitted in its fleet. To "right size" its fleet, Mn/DOT monitors equipment utilization on an ongoing basis for the purposes of making sure equipment is used enough to justify its presence. In July 2002, Mn/DOT developed a performance measure called *Equipment Utilization Rate Goals (targets)*. Equipment Utilization Rate Goals are established for selected categories of mobile equipment including all light, medium and heavy duty vehicles, snow plow trucks, loaders, mowers, tractors, motor graders, etc. They represent about 70 classes of mobile equipment that comprise 75 percent of Mn/DOT's total fleet investment. The targets are being implemented in a phased-in manner as follows:

  - ✓ 80 percent of the fleet be above minimum utilization level target by July 2003
  - ✓ 95 percent of the fleet be above minimum utilization level target by July 2005

[24] Fleet Expenditure Reduction Plan, (Minnesota Department of Administration, 2004).
[25] Richard A. Stehr, Guidelines for Implementation of Fleet Management, (Mn/DOT Memorandum, July 30, 2002), p. 2.

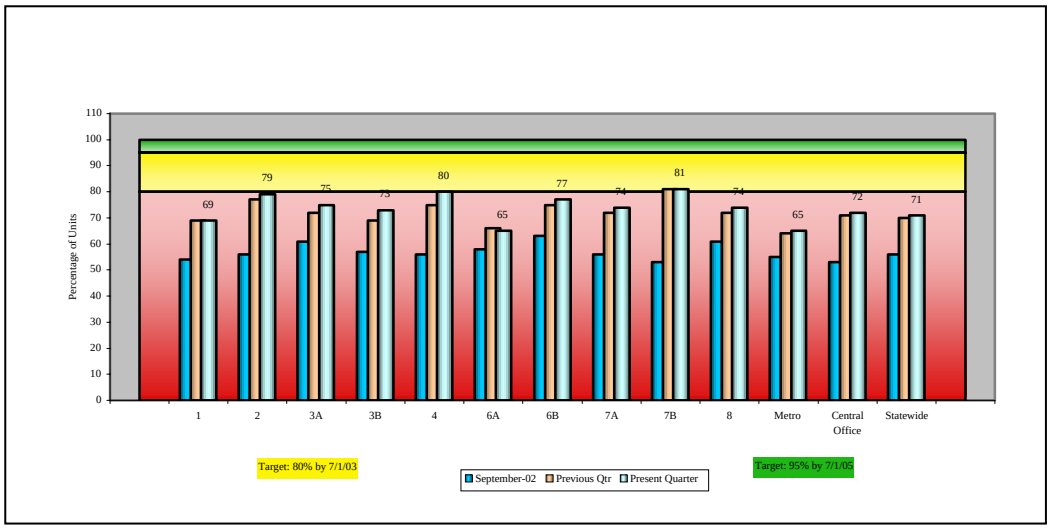
These goals are defined in terms of the minimum number of miles or hours that units in a given class are expected to be utilized over a 12-month basis. In early 2002, the consulting firm of Kelly Walker Associates recommended Utilization Rate Target levels. Their recommendations were based on surveys of a variety of public and private agencies. These recommendations were modified to "challenging yet deemed achievable" levels and were approved by Mn/DOT's upper management in July 2002.

The targets for minimum annual equipment utilization were set at:

- ✓ 8,000 miles per year (3,500 miles for seasonal snow plow trucks)
- ✓ 500 hours per year (125 hours for seasonal snow and ice support equipment)

The progress to date on attaining the utilization performance target is shown in the Figure 3-7. The initial targets were aggressive. In September of 2002 the statewide utilization was 57 percent. This rose to 67 percent by July 2003 and is currently at 69 percent in 2004. This is still well below the 80 percent target for July 2003. One District did meet the 81 percent target.

Figure 3-7
Equipment Achieving Minimum Utilization



Source: Mn/DOT District Operations Performance Data Summary Report, 2004

- **Units Within Life-cycle**

Determining the life-cycle of a class of equipment is based on a number of factors. Perhaps the biggest driver is economics. This includes the cost of maintenance and repair as equipment accumulates usage and age, resale value and the simple principal of minimizing loss due to depreciation, downtime, i.e., the degree of which the equipment is unavailable because of breakdowns, and lastly, the loss of value due to technological age of equipment.

Performance targets set in July 2002 were as follows:

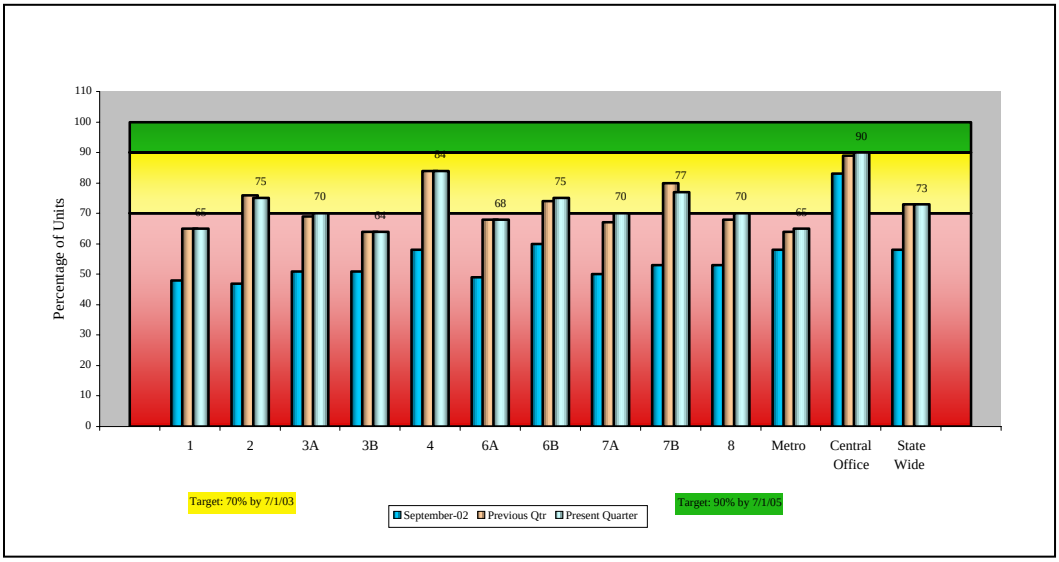
- ✓ 70 percent of the fleet within life-cycle by July 2003
- ✓ 90 percent of the fleet within life-cycle by July 2005

Mn/DOT uses a state-of-the-art, equipment management information system (EMS-M4) to provide fleet managers with not only average life-cycle information, but also running repair costs of parts and labor, and downtime. The EMS plays an important role in defining the most economical life-cycle for different classes of equipment. Over the past 20 years, close monitoring of economical and technological life of equipment proved that some classes of equipment could be retained longer, some shorter. As a result, optimum life-cycles have and continue to be adjusted according. Current life-cycles are:

- ✓ 5 years for cars
- ✓ 7 years for pickups
- ✓ 12 years for snowplow trucks
- ✓ 15 years for 4WD loaders
- ✓ 20 years for mower and tractors
- ✓ 20 years for motor graders

September 2002 was used as a baseline (Figure 3-8). At that time, only 57 percent of the total fleet was within life-cycle. By July 2003, the statewide average had risen to 75 percent. Since 2003, no significant progress has been made – July 2004 showed 73 percent of equipment within life-cycle. This lack of continued progress may be due to budget reductions in 2002 to 2003 and will worsen as equipment costs increase.

Figure 3-8
Units within Life-Cycle



Source: Mn/DOT District Operations Performance Data Summary Report, 2004

C. Policy Directions – Financial Implications

There are two key documents that provide direction with respect to managing Mn/DOT's overall equipment and vehicle fleet. In July 2002, Mn/DOT instituted fleet management performance measures to reduce operating expenses and increase reliability. This was followed by a January 15, 2004 Fleet Expenditure Reduction Plan developed by the Minnesota Department of Administration. This plan is a three year-phased plan that was developed in response to legislative direction. The plan is intended to ensure that agencies and enterprises are making smart and informed equipment management decisions. This plan goes beyond managing Mn/DOT's fleet and encompasses statewide policy directives such as use of personal vehicles for work activities, appropriate use of state vehicles, uniform purchasing guidelines, fuel choice directives, and development of enterprise-wide fleet management database. The intent of these directives is to improve overall fleet management and reduce costs.

Another key factor of fleet management is managing the fleet so that it continues to be reliable and perform the intended function. As equipment ages, more maintenance is typically required (equipment is less reliable) and parts become more difficult to obtain (end of life-cycle). Based on the "right sized" fleet and standard equipment life-cycles, there is a need to replace a certain number of units each year. For Mn/DOT, this analysis showed that $2.9 million annually in additional funding is needed to stay within the target life-cycle.

There are other factors affecting the cost of replacement funding that are not included in the $2.9 million figure. One deals with inflation due to high increases in steel that is having an unpredictable impact on the cost of equipment. Two recent Governor's Executive orders have other financial implications as well. For example, Governor's Executive Order 04-08 dated August 6, 2004 calls for state agencies to *"purchase or lease the most fuel efficient and least polluting vehicles that meet the operational needs of the state department."* Snow plow trucks capable of operating on bio-diesel or ultra low sulfur are projected to cost 30 percent more (equivalent to $15,000-20,000 per truck). Secondly, Governor's Executive Order 04-10 dated September 27, 2004 orders agencies to *"reduce the use of gasoline by on-road vehicles owned by state departments by 25 percent by 2010 and by 50 percent by 2015, and the use of petroleum-based diesel fuel by those vehicles 10 percent by 2010 and 25 percent by 2015."* The goal is move toward cleaner fuel, increase miles per gallon and support hybrid electric cars and hydrogen-powered vehicles. The financial implications of these have not yet been quantified but it is known that diesel powered pickups cost and additional $4,600.

D. Implementation Strategies

Mn/DOT has a diverse equipment fleet that is needed to perform all of the different maintenance activities. These activities are constantly changing to better respond to public demands and a changing environment (e.g., night maintenance work requires different equipment, public demand to minimize delays results in need to complete work faster and reduce time duration of lane closures). The following are potential strategies for achieving the fleet performance targets:

- Mn/DOT's EMS system generates utilization reports and graphs by equipment class as well as by individual units. Districts who best utilize their equipment are currently being queried for "best practices" and this information used to assist other Districts in meeting the utilization targets. Mn/DOT will use this information to set targets by individual class (as opposed to a blanket 8000 miles or 500 hours per year for all classes established in July 2002). Mn/DOT will also set targets based primarily on averages achieved within Mn/DOT by class.

- Encourage the use of the following to improve equipment utilization (spread usage over fewer units), and reduce usage needs.

  - ✓ Double-shifting of equipment
  - ✓ Encourage use of central motor pool
  - ✓ Reorganizing operations at a District vs. area or sub-area level
  - ✓ Sharing equipment between operating units/Districts
  - ✓ Local renting/leasing for seasonal needs
  - ✓ Lowering need for business travel (less meetings, video conference)
  - ✓ Encouraging employee use of personal vehicles
  - ✓ Centralized purchase w/lease to District/office

- Incorporate usage of Enterprise-wide Fleet Management database into overall agency fleet management decisions

- The federal government is requiring significant improvements to diesel engines (change in standards to reduce pollutants). These requirements are anticipated to increase overall costs of future diesel equipment (i.e., snowplows by $10,000 per unit).

3.2.3 ELECTRONIC COMMUNICATIONS

A. Introduction and Background

The Office of Electronic Communications (OEC) of Mn/DOT's Operations, Safety, and Technology Division, is the principal organization responsible for the design, installation and maintenance of electronic communication systems in Minnesota. OEC provides services in eight different categories[26]:

- Communications Infrastructure Maintenance (CIM)
- Tower/Building Maintenance (TBM)
- Electronic Equipment Repair (EER)
- System Upgrade/Implementation (SUI)
- Shared Public Safety Radio (SPSR)
- Transportation Operations Communications Center Deployment (TOCC)
- Office Management (OFGT)
- Inventory Control Center (INVC)

[26] Based on information received from the Office of Electronic Communications, Mn/DOT.

The OEC provides these services to the large mobile workforce of the Department of Transportation, the Department of Public Safety (DPS), and the Department of Natural Resources (DNR) who rely on mobile communications in the performance of their daily operations. In addition to state agencies, OEC indirectly serves all 25,000 Public Safety professionals within a nine county (seven county metropolitan area along with Chisago and Isanti Counties) metropolitan area through its maintenance of the regional public safety radio system backbone. A brief description of these radio systems and services is provided below.

Voice Communications

Mn/DOT uses Very High Frequency (VHF) radio system to provide wireless two-way voice communications throughout the state. Voice communication services provided through the VHF radio system are shown below:

A1. **VHF Mobile Coverage for Mn/DOT** – Mobile coverage is defined as providing radio signals from base units to radio devices installed in vehicles for voice communications. Statewide mobile coverage for snowplow, maintenance, and construction operations is accomplished using a VHF (150 MHz) radio system. Design standards for this system suggest coverage to 95 percent of required locations, 95 percent of the time. Currently the Mn/DOT system uses 65 transmitters that cover approximately 68,900 sq. mi. of Minnesota's total land area of 84,000 sq. mi.

A2. **VHF Portable Coverage for State Patrol** – Portable coverage is defined as providing radio signals from base units to radio devices worn on a person's belt while standing outside of a vehicle or building for voice communications. Statewide portable coverage for accident investigation, traffic control, administration, criminal investigation, and other law enforcement operations for State Patrol is accomplished using a VHF (150 MHz) radio system. It should be noted that due to FCC requirements, the State Patrol cannot use the same frequencies as the Mn/DOT system to conduct law enforcement activities. Design standards for this system suggest coverage to 95 percent of required locations, 95 percent of the time. The State Patrol system currently uses 87 transmitter stations for its operations.

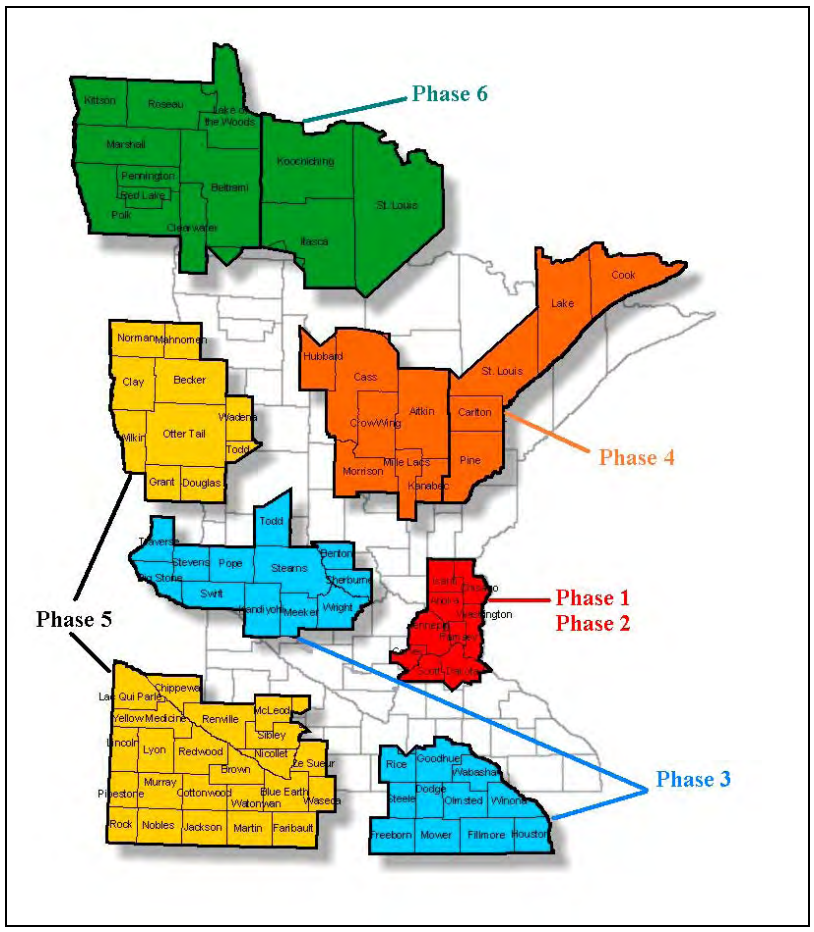
A3. **VHF Portable Coverage for DNR** – Coverage of the entire state land area to conduct activities related to the operation of the DNR forestry is accomplished using a VHF (150 MHz) radio system. Due to FCC requirements, the DNR cannot use the same frequencies as Mn/DOT and/or State Patrol system to perform conservation activities. The DNR requires coverage to 75 percent (58,800 sq. mi.) of the total land area in Minnesota that is currently served by 49 transmitter stations.

The current VHF radio systems use a wideband analog technology that limit and in some cases restrict intercommunication between multiple state agencies. In addition, the Federal Communications Commission (FCC) has mandated that all VHF radios manufactured after January 1, 2005 must be narrowband capable. In order for the manufacturers to comply with this mandate, they will have to change from analog to digital technology. In addition to the mandate to the manufacturers, the FCC indicated that they would no longer license wideband VHF

systems after the January 2005 date as well. Further mandates issued by the FCC indicate that the existing VHF wideband analog technology will be phased out by approximately 2018. An 800 MHz digital trunked radio system is proposed to replace the current VHF systems in use by the agencies today. A description of this radio system is provided below:

A4. **800 MHz Shared Digital Trunked Radio** – This shared system, also called the Allied Radio Matrix for Emergency Response (ARMER) system uses 800 MHz radio frequencies and provides seamless voice coverage to portable radio devices worn on the belt while outside of vehicles and buildings. Design standards for this system suggest coverage of 95 percent of required locations, 95 percent of the time. The new 800 MHz digital system has already been or is being implemented in the nine-county area. Figure 3-9 shows the phases for the implementation of the 800 MHz Digital Trunked Radio System throughout Greater Minnesota. Mn/DOT was identified as the natural agency to develop and manage the system. As part of the development and management of the system, Mn/DOT will take on a substantial portion of its cost; however, other state and local agencies make financial contributions to maintain the system as well.

Figure 3-9
Statewide ARMER Implementation Areas



Source: Office of Electronic Communications, Mn/DOT

Data Communications

In addition to voice communications, Mn/DOT also manages the transfer of data through the Mobile Data Computer (MDC) system. This system is described below:

B1. **Mobile Data Computer (MDC) System** – Mobile coverage for MDCs is defined as providing digital radio signals from base units to radio devices connected to laptop computers installed in vehicles. This is accomplished using an 800 MHz radio system. Statewide mobile coverage to patrol officers with laptop computers is provided through MDCs. This is not a land-area based coverage, but it is based on total mileage of main highway corridors as determined by Mn/DOT and State Patrol. The system mileage goal was set at 1,431 miles covering eight corridors. Design standards for this system suggest coverage to 95 percent of required locations, 95 percent of the time. Currently, there are 21 MDC stations in operation.

Analog to Digital Microwave System Conversion

The current analog microwave system used by the State of Minnesota was built in the 1970s. The analog technology operates on the 2 GHz frequency range. In 1998 the FCC reallocated the 2 GHz frequency band to satellite and Personal Communication Services (PCS). Public safety agencies nationwide were grandfathered on the 2 GHz frequencies, but on a secondary basis. This means that if Mn/DOT makes a change to the current microwave system, they must also change to a new frequency (6 GHz). To compound the problem, manufacturers no longer produce analog equipment or parts to repair the existing equipment. Therefore, there is a need to update the microwave system from analog to digital technology. Minnesota is not the only state faced with this problem; other states across the country that also use the 2 GHz analog technology also need to update their systems. A description of the digital system is provided below:

C1. **Digital Microwave System** – The digital system operates on frequencies operating in the 6 GHz frequency range and requires 133 microwave hops (paths) to provide digital microwave service throughout the state. Design standards for this system are 100 percent of locations (towers), 99.999 percent of the time. The design criteria for this digital microwave system are based on connecting all state owned radio communications towers via microwave radio signals.

The digital microwave system will accommodate the VHF systems, the 800 MHz trunked system, Mobile Data Computer system, and other future applications that may arise. The existing towers that are in place for the analog microwave system can be reused for the digital system however; the microwave radio equipment that is mounted on the towers needs to be replaced in order to accommodate the digital microwave system. Because radio signals do not travel as far in the 6 GHz band as they do in the 2 GHz band, additional towers are needed between the existing towers. The conversion would require replacing 182 analog microwave radio base stations and associated dishes (antennas) with digital stations and dishes, at 91 existing tower locations.

System Maintenance

Overall system maintenance comprises of five activities. These are described below:

- **Mobile Equipment Installation** – The primary users of mobile equipment include Mn/DOT, State Patrol, and DNR. Mobile equipment installation requires the vehicle to be taken to a Mn/DOT Radio Shop. During this time, the vehicle is out of service. Therefore, installation of mobile equipment must be completed correctly and on the scheduled date to prevent the vehicle from staying of out for service for a longer time. The calculation is based on the total number of mobiles/portables purchased during the year and is the percentage of mobiles/portables installed within 30 days of receipt.

- **Stationary Radio Equipment Installation** – Stationary radio equipment, also known as fixed equipment, includes base stations and antennas for VHF, 800 MHz, MDC, and microwave systems, and communications consoles. The calculation is based on the number of stations purchased during the year and is the percentage of stations installed within 30 days of receipt.

- **Electronic Equipment Repair** – This service includes the repair of all mobile, portable, base station, microwave, and console radio equipment. Radio failures cause unscheduled interruptions of services to customers. This can be costly in terms of money as well as safety to the citizens of Minnesota. If a mobile/portable radio device cannot be repaired while the customer waits, they are given a replacement unit. The actual radio device must then be repaired within two weeks to avoid depleting the stock of replacement radio devices. Fixed station devices are repaired within 24 hours of notification. The calculation is based on the percentage of equipment repaired within these required time-frames.

- **Preventive Maintenance** – This is a critical component to maintaining a high system performance. Each major component of each radio system must be checked annually to detect problems before they occur. Components that receive annual preventive maintenance (PM) include all fixed radio equipment, and microwave stations. The calculation is based on the total number of units that receive annual preventive maintenance (PM) divided by the total number of fixed radio and microwave stations. This is expressed as a percentage.

- **Equipment Replacement** – All electronic equipment eventually wears out. Aging equipment is the largest contributor to system failures and failures lessen the reliability and performance capability of the system(s). Based on industry standards for specific types of communications equipment, OEC has implemented a recommended replacement cycle. Equipment is tracked by Asset Numbers (AN) when purchased. A report of Asset Numbers indicates which equipment is at or beyond the projected life-cycle.

B. Performance Measure

The Office of Electronic Communications identified two measures that provide overall performance indicators for the electronic communications activity – *Electronic Communications Coverage* and *Electronic Communications Reliability/Maintenance*. These are described below:

- **Electronic Communications Coverage**

  System coverage is the most visible measurement of system performance and measures *statewide geographic coverage of communications*. Coverage for the entire system is based on the percent of coverage of voice (A1, A2, A3, and A4) and data (B1) communications, and digital microwave system coverage (C1). Because the analog system eventually phases out and the entire system is converted to digital system, a weighted method was used to calculate the coverage of the entire system (systems being implemented are given more importance). Projected conversions of the different systems, as shown by the percentage of their respective coverage areas are shown in Table 3-5). As shown in this table, coverage for VHF systems would decline as the 800 MHz and digital microwave systems are developed. The conversion is anticipated to be completed by 2011, depending upon funding. Trends in historic and projected system coverage are shown in Figure 3-10.

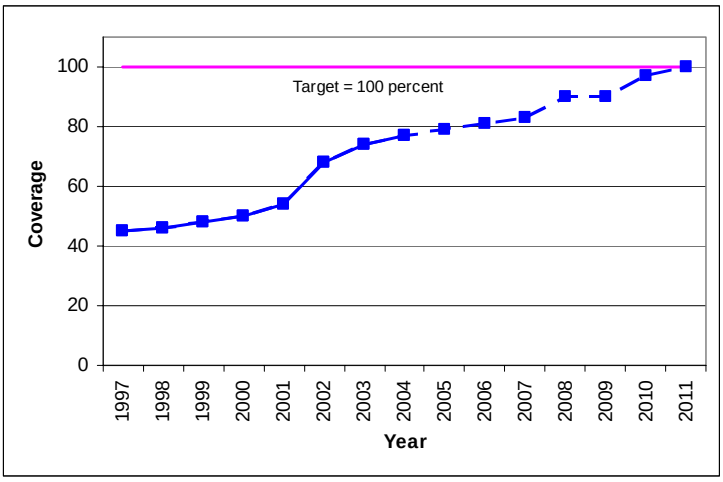
Table 3-5
Electronic Communications System Coverage (Percent)

		Voice Communications				Data		
	Year	VHF Mobile Coverage Mn/DOT	VHF Portable Coverage Patrol	VHF Portable Coverage DNR	800 MHz Trunked Coverage	MDC Coverage	Digital Microwave	Coverage Rating[1]
		A1	A2	A3	A4	B1	C1	
Historic	1997	73	60	55	0	10	0	45
	1998	73	63	55	0	10	0	46
	1999	75	65	61	0	10	0	48
	2000	78	68	61	0	20	0	50
	2001	82	76	61	0	30	0	54
	2002	82	76	61	10	53	25	68
	2003	82	76	61	10	75	40	74
	2004	82	76	61	10	90	47	77
Projected	2005	82	76	61	10	100	53	79
	2006	82	76	61	10	100	64	81
	2007	82	76	61	10	100	75	83
	2008	62	55	41	37	100	86	90
	2009	32	35	21	57	100	100	90
	2010	13	14	10	84	100	100	97
	2011	0	0	0	100	100	100	100

Source: Office of Electronic Communications, Mn/DOT

[1] Calculation for Coverage = ((A1+A2+A3)/3+A4)*0.7+B1*0.1+C1*0.2)

Figure 3-10
Historic and Projected System Coverage (Percent)



Source: Office of Electronic Communications, Mn/DOT

- **Electronic Communications Reliability/Maintenance**

System reliability/maintenance is measured in terms of *the percent of maintenance activities completed within the required time-frames.* Factors contributing to the reliability and maintenance of the system are equipment installation, repair and preventive maintenance. All factors are weighted equally and rating for the entire system maintenance was calculated based on the percent of target maintenance conducted. Historic as well as projected percentages of these maintenance activities are shown in Table 3-6 and Figure 3-11.

Table 3-6
Electronic Communications System Reliability/Maintenance (Percent)

	Year	Mobile Installation	Fixed Equipment Installation	Equipment Repair	Preventive Maintenance	Reliability/ Maintenance Rating[1]
Historic	1997	98	90	90	95	93
	1998	98	90	90	95	93
	1999	98	90	90	95	93
	2000	98	90	90	95	93
	2001	72	50	98	29	62
	2002	53	83	91	60	72
	2003	4[2]	33	89	38	41
	2004	44	4[3]	91	36	44
Projected	2005	59	20	95	51	56
	2006	74	35	95	65	67
	2007	85	50	95	75	76
	2008	90	75	95	85	86
	2009	90	85	95	95	91
	2010	90	90	95	100	94
	2011	90	90	95	100	94

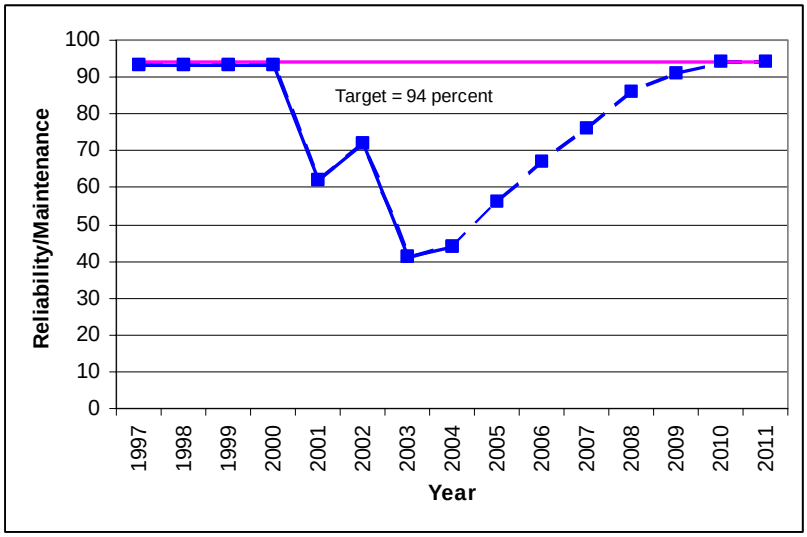
Source: Office of Electronic Communications, Mn/DOT

[1] Calculation for rating is the average of the percentages of the four factors shown above.

[2] 300 mobile radio equipment could not be installed as the snow-plows that they were to be installed on did not arrive within the 30 days time-frame.

[3] Digital microwave equipment was bought in advance with funds ($3 million) left over by the end of the year. This equipment is scheduled to be installed in 2005 and 2006 as part of the analog to digital conversion project.

Figure 3-11
Historic and Projected System Reliability/Maintenance (Percent)



Source: Office of Electronic Communications, Mn/DOT

C. Policy Directions – Financial Implications

Communications is an area that affects numerous state agencies and local governments. The policy direction for this area has been previously established and is part of a national effort to upgrade communications technology and abilities. Technology in this area is rapidly changing with voice and data information being combined and carried over digital systems. The present analog system will not be supported long-term, nor will one be able to find analog parts and replacement equipment long-term.

This trend is consistent with national security efforts and will in the long-term reduce the duplication of local communications systems, and therefore reduce overall costs to taxpayers. As part of this effort, Minnesota is developing a backbone infrastructure that can support both voice and data communications for multiple agencies. Developing this system will have some initial financial implications, and it will have ongoing maintenance costs. A significant portion of these maintenance costs is software related and will be ongoing. Digital systems provide more flexibility do to computer software and hardware.

The OEC has developed detailed estimates of conversion costs as well as ongoing maintenance costs. An $18 million program was proposed for the microwave conversion project. In FY 2003, $3 million was funded by Mn/DOT from its operation budget. The remaining $15 million will be funded through state road construction funds from FY 2006 through 2008 at $5 million per year. These revenues are intended to support aggressive advance conversion projects including installation of new towers and base stations. There is a shortage of $4.5 million for the two biennia (2006-09). OEC staff has indicated that overall a total of $8.5 million is needed for the completion of the analog to digital conversion project by 2011.

Currently, maintenance activities are supported by 39 (29 in Greater Minnesota and 10 in the Metro area) radio technicians. In order to achieve target maintenance performance additional FTE's need to be hired from FY 2006 through FY 2010. These costs are shown in Table 3-7.

Table 3-7
Cost for Additional Staff[1]

Year	FTEs	Estimated Cost
2006	6	$445,200
2007	3	$222,600
2008	3	$222,600
2009	3	$222,600
2010	2	$148,400
	Total	**$1,261,400**

[1] This is an annual cost and includes cost of supporting equipment to conduct work.

In addition to adding staff, OEC will also require software upgrades and renewed support contracts in the amount of $430,000 per year. This equates to a total need of $1,527,800 in the first biennium and $1,305,200 in the second biennium[27] for the maintenance area.

D. Implementation Strategies

The current radio systems were designed and implemented in the 1970s. FCC rule changes as described previously in this section have made the current system obsolete. OEC has developed a replacement plan to replace the existing analog microwave system with digital technology. This plan will involve upgrading the existing towers with digital equipment as well as the installation of new tower sites.

The overall technology used by current systems in greater Minnesota (wideband analog) is not compatible with Federal Communications Commission (FCC) frequency use changes or the technical changes mandated by FCC on manufacturers. Therefore, in addition to replacing the existing analog microwave system with digital technology, the state is also faced with replacing the three existing VHF systems with the 800 MHz digital trunked radio system. As noted earlier, the 800 MHz digital trunked radio system has already been implemented in the metro area and is planned to be implemented in Greater Minnesota. Implementation strategies include:

- System replacement should be carefully planned for orderly growth and to ensure a smooth transition from the current radio system over to the new 800 MHz trunked system. It is recommended that the system should be implemented in phases over a five-year period – implementing two Districts per year. This will also reduce the amount of time and money the state must invest in maintaining two radio systems.
- The initial system technical design should take into consideration immediate infrastructure installation and upgrade needs as well as future system growth requirements.
- Budgetary readiness of various agencies for transition to the new system should be realized and incorporated in the implementation plan.

[27] Based on OEC budget development.

- Continue to pursue partnerships to develop shared communications systems and continue to work with other state and local agencies to develop shared digital system.
- Mn/DOT should hire additional staff to keep up with the maintenance activities of the system and meet performance measures.

3.2.4 INFORMATION TECHNOLOGY (IT) INFRASTRUCTURE PRESERVATION

A. Introduction and Background

Mn/DOT has over 200 business applications and technology tools. These applications and tools help Mn/DOT manage the system and deliver services faster, better and more cost-effective. Leveraging the use of future technologies is a key component in continuing to increase efficiency.

Most of the maintenance areas discussed in this report rely on technology and Information Technology (IT) infrastructures to collect, analyze, report and communicate data. Examples of these include bridge management, pavement management, maintenance work management, facility management, traffic/safety management and financial management systems. These systems are used everyday to manage the transportation system. Therefore, it is critical that these systems are reliable and cost-effective IT infrastructure is critical to delivering and tracking the services it provides.

At Mn/DOT, three functional offices within the Operations, Safety and Technology Divisions provide a form of Wide Area Network (WAN) that provides data services to the entire Mn/DOT organization:

- **Office of Traffic, Safety, and Operations (OTSO)** – Provides a freeway-based cable plant (primarily fiber) to support video cameras, changeable message signs, loop detectors, and signals to the Twin Cities metropolitan area.
- **Office of Electronic Communications (OEC)** – Provides statewide analog and digital systems for voice and data systems.
- **Office of Information Technology (OIT)** – Provides a Transmission Control Protocol/Internet Protocol[28] (TCP/IP) data network service that enables computers, both desktop and servers, to communicate with each other within Mn/DOT and with external organizations.

The Office of Information Technology is responsible for IT functions throughout Mn/DOT. These functions include the planning, design, implementation, and support of the IT WAN and data and/or application servers used to support department business applications. Servers and Routers are two important components of Mn/DOT's IT WAN. Computer applications are supported by 300 servers that are located in Mn/DOT's Central Office of Network Operations Center (NOC). Mn/DOT also owns 85 routers that play an important role in communicating data

[28] The suite of communications protocols used to connect hosts on the Internet. TCP/IP uses several protocols, the two main ones being TCP and IP. TCP/IP is built into the UNIX operating system and is used by the Internet, making it the de facto standard for transmitting data over networks. Even network operating systems that have their own protocols, such as Netware, also support TCP/IP. Source: www. webopedia.com.

between various departments and offices. Without these data routers communication and sharing of electronic files is not possible. Servers and routers should be kept within service lives to maintain the quality of service (limit computer downtime) for Mn/DOT's more than 200 IT applications (maintain network availability time greater than 99.6 percent[29]).

As the need has grown for automation and analysis of data, Mn/DOT's IT WAN and centrally managed server farms have evolved and expanded on a project by project or one time funding basis. However, in 2003, as part of a $36 million funding shift, OIT's base budget was reduced $6.2 million per year. One of the net effects of this reduction is the inability to preserve IT infrastructure components such as network routers or data/application servers on a planned life-cycle basis. This has resulted in some servers and routers being used beyond the industry life-cycle. Continuing this practice will likely result in more frequent interruptions of service and lower quality of service for user applications.

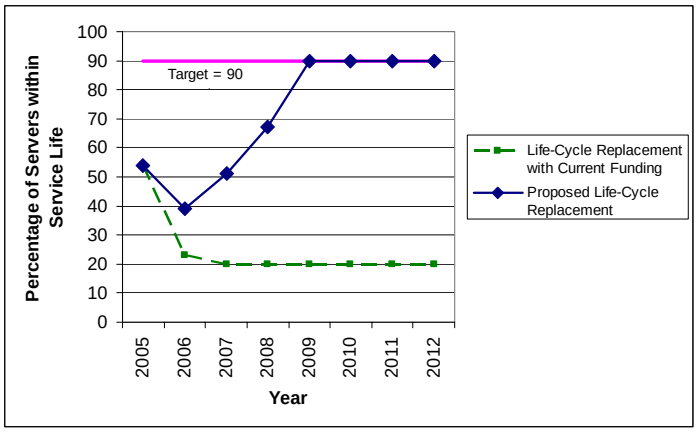
B. Performance Measure

Based on industry guidelines and best practices, individual performance measures were developed for the replacement schedule of servers and routers. These performance measures are in developmental stage.

- **Servers**

  The proposed measure is the *percentage of servers that are within recommended industry service lives*. The target for this measure is to have 90 percent of the 300 production servers within the recommended service lives (within 12 months off warranty or a four-year replacement cycle[30]). Projected server replacement schedule is shown in Figure 3-12.

Figure 3-12
Percentage of Servers within Recommended Service Life (2005-2012)



Source: Mn/DOT, Office of Information Technology

- **Routers**

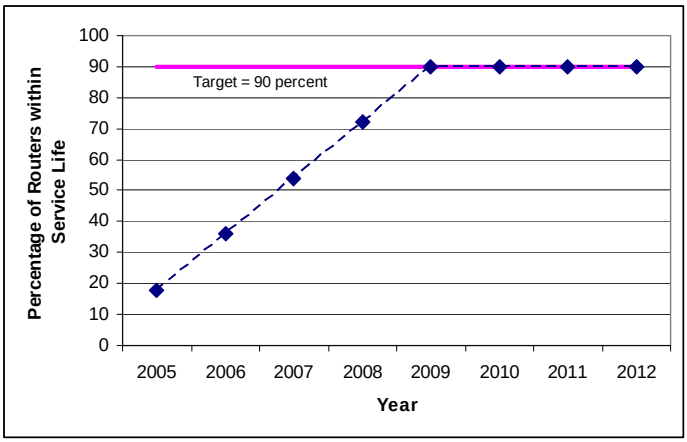
The proposed performance measure is the *percentage of routers that are within recommended industry service lives*. The target for this measure is to have 90 percent of the 85+ production routers within the recommended service lives (a five-year replacement cycle[31]). Projected router replacement schedule is shown in Figure 3-13.

[29] This standard was internally established by Mn/DOT with the assistance of a consultant. The standard was based on historical uptime, network redundancy, staffing, and funding data gathered from Mn/DOT's network management systems.

[30] Drew Robb, Keeping Costs in Check, (Network World, 2002).

[31] Drew Robb, Keeping Costs in Check, (Network World, 2002).

Figure 3-13
Percentage of Routers within Recommended Service Life (2005-2012)



Source: Mn/DOT, Office of Information Technology

C. Policy Directions – Financial Implications

Currently, 54 percent of the 300 servers are within the recommended service life. By 2006, this number will drop to 23 percent without additional investment. The current budget allows replacement of approximately 20 servers per year. In order to achieve the 90 percent target by 2009, 68 servers would need to be replaced per year on an ongoing basis. The funding gap is the 68 servers total minus the 20 per year already budgeted, or 48 servers per year. The hardware and labor costs of replacing 48 servers are $412,000 per year. Beyond 2009, a replacement rate of 25 percent should be maintained to be at 90 percent target replacement schedule.

Eighty-two percent of the 85 routers are currently outside the recommended replacement cycle. To achieve the 90 percent target by 2009, 76 routers would need to be replaced by 2009. However, funds have already been allocated to replace 15 routers in 2005. Therefore, 15 routers would need to be replaced per year on an ongoing basis. The hardware and labor costs for replacing 15 routers are $190,000 per year. Thereafter, 20 percent of routers should be replaced on an annual basis to maintain 90 percent target. Based on these two components, servers and routers, a total of $602,000 is needed per year to maintain these components within 90 percent industry standards.

D. Implementation Strategies

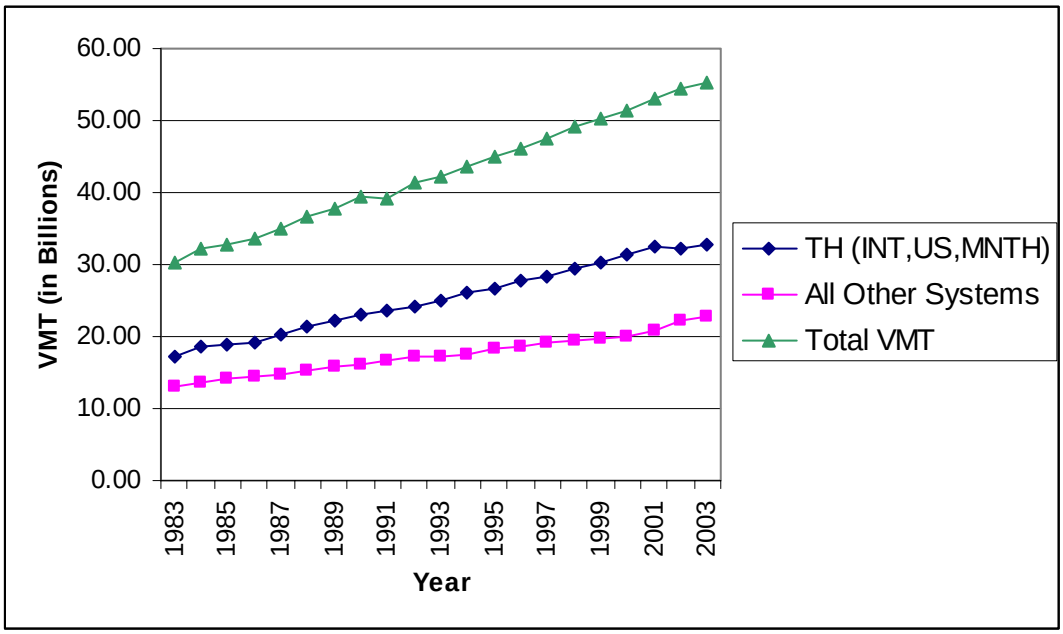
Mn/DOT has been investing in network and server infrastructure as monies become available (i.e., as unbudgeted and/or one time funding). Though this strategy has expanded the system to where it is today, it continues to defer the majority of replacements to one-time investments. These one-time investments are less efficient in allocating staff resources, and they put the overall system at more risk of downtime due to age. Implementation strategies to overcome these issues include:

- Work closely with the State Drive to Excellence efforts to investigate this infrastructure preservation as one of the business transformation areas and share infrastructure as a State Enterprise system.
- Continue to track historic and current annual performance levels (i.e., either percentage of downtime and/or percentage of uptime or total user hours lost) for system reliability.
- Continue to consolidate the system by reducing overall numbers of servers and the number of different application infrastructures.
- Work towards goal of budgeting for annual replacement of portion of network and server infrastructure to meet performance targets.

3.3 USER MOBILITY AND TRAVEL TIME RELIABILITY[32]

Reducing congestion and minimizing impacts of incidents and maintenance activities on Twin Cities Metropolitan Urban Freeway System (MUFS) users is a significant challenge that will only increase as the metropolitan area adds over a million people by 2030. Increases in population will result in greater traffic volumes throughout the metropolitan area and the state (Figure 3-14). Higher volumes not only increase "wear and tear" on bridges and pavement, but also make it more difficult to conduct maintenance operations. Higher volumes also make incident removal more critical with respect to minimizing user delays.

Figure 3-14
Annual Statewide VMT Trends (1983-2003)



Source: Mn/DOT Office of Transportation Data Analysis

Mn/DOT's Statewide Transportation Plan identified a number of policy areas, goals and strategies to deliver better services to users. The policy that most closely addresses freeway operations and management is Policy 3. The objective of this policy is to "Effectively Manage the Operation of the Existing Transportation System to Provide Maximum Service to Customers." The intent of this is to reduce delays to users by identifying, responding to, and removing incidents quickly, and by managing maintenance activities to minimize potential delays and impacts to users. According to the Texas Transportation Institute (TTI), 71 cities have developed programs that incorporate operational solutions in an effort to improve mobility and travel reliability. These programs are estimated to have saved an estimated 170 million hours nationwide in 2002[33].

[32] The majority of these measures focus on Twin Cities Metropolitan area.
[33] Schrank, David, and Tim Lomax, The 2004 Urban Mobility Report, (Texas Transportation Institute, 2004).

As part of developing the HSOP, three areas within User Mobility/Travel Reliability were identified as follows:

1. Freeway Management

2. Lane Closures

3. Signal Performance on Arterial Routes

These areas were further investigated and are discussed in more detail below.

3.3.1 FREEWAY MANAGEMENT

This area emphasizes management of urban freeway traffic flow in the Twin Cities Metropolitan area. It focuses on responding and removing incidents that affect traffic flow.

3.3.1.1 Freeway Incident Management (Travel Time Reliability)

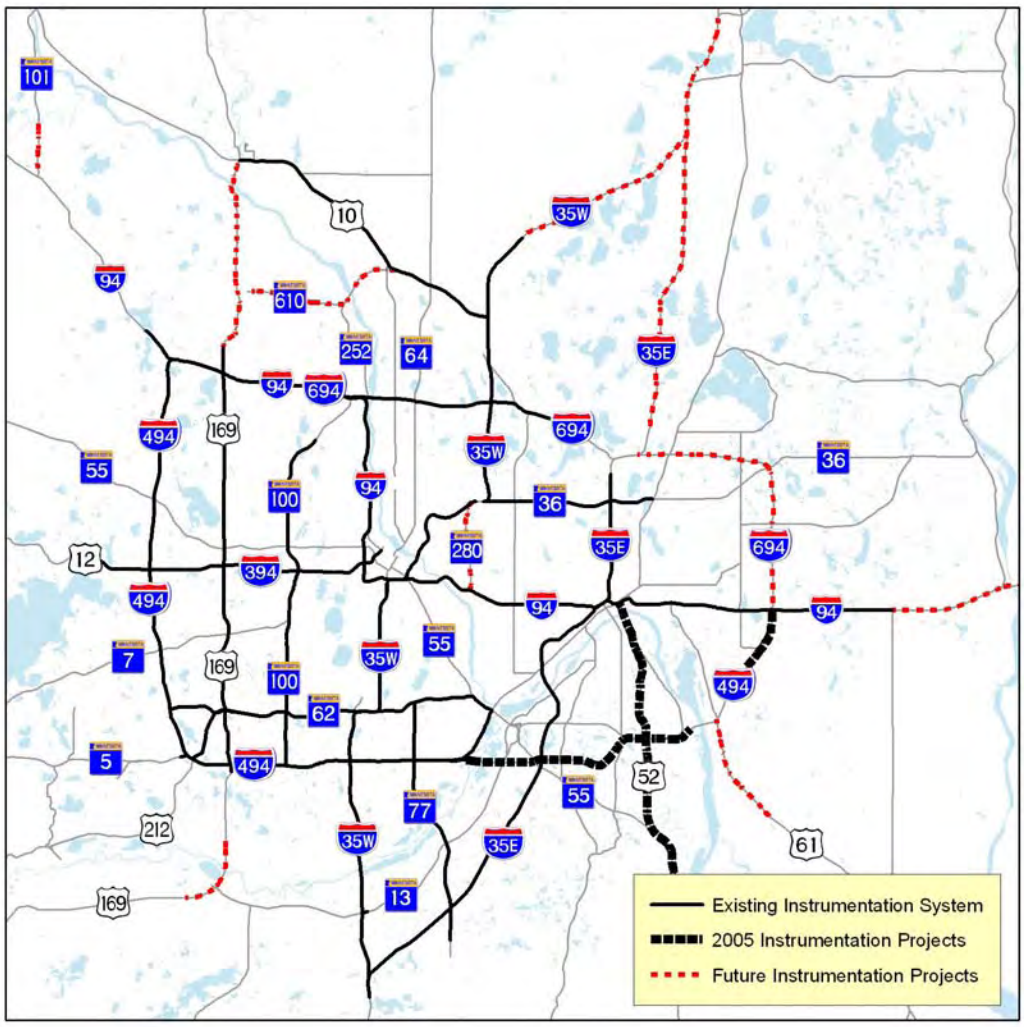
A. Introduction and Background

National studies have shown that there is a direct correlation between congestion and incidents (the more congestion there is the more likely crashes are to occur). Moreover, incidents account for over 50 percent of all user delays. Mn/DOT has made significant investments and program commitments to identify incidents and/or potential problems as quickly as possible and to remove and/or mitigate the impacts of these problems on the users of the system. The focus of this investment has been on selected corridors that are part of the Metropolitan Urban Freeway System (MUFS) shown in Figure 3-15. This investment not only reduces user delay, it also reduces secondary crashes that can occur as a result of vehicle backups. Previous studies have indicated that for every one minute an incident remains there is a 2.8 percent chance that a secondary will occur. Also, depending on time of day and location, studies have found that 15 to 20 percent of all crashes are secondary crashes caused by the congestion from a previous incident. In addition, studies have determined that these general rules of thumb apply with respect to impacts on congestion:

- 4 to 1 rule: For every one minute an incident remains, four minutes of congestion are created.

- For every six minutes an incident remains, one mile of congestion is created.

Figure 3-15
Metropolitan Urban Freeway System (MUFS) – Existing and Future



Source: Mn/DOT Regional Transportation Management Center (RTMC)

Cameras and vehicle detectors on the system are used to collect information and relay it to the Regional Transportation Management Center (RTMC). RTMC staff monitors the operation of the system and can quickly react to traffic problems. Staffing and monitoring efforts are focused on the peak travel periods (morning and evening rush hours); however, Mn/DOT provides monitoring staff twenty-four hours a day seven days a week; with increased monitoring levels on weekdays from 6:00 A.M. to 7:00 P.M. This state-of-the-art RTMC is used to:

- Identify traffic incidents, stalls or other operational problems,
- Confirm reported incident locations i.e., respond to cell phone reports for sending assistance,

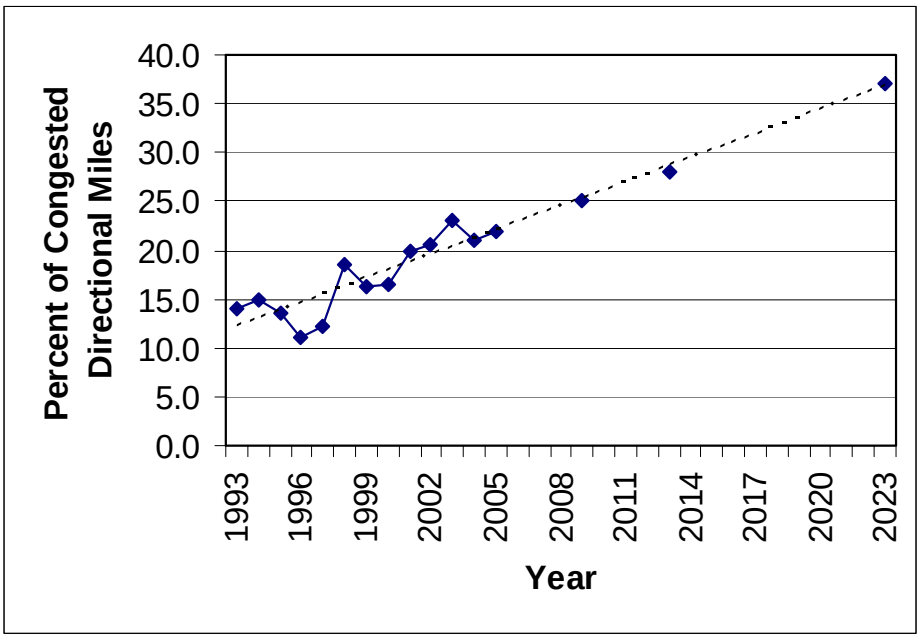
- Identify extent of problems to send proper resources (i.e., ambulance, Freeway Incident Response Safety Team (FIRST), tows, fire, clean-up crews – normally if patrol would be dispatched and have to arrive on site before other resources are called),

- Monitor and adjust metering system, electronic message boards and other devices in order to provide information to facility users and to minimize mainline and ramp queue delays, and

- Provide direct links for radio, television and other media as a way to communicate traffic problems and potential alternate routes.

Currently there are 320 centerline miles on the MUFS. These routes serve as the most important mobility routes within the Twin Cities Metropolitan area. However, only two-thirds of these routes (233 centerline miles) are instrumented and monitored with cameras, pavement sensors, metering and message boards. As volumes continue to increase throughout the Twin Cities Metropolitan area, more of the urban freeway system is expected to become congested; historical trend data suggests miles of congestion could increase from 23 percent of the MUFS to 37 percent by 2023 (Figure 3-16).

Figure 3-16
Percent of Congested Miles on the Twin Cities Urban Freeway System



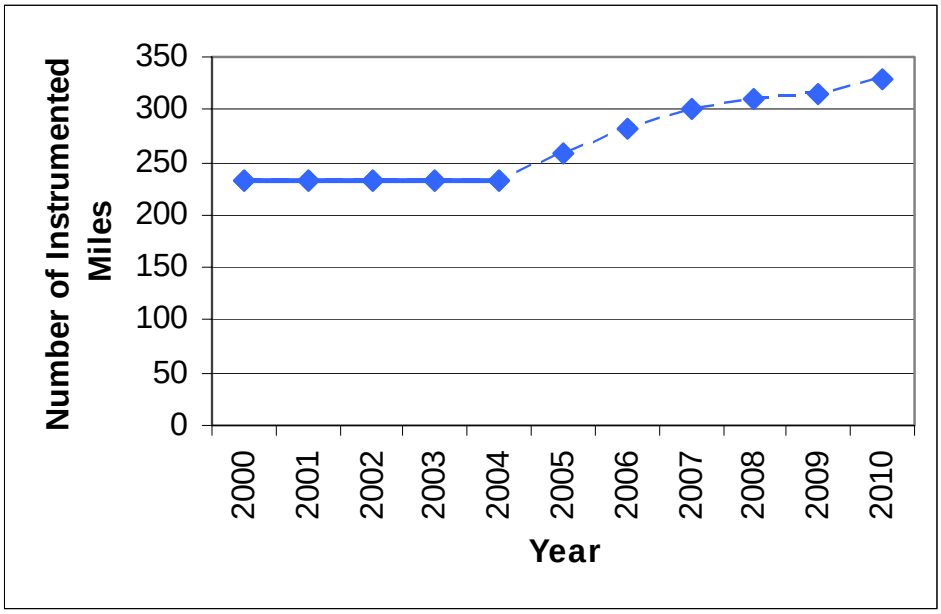
Source: Mn/DOT District Operations Performance Data Summary, 2004

This growing congestion will result in an increase in incidents and a need to respond more quickly to those incidents to minimize user delay and secondary crashes. A Federal Highway study found that for each minute of lane blockage, there is five additional minutes of other user delay that is created. Therefore, clearing blockages quickly has significant benefits to other users.

B. Performance Measure

Mn/DOT's proposed measure for this area is *the percentage of the MUFS that is instrumented with cameras and pavement sensors.* While this is an input measure, it does measure the ability to identify and communicate problems on the system. The overall goal is to have the entire 320-mile MUFS instrumented by 2009 (Figure 3-17). This would allow the Regional Transportation Management Center (RTMC) to monitor, manage and help direct responses to incidents as well as manage traffic demands on these critical urban freeways in the Metropolitan area.

Figure 3-17
Instrumented Miles – Metropolitan Urban Freeway System



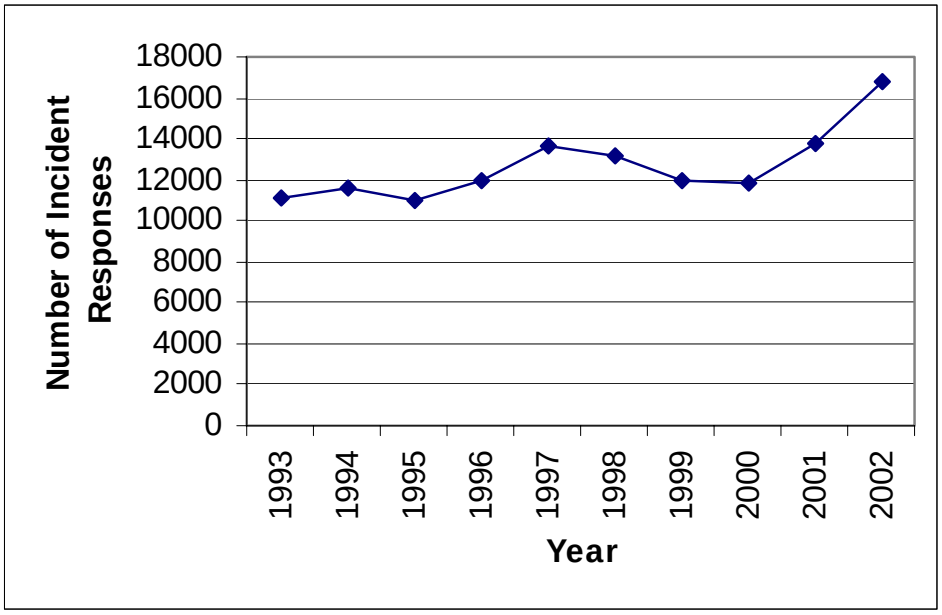
Source: Mn/DOT Regional Transportation Management Center (RTMC)

C. Policy Directions – Financial Implications

Because over 50 percent of all user delay is caused by incidents, crashes and disabled vehicles, developing systems to more quickly respond and clear these problems has been shown to significantly benefit user mobility and travel reliability. As previously stated, FHWA is working to establish programs in the 75 largest metropolitan areas to identify effective strategies and put in place regional frameworks to help combat rising congestion levels. The financial implications of achieving a fully-instrumented system are outlined below:

- Installation of loops, cameras, and other electronic devices on the uninstrumented portion of the MUFS would cost nearly $10.0 Million (57+ miles of instrumentation). The initial cost of this should be considered a capital cost. Some additional funding may be available from the new federal transportation bill for ITS type projects. Completing the MUFS system would be one potential use for these funds. Locations of 80+ miles of additional coverage is shown in Figure 3-18 and Table 3-8 shows the priority for instrumentation and cost for each project.

Figure 3-18
FIRST Unit Activities (1993 to 2002)



Source: FIRST (Highway Helper) Access Database

Table 3-8
Priority and Cost for Instrumentation Projects[1]

Priority	Highway	From	To	Estimated Cost	Length (mi.)	Fiscal Year
1	I-35E	CR E	I-35W	$2,023,000	11.9	2006
2	I-35W/35	Lexington	TH 8	$2,210,000	13.0	2006
3	TH 169	77th	TH 10	$1,479,000	8.7	2007
4	I-694	I-94	I-35E	$1,632,000	9.6	2007
5	I-94	CR 15	St. Croix River	$850,000	5.0	2008
6	TH 61	I-494	80th St	$731,000	4.3	2008
7	TH 169	CR 1	CR 18	$391,000	1.7	2009
8	TH 280	I-94	I-35W	$680,000	3.4	2009
			Totals =	**$9,996,000**	**57.6**	

[1] 25.2 miles were budgeted for instrumentation and are scheduled to be completed in 2005.

- Increasing size of the electronic system also increases the need to maintain the various components of the system. Therefore in addition to the current staffing levels[34], additional staff will be needed to monitor the video screens and dispatch appropriate resources. Specific staff that are needed to maintain the system include:

  - ✓ Four more integrators[35]. This staff works with the electronic feeds from the pavement sensors and cameras (getting data back to RTMC).

  - ✓ Four more maintenance technicians. This staff does preventive and routine maintenance on loops, cameras and ramp meters.

  - ✓ Two more dispatchers. With the additional coverage area (57+ centerline miles), an additional monitoring sector would be set up. This requires two additional staff to cover the 16-hour shift.

  The estimated cost of adding staff to cover the additional instrumentation of 57 miles is shown in the Table 3-9. The table shows that two additional staff would be added the first year, two more in 2007, two more in 2008 and four additional staff in 2009. If the number of instrumented miles is reduced or implemented at a slower pace the staffing-level would be adjusted accordingly.

Table 3-9
Estimated Operational Cost of Adding Staff[1]

Year	Staff	Estimated Cost
2006	2	$150,000
2007	4	$300,000
2008	6	$450,000
2009[2]	10	$750,000

[1] Annual cost for additional staff

[2] Ongoing annual costs are $750,000 beginning in 2009

The instrumented system does help reduce response times as well as make communication activities between FIRST units, State Patrol, Fire and other emergency services easier. The RTMC confirms incident locations and their magnitude so that proper resources respond to the incident at the earliest possible time. This minimizes blockages and reduced delays for users, and it leads to better response times for emergency personnel.

[34] The current staffing levels are – five integrators, eleven maintenance technicians, and six dispatchers at a base budget of approximately $1.4 million. The additional staff will bring the total staffing level to 22; an increase of around 45 percent.

[35] There is currently enough overtime being worked to fund two full-time staff.

D. Implementation Strategies

The instrumentation of the MUFS system should correspond to increased use of the system (instrument areas that have worst incident and congestion problems first). In addition, the system should be developed to provide secondary benefits of delivering real-time travel estimates to users. As part of the implementation of this Mn/DOT should:

- Carefully evaluate the cost of expanding the instrumentation of the system with other potential options to improve response and clearance times.
- Identify potential funding sources to expand system
- Review maintenance and operations processes to minimize ongoing maintenance costs
- Consider change in legislation to allow fees to be charged to motorists that require assistance. Fees would help defray cost of maintaining system.

3.3.1.2 Incident Response and Removal

A. Introduction and Background

High traffic volumes and speeds on Metropolitan Urban Freeway System (MUFS) make it hazardous for users who are trapped along the shoulder of the road, with mechanical or other problems, and for those users that are involved in traffic incidents. It is also hazardous for other roads users as traffic flows usually become unstable and there can be large speed differentials that can result in secondary crashes.

Source: Mn/DOT Office of Maintenance
FIRST Unit and State Patrol

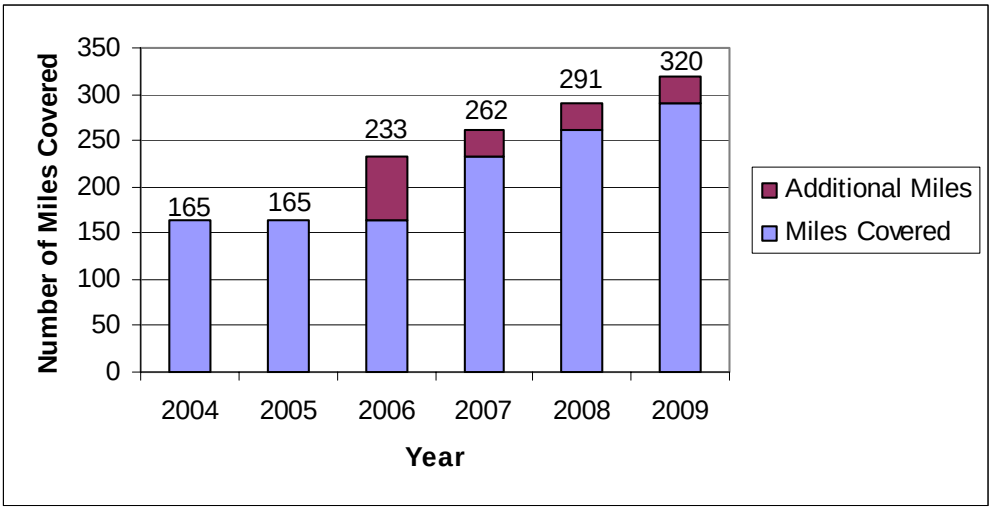
In an effort to assist the State Patrol in responding to incidents, and also respond to problems that don't require State Patrol involvement (i.e., stalls, flat tires), Mn/DOT developed a field response program called the Freeway Incident Response Safety Team (FIRST). The primary function of the FIRST units is to remove and/or respond to stalls, incidents or other problems, to clear and/or mitigate the impact of these problems on the travel lanes as soon as possible, and to minimize delays and secondary crashes[36]. In addition, they assist other responders such as the State Patrol, ambulance, fire and tow services as needed and are in direct communication with the RTMC. Currently, there are eight FIRST routes that cover 165 miles of the 320 mile MUFS. These teams operate on weekdays from 6:00 A.M. to 7:00 P.M. In the 2003, these teams responded to 17,000 incidents (Figure 3-16). Due to lack of financial resources, FIRST coverage is 68 miles short of the current 233 miles of instrumented urban freeway system.

[36] National studies on similar programs have indicated a benefit-cost ratio of 8:1 to 10:1. Mn/DOT's last benefit-cost ratio was 4:1; however this analysis looked at user delays only, not secondary crashes.

B. Performance Measure

This performance measure is the field counterpart to the incident identification and monitoring side of the operation discussed 3.3.1.1. The proposed measure is the *percentage of the instrumented MUFS that is covered by a FIRST team*. Figure 3-19 shows the implementation of FIRST route coverage from 2004 to 2009. The proposed measure for this area is an input measure; however, this measure directly affects the Statewide Plan measure of average incident response time.

Figure 3-19
Implementation of FIRST Route Coverage



C. Policy Directions – Financial Implications

The national policy direction is to develop more of these operational teams that respond and clear incidents. Numerous other cities and large metropolitan areas have developed similar programs such as the Minute Man in Boston, Colorado Incident Management Coalition (CIMC) in Denver, Motorist Assistance Patrol (MAP) in Houston, Memphis, and New Orleans, the Connecticut Highway Assistance Motorist Patrol (CHAMP) in the Greater Hartford Area and along the I-95 corridor, and the Highway Emergency Local Patrol (HELP) in New York. It is estimated that nationally these types of programs have resulted in a 40 percent reduction in the duration of major incidents. A benefit-cost study of the FIRST program conducted in January 2000 by Mn/DOT found that it provided four times the benefits with respect to their costs. Similar programs nationwide have provided benefits ranging from three to 23 times their costs[37]. There are two primary principles that should guide the decision about adding FIRST routes: routes should only be added to cover the instrumented portion of the freeway system; and routes should only be added to areas that have incident problems and/or areas where congestion problems occur regularly.

[37] Khattak, Asad, and Nagui Rouphail, Incident Management and Assistance Patrols: Assessment of Investment Benefits and Costs: Executive Summary, (NCDOT Research Project 2003-06, 2003), p. 1.

Adding two additional FIRST routes (approximately 68 miles) would cover the remaining portion of the MUFS that is currently instrumented. This could occur immediately if funds were identified. Adding additional routes to cover the full 320-mile MUFS (an additional 57 miles) would take an additional three routes, but should not be done until these 57 miles are instrumented.

Each FIRST route includes two staff and a vehicle for a total cost of $150,000 per route. To complete the coverage for the MUFS system an additional $300,000 is needed. If the FIRST units are expanded to the entire MUFS system then, three additional FIRST units would need to be added. If the total MUFS were covered by the end of 2009, the additional annual cost is estimated at $750,000 annually (Table 3-10).

Table 3-10
Estimated Cost of FIRST Routes to be Added

New Routes	Description	Annual Cost[1]	Estimated Year
1 and 2	TBD	$300,000	2006
3	TBD	$450,000	2007
4	TBD	$600,000	2008
5	TBD	$750,000	2009

[1] Annual cost of FIRST routes assuming $150,000 per route per year.

The impacts of reducing the current coverage of the FIRST program (program cuts) or not extending the FIRST program to freeway areas that will become increasingly congested will be borne by the users of the system. The greatest impacts will be on users that find themselves stranded on facilities with little or no way to extricate themselves from a hazardous situation and the State Patrol or other law enforcement staff is not available to assist.

D. Implementation Strategies

FIRST units have been shown to be effective in minimizing impacts of vehicle stalls and incidents on other users[38]. Strategies for implementing additional routes should focus covering existing instrumented system, before considering expanding to the remaining MUFS routes. Mn/DOT is exploring ways to incorporate private funds (through sponsorships) as a way to fund the cost of additional routes[39]. In addition, it should seek to better track workloads, response times and responses per vehicle or route, to show that dollars are well managed and service is effective. Mn/DOT should also continue to support the quick removal legislation that allows towing of vehicles to minimize user delays and improve safety. In addition, it should continue to pursue strategies and technologies that promote quicker clearance of crashes, including partnering with other agencies such as DPS. As another option for defraying costs, Mn/DOT could pursue changes in legislation to allow fees to be charged to motorists that require assistance.

[38] Highway Helper 2000 Summary Report, (Mn/DOT Office of Traffic, Security and Operations, 2000).
[39] This has been done in other metropolitan areas.

3.3.2 LANE CLOSURES

In the Twin Cities Metropolitan area where volumes are extremely high, lane closures have a significant impact on traffic flow and subsequently to users of the system. In an effort to minimize impacts to users, Mn/DOT established lane closure guidelines to give maintenance and construction staff direction on their use. The purpose of these guidelines is to minimize user delays where Mn/DOT has control over the time and location of the closure. Planned lane closures are done in order to make infrastructure repairs and/or clear snow from bridges and guardrail areas; unplanned closures are done to respond to emergency situations such as pavement blow-ups or spills, or severe crashes that close facilities for extended periods. In these instances, lane closures are required for public safety purposes until repairs are made and/or lanes are cleared. The specifics of these maintenance closures and how Mn/DOT can address the changing needs in this area are outlined in the following sections.

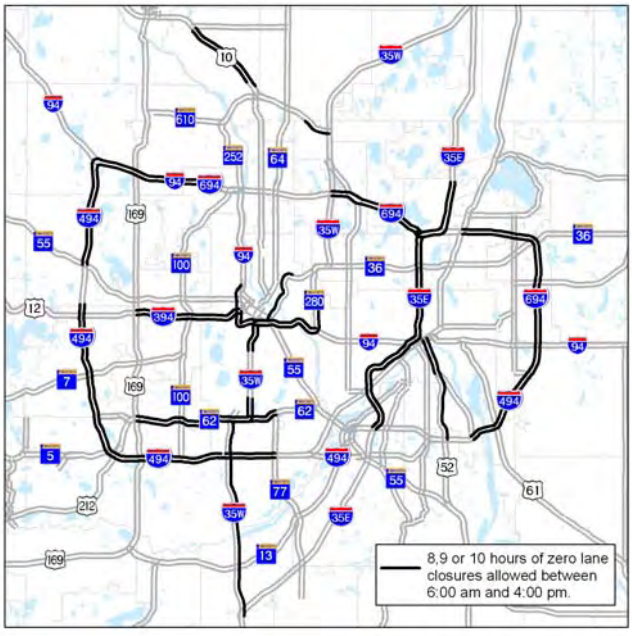
Source: Mn/DOT Office of Maintenance
Planned Lane Closure for Snow Removal

3.3.2.1 Planned Lane Closures

A. Introduction and Background

Planned lane closures are required in order to safely conduct many maintenance activities (i.e., guardrail repair, some light repair, pavement patching, joint repair, bridge preventive maintenance, and snow and ice cleanup). Due to high traffic volumes, guidelines and standard practices have been developed which limit planned lane closures based on hourly volume thresholds. Many miles of the MUFS have volumes, which exceed these thresholds for most of the daylight work hours (Figure 3-20).

Figure 3-20
Highly Restricted Facilities–2004 (Planned Lane Closures)



Source: Metro District Traffic

As a result, non-emergency work that requires lane closures on highly restricted facilities (as defined by the Lane Closure Manual), by policy directive, must be done at night to avoid significant user impacts. As the volumes increase on the MUFS, more and more of the system will come under these lane closure restrictions. Between 2001 and 2003, 60 out of the 204 roadway segments had increased lane closure restrictions. In addition, the number of segments with no lane closure was reduced from 34 in 2001 to 25 in 2003 (nine previously unrestricted segments became restricted and 51 segments had restrictions expanded to more hours of the day). Between 2004 and 2009, lane restrictions

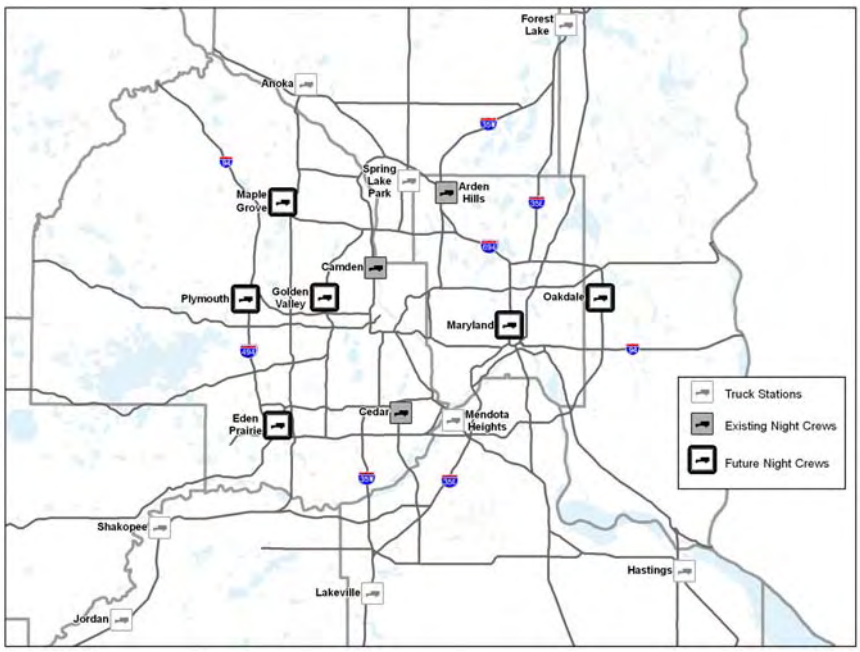
are anticipated to grow as average daily traffic volumes increase. In order to follow these guidelines, more of the maintenance activities will need to be shifted to off-peak hours (night-time work).

B. Performance Measure

The proposed measure is a developmental measure. The measure is the percentage of all planned lane closures done at night as part of normal maintenance operations activities on high volume areas. This would have the effect of increasing the number of night maintenance crews in the Twin Cities Metropolitan area to reduce the number of planned lane closures during the day (high-volume time periods). The proposed measure for this area is an indirect measure because there is not a good way to capture and compare the total daytime and nighttime work delays (volume disrupted over a length of time).

Currently Mn/DOT operates three night crews in the Twin Cities Metropolitan area. These are located in Cedar Avenue, Camden, and Arden Hills. It is estimated that two additional night crews will be added between 2006 and 2009, and potentially four more night crew conversions will be needed beyond 2009. These crews are necessary to perform critical infrastructure repairs while meeting lane closures guidance and user expectations with respect to impacting traffic flows. Figure 3-21 shows the location of existing truck stations, existing night crews, and future night crews. Based on present demands and geographic coverage of the system, the following is the initial priority for conversions to night crews: 1) Maryland, 2) Oakdale, 3) Eden Prairie, 4) Maple Grove, 5) Plymouth Truck Station, and 6) Golden Valley.

Figure 3-21
Location of Truck Stations and Night Crews



Source: Metro District Traffic

C. Policy Directions – Financial Implications

The direction of Mn/DOT, with respect to planned lane closures, is consistent with other areas across the country. Mn/DOT's focus has been to minimize lane restrictions, especially during high volume or lane usage times. In addition, the direction is to recover the lane usage and capacity and to restore them to full flow as quickly as possible.

The financial implications of responding to the changing traffic conditions include some additional support and supervising staff that is not on the night shift in the locations where these crews would be based (this is an ongoing annual cost), and a one time cost for purchasing of additional equipment that is needed to conduct night-time operations (safety equipment, lights, etc.). It is anticipated that one additional night crew will be needed for each biennium. The cost for converting these crews, as outlined above, is shown in Tables 3-11 and 3-12.

Table 3-11
Estimated Annual Additional Staff Costs (per crew)

Additional Staff	Estimated Costs
One additional mechanic	$58,500[1]
One additional TGS (Supervisor)	$57,200[1]
Shift differential[2]	$17,500
Totals	**$133,200**

[1] Includes salary and benefits.
[2] Cost differential night rates versus day rates.

Table 3-12
Estimated Initial (one time) Equipment Costs (per crew)

Equipment[1]	Estimated Cost
(1) Light tower	$25,000
(2) Crash attenuators	$26,000
(1) Emergency response truck plus equipment and signs	$93,000
(1) Guardrail truck with auger	$100,000
(1) Message board trailer	$35,000
(1) 12 ton trailer	$14,000
(1) Black top trailer	$15,500
(1) ¾ ton Pickup and cone setter bar	$18,000
(1) Cone setter on flat rack	$10,000
Totals	**$336,500**

[1] Equipment needs over/above daytime equipment.

Two choices were identified with respect to not converting day crews to nighttime operations. First, Mn/DOT could modify the guidance that it is currently working under that restricts lane closures when volumes exceed certain thresholds. This would permit lane closure work during the day. However, this would cause substantial user delays and potential safety problems that result from long queues and backups. This would also be very unpopular with the public and it would be inconsistent with the direction provided in the Statewide Transportation Plan, which focused on minimizing user delays.

Secondly, Mn/DOT could choose to reduce the level of maintenance in high-volume corridors with the exception of instances that had significant impacts to public safety and/or potential for exposure to liability. Work in these corridors could be prioritized and assigned to current night crews. This method would likely result in greater work backlogs for night crews and some work going without repair.

D. Implementation Strategies

Mn/DOT has completed the conversion of a number of day crews to night crews and will likely need to convert additional crews as volumes increase in the Twin Cities area. These crews will be essential for repairing key facilities while minimizing impacts to users. In addition to conversion to night crews, Mn/DOT should continue to look for ways to infuse more maintenance work into construction work zone areas, thereby minimizing the number of lane closures and traffic disruptions. Mn/DOT also should continue to explore ways to improve work efficiency, use longer lasting materials to reduce frequency and length of closure times.

Source: Metro Maintenance

3.3.2.2 Unplanned Lane Closures

A. Introduction and Background

One of Mn/DOT's responsibilities is to respond to emergency situations where special equipment is needed to clean up and/or restore the roadway to a safe and useable condition. Trucks can overturn spilling their cargo, crashes can result in damaged facilities that need to be cleared from the travel lanes, and pavement problems can occur due to high temperatures during the peak summer months (blow-ups). These incidents can cause significant delays to motorists and often impact traffic at the worst times, causing major traffic delays that affect commercial and other vehicle movements, and they can result in secondary incidents or crashes in the backups or traffic queues. As the metro area freeways become increasingly congested, this will become more of an issue.

B. Performance Measure

The measure is a developmental measure. The proposed measure is *to identify, respond and clear unplanned lane blockages within two hours***.** Currently, the largest numbers of unplanned lane closures are a result of pavement blow-ups that occur on hot, humid days. These blow-ups generally occur in the late afternoon and/or early evening during peak traffic times. This usually results in significant backups and user delays until the roadway is repaired. During an average summer, Mn/DOT responds to approximately 20 pavement blow-ups.

C. Policy Directions – Financial Implications

The primary policy direction is to better prepare for and anticipate these events so that user delays can be minimized when they occur. This would mean staging equipment and holding over crews on overtime when weather conditions are such that pavement blow-ups are likely. For example, limited emergency equipment is available at different locations in the metropolitan area. These locations may or may not be convenient or near pavement blow-up sites. In order to respond to incidents, some time is lost to gather the proper resources and get to the incident site. To improve response time, incident response trailers would be stationed at key truck stations throughout the metro area, thereby minimizing response time. These trailers would have all of the traffic control equipment necessary to respond to and manage traffic (Figure 3-22).

Figure 3-22
Location of Incident Response Trailers

Source: Metro District Traffic

Pavement blow-ups often occur in the late afternoon/early evenings on high-temperature, high-humidity days from June to August. Often, these occur just after the normal workday ends. Time is lost recalling crews to address problems. To respond more quickly, it is suggested that crews be held over on these days where potential problems might occur. Based on past practices, it is estimated that 20 such days occur each year and the cost to hold over two crews would be approximately $2,500 per day. The one time equipment cost for this activity is $120,000. This is estimated to reduce response and repair times by one hour over the current practices. Therefore, the total need is estimated at $0.2 million and $0.1 million for the first and second bienniums respectively.

D. Implementation Strategies

The objective of this measure is to reduce user delays by being better prepared to react to incidents that require repairs. Strategies for achieving the measure include:

- Better track historic pavement blow-up areas, response times, and times to clear incidents so that service can be better evaluated.
- Better define weather characteristics of days when pavement blow-ups occur so that costs for holding over crews will be minimized.
- Better organize and prepare equipment so that response time is shorter.
- Review potential long term fixes to prevent blow-ups from occurring.
- These activities should be considered as an enhancement to existing services.

3.3.3 SIGNAL PERFORMANCE ON ARTERIAL ROUTES

A. Introduction and Background

Improving signal performance supports Policy 3 of the Statewide Transportation Plan. This policy focuses on effectively managing the operation of the existing system to reduce delays to users. Signals are the primary controls on key arterials that serve as major feeder and parallel reliever routes to the Metropolitan Urban Freeway System (MUFS). They carry a significant amount of overflow commuter traffic and their operation affects a substantial number of users. Mn/DOT maintains over 600 signals on the state highway system in the Twin Cities Metropolitan Area (TCMA). One of Mn/DOT's responsibilities is to manage the signalized intersections so that they efficiently and safely move traffic. This requires responding to user complaints of signal timing problems, conducting retiming studies, and evaluating intersections to assess geometrics and operations in order to make recommendations to address safety-related issues.

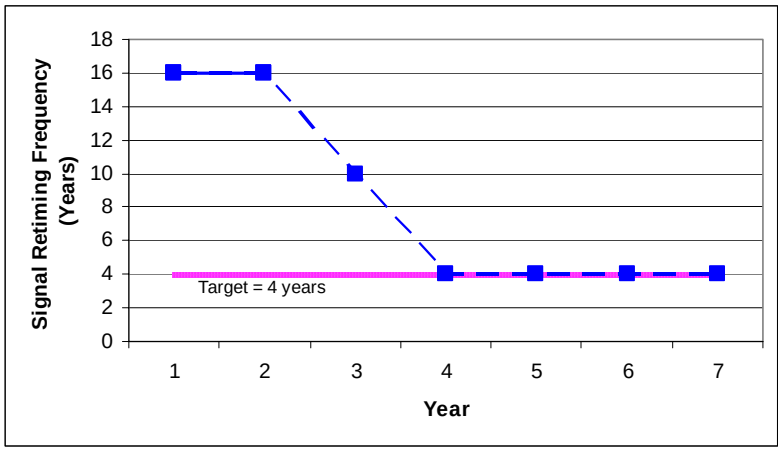
Based on national studies, signal retiming and/or making minor improvements to intersection geometrics can have the following benefits[40]:

- Improves air quality and reduce fuel consumption
- Reduces congestion and saves travel time
- Reduces the number of severe crashes
- Reduces aggressive driving behavior
- Minimizes or may eliminate the need to construct additional capacity

B. Performance Measure

This is an emerging measure. There is limited data; however, the data should be relatively easy to track and the measure has national benchmarks or best practices. The proposed measure is *the average length of time between signal retiming evaluations.* Figure 3-23 shows current and target signal retiming frequency.

Figure 3-23
Signal Retiming Frequency



The purpose of this measure is to ensure that the arterial system is being monitored and systematically evaluated to ensure that the signals are responsive to changing traffic patterns and traffic demands. National studies have noted significant user benefits of retiming studies. In California, a statewide traffic signal retiming program resulted in 7 percent reduction in overall travel times, a 15 percent reduction in delay and a 9 percent savings in fuel usage – all while achieving a benefit cost ratio of 58 to 1. Another example in Abilene, Texas achieved a 13 percent reduction in travel times, a 37 percent reduction in delay and a 6 percent savings in fuel usage.

C. Policy Directions – Financial Implications

Based on current staffing and funding levels, signals are retimed on a 16-year schedule in the TCMA. This frequency is based on total staffing of approximately 1.5 FTEs, which equates to a ratio of 423 signals per staff person[41]. The international standard as identified by the Institute of

[40] It's About Time – Traffic Signal Management: Cost Effective Street Capacity and Safety, (Federal Highway Administration).
[41] FTEs are full time staff equivalent (1 FTE = one full time staff)

Transportation Engineers (ITE) is 75 to 100 signals per traffic engineer. This should be used as a rule-of-thumb to achieve a recommended signal retiming frequency of once every four years. Signal retiming updates are needed to ensure that timing plans are efficiently responding to traffic volumes changes and/or traffic pattern changes. Poorly timed signals can lead to frustrated motorists and safety problems as well as wasted time and poor fuel economy. Several retiming studies were recently completed in the Twin Cities metro area. The TH 55 corridor had a benefit-cost ratio of 133 to 1 and a retiming of the TH 65 corridor had a benefit-cost ratio of 44 to 1.

To increase the frequency of signal retiming to a four year schedule would require an additional $250,000 (one additional FTE at $80,000 and $160,000 per year in consulting contracts and one vehicle at $10,000). Based on previous benefit-cost analyses of retiming projects this would have a significant payback to roadway users.

D. Implementation Strategies

The Twin Cities Metropolitan area has significant growth occurring. One of the impacts of this growth is continued change in traffic demands. Signal timing needs to be maintained to account for these changes. Retiming frequency needs to be improved from nine years to four years. This requires putting more resources towards periodic monitoring of intersection volumes and a review of signal timing to ensure that it is responding to traffic demands in the most efficient manner. To address the gap in frequency of retiming studies the following is recommended:

- Add one additional traffic engineer to conduct 15 to 20 retiming studies and to coordinate and oversee retiming studies done through consultants.
- Retain consultants to conduct retiming studies for 70 to 80 intersections per year.
- Retiming studies should first focus on 400 signals that are part of arterial corridors with the highest priority given to those arterials that are in high-growth corridors and/or areas where signal timing complaints are the greatest.
- Track or monitor retiming study progress, add in special timing plans for holidays, recreational days, and/or other special events to better respond to traffic changes.
- Retiming work should be tracked annually so that progress can be monitored. In addition, benefit-costs should be periodically assessed to make sure that retiming work is cost-effective. Corridor characteristics should be summarized and studies should be categorized so that potential benefits of retiming can be estimated based on the type of corridor.
- As timing is updated for the second time (four years down the road) there should be a benefit-cost analysis done to assess benefits of second retiming work. How much change occurred? Has level of benefits changed? Are there diminishing returns? Should there be different retiming frequencies based on corridor area (level of growth)?

3.4 SNOW AND ICE MANAGEMENT

A. Introduction and Background

The most highly valued maintenance service that Mn/DOT provides is snow and ice removal. These activities primarily occur from October to April on over 12,000 miles of the state highway system throughout Minnesota. Minnesotans expect to be able to carry out normal activities through most weather events, and to have transportation facilities that can safely accommodate travel shortly after the event has passed. As such, activities associated with clearing snow and restoring roadways to bare pavement conditions are a very high priority to road users.[42] Mn/DOT has allocated significant resources to these activities and has tracked its performance for many years.

Source: Mn/DOT Office of Maintenance
Snow and Ice Removal

There is a significant amount of variability in the weather from region to region and from year-to-year in Minnesota. For example, in 2003-04 the average snowfall was 66.3 inches, while in 2002-03 the average was 35.0 inches. However, snowfall is just one of many factors that affect snow and ice removal costs. Other factors include event duration, moisture content of precipitation, air temperature, pavement temperature, timing of event (weekend or in rush hour), and wind. Generally, the northeastern portions of the state get more snow and colder temperatures, while the western portions have to deal with wind and drifting snow.

B. Performance Measure

This is a mature measure. The performance measure for snow and ice is *the number of hours to achieve bare lanes after a weather event ends*[43]. Target level of service is based on market research and varies by roadway traffic volume. State trunk highways have been classified by volume into five groups. The classifications addressed by this measure are: super commuter (SC), urban commuter (UC), rural commuter (RC), primary collector (PR), and secondary collector (SE) routes. The measure identifies a goal for the number of hours after a weather event ends before bare lane is provided between the "wheel track" portion of the driving lanes. The targets set for the overall system and five types of roadways are shown in Table 3-13.

[42] Based on customer surveys.
[43] Bare lanes within "wheel-track" area.

Table 3-13
Target Clearance Times for Snow and Ice Removal

	Target Clearance Time (Hours)
Overall System	10
Super Commuter (SC)	1 to 3
Urban Commuter (UC)	2 to 5
Rural Commuter (RC)	4 to 9
Primary Collector (PR)	6 to 12
Secondary Collector (SE)	9 to 36

Snow and ice removal times are a function of personnel available, equipment, chemical usage, time of day and type of weather/storm and the ability to get ahead and stay ahead of the storm. Salt, sand, deicer and brine solutions are applied along with mechanical removal methods using plows and underbody blades.

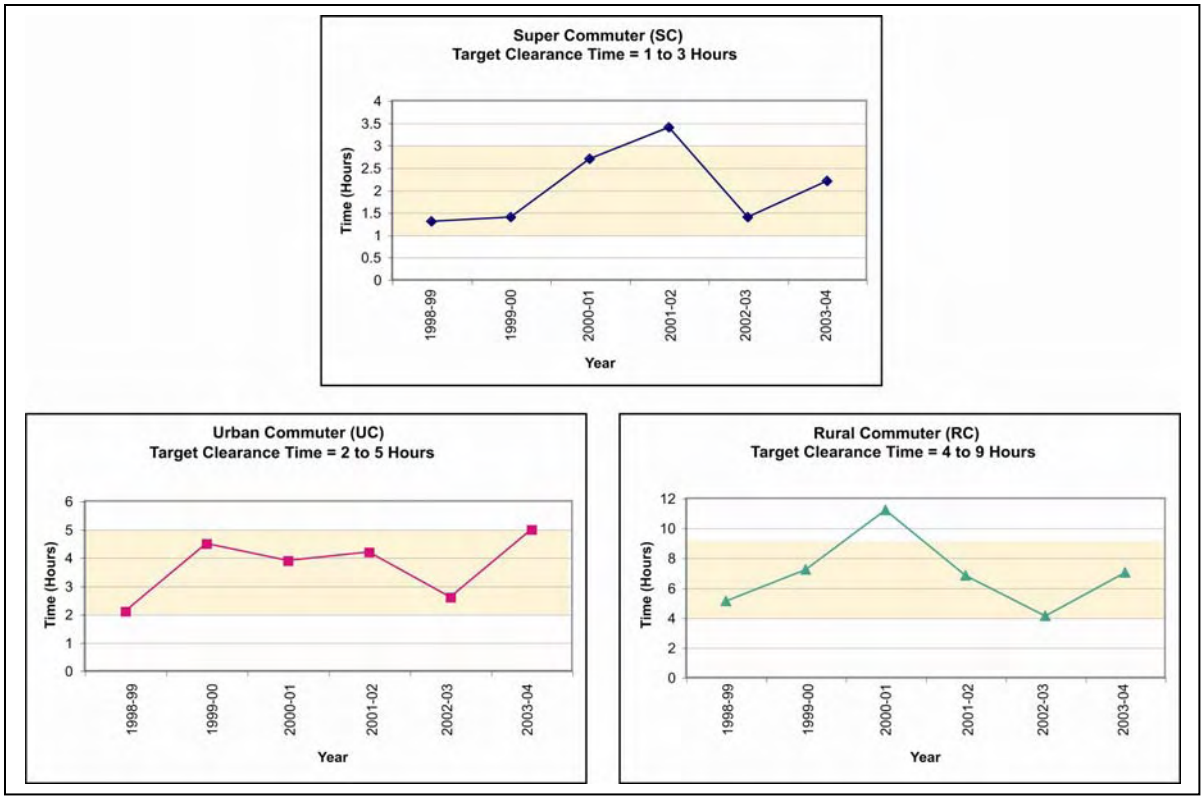
The annual snow and ice removal costs for these different categories range from a high of $2,660 per mile for super commuter to a low of $841 per mile for a secondary collector (2003 dollars).

Historical trends indicate that the average bare lane recovery times for commuter roadways have generally increased between 1999 and 2001 (Figure 3-24). Rural commuter routes and overall system clearance time improved in 2002 and clearance time for all commuter routes decreased in 2003 and increased again in 2004.

Historical changes in performance are difficult to quantify due to meteorological factors, changes in system size, changes in technology and management practices, and changes in labor force. However, in both instances, clearance times were well within target levels. The targets reflect customer expectations based on user surveys. Mn/DOT is committed to providing reasonable prioritized service to highway users and consistent snow and ice removal times.

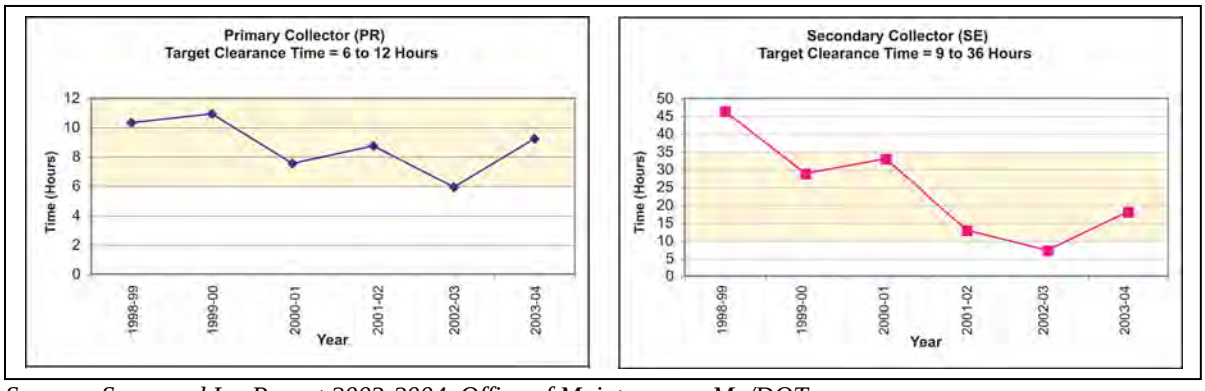
Figure 3-25 shows historical trends of average clearance time for collector roadways.

Figure 3-24
Statewide Average Regain Time – By Commuter Classification



Source: Snow and Ice Report 2003-2004, Office of Maintenance, Mn/DOT

Figure 3-25
Statewide Average Regain Time – By Collector Classification



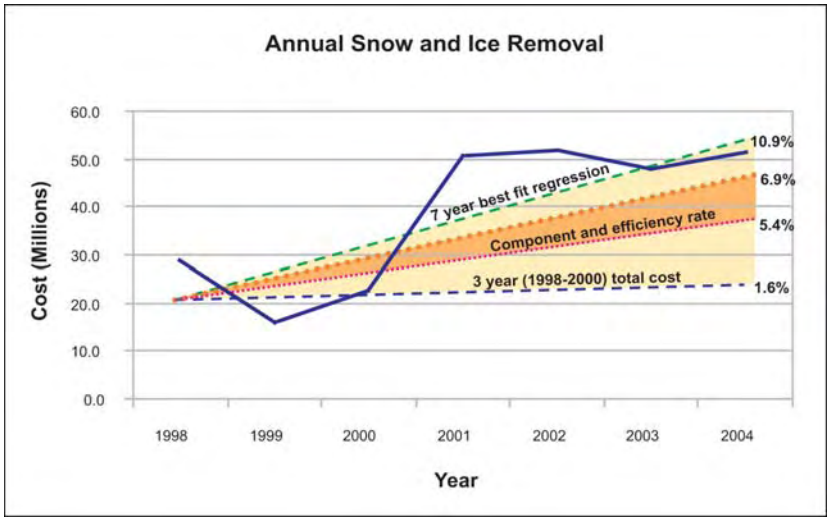
Source: Snow and Ice Report 2003-2004, Office of Maintenance, Mn/DOT

C. Policy Directions – Financial Implications

Snow and ice removal is the largest part of the maintenance and operations budget. In 2004, which was identified as a typical winter, the expenditures for snow and ice removal were approximately $46 million. This is nearly a third of the entire maintenance and operations budget. Historically, Mn/DOT has utilized whatever resources are necessary to clear snow and ice from Mn/DOT roadways. As such, the expenditures for this area fluctuate based on the weather conditions. Some winters are light in snowfall and/or there are only a few big events that require significant snow removal efforts. Other winters require much more effort: frequent snowfalls occur, events occur on weekends (which increases labor costs), snow is followed by bitter cold thereby reducing the effectiveness of chemicals, and/or wind or blowing snow requires constant sweeps of the system in open areas to ensure roads are not drifting shut or lanes are icing up.

Because of the variance in weather from year to year, annual snow and ice cost trends can not be used to directly project future snow and ice costs with certainty. An attempt was made to normalize annual snow and ice costs using the Winter Severity Index (WSI)[44]. Figure 3-26 shows cost increases ranging from 1.6 percent to 10.9 percent annually depending upon the number of years selected for the trend.

Figure 3-26
Annual Snow and Ice Cost Trends (Normalized)



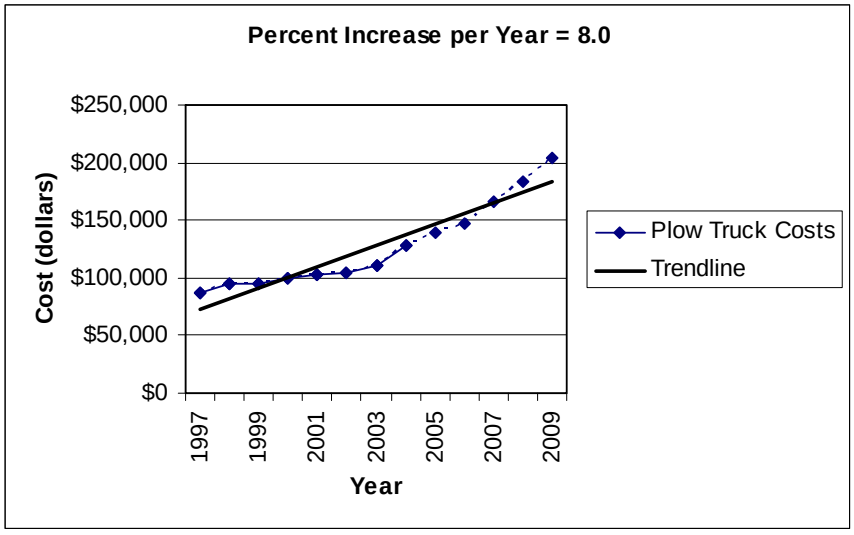
Because of this uncertainty, a second approach was used to better quantify cost trends. Changes in snow and ice expenditures were estimated based on cost trends of major components that make up the snow and ice costs. These trends were then used as an indicator for growth in snow and ice expenses. The major cost components include labor, equipment, and salt costs. Costs for these elements account for over 95 percent of the snow and ice removal costs. The three factors are summarized as follows:

[44] WSI measures the severity of winter (between December 1st and April 30th) based on number of snow events, number of freezing rain events, amount of snowfall, and duration of snow storms on days when minimum temperatures are zero degrees Fahrenheit or below. It is uncertain how well WSI can gauge the severity of the overall winter season and correlate to the effort required for snow and ice removal. It is recommended that the methodology for calculating WSI be further investigated so that events occurring during different years can be compared on a common scale.

Source: Mn/DOT Office of Maintenance

- **Equipment –** Average plow truck costs were documented from 1997 to 2009. These costs have increased at a rate of 8.0 percent per year. In addition to these costs, operating costs such as fuel, tires, vehicle maintenance and cutting edges have increased significantly. Capital equipment and equipment operating costs make up approximately 50 percent of snow and ice operations cost. A trend line was calculated and a growth rate was computed (Figure 3-27).

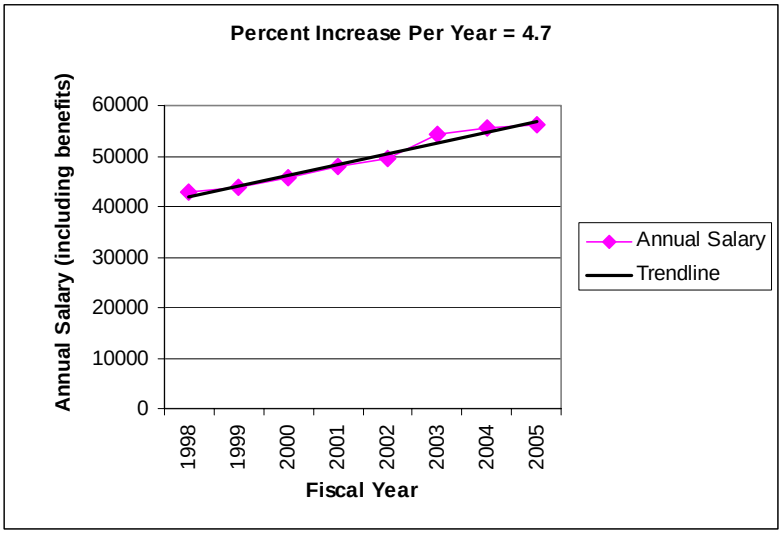
Figure 3-27
Average Plow Truck Costs (1997-2009)



Source: Mn/DOT Fleet Management – 2005

- **Labor** – Representative (FTE) labor costs, including overhead and benefits for the Transportation Generalist Class (TG), which makes up to 70 to 80 percent of the operator population, were calculated from 1998-2004. A best-fit linear regression line was then calculated and an average annual growth rate was computed (Figure 3-28). Based on cost accounting data, labor costs make up 21 percent of snow and ice operations cost.

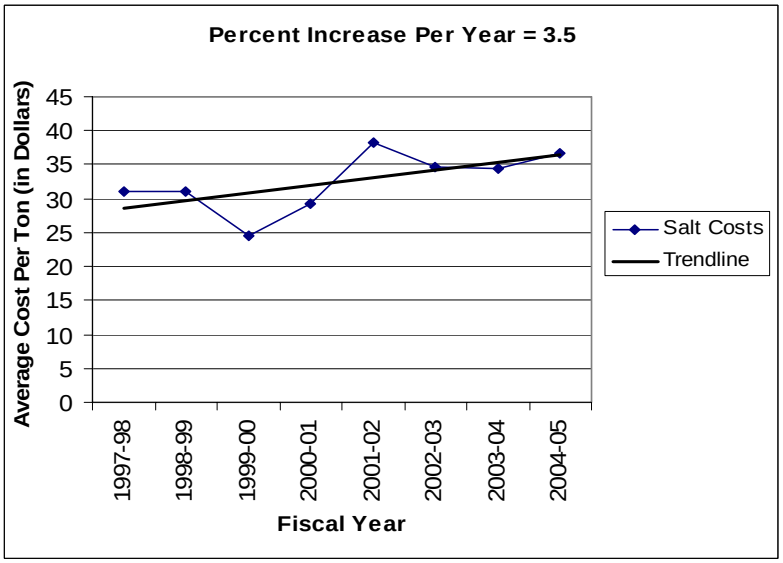
Figure 3-28
Labor Trends – Transportation Generalist Class



Source: Mn/DOT Snow and Ice Management Committee – 2004

- **Salt** – Unit costs for salt were calculated for years (1997-2004). A best-fit linear regression line was plotted and growth rates were computed at 3.5 percent (see Figure 3-29). Salt costs make up approximately 25 percent of snow and ice operations cost.

Figure 3-29
Salt Cost Trends



Source: Mn/DOT Snow and Ice Management Committee – 2004

These individual components range from 3.5 to 8.0 percent increase. Using these individual growth rates and aggregating them together based on their percentage of the snow and ice costs yields an average annual rate increase of 5.9 percent.

Finally, an analysis was done to assess the impact of adding lane miles to the system through 2009, and assessing the impact of having more lane miles in higher classifications due to increases in traffic volumes (roadways in higher classifications have shorter regain times[45] and therefore higher costs on a per mile basis for snow and ice removal due to higher levels of service). The additional lane miles and changes in road classifications account for approximately a one percent annual increase in snow removal costs. The aggregated increase in snow and ice cost based on individual components is totals 6.9 percent[46]; however, better equipment training and knowledge of storm and weather conditions have increased efficiencies. These efficiencies are estimated at 1.5 percent annually[47]. Therefore, the estimated real cost increases for snow and ice are increasing at 5.4 percent (6.9 - 1.5 = 5.4). These costs are shown in Table 3-14 in comparison to the current budget allocation.

Table 3-14
Calculation of Snow and Ice Gap (in Millions)

Year	2004	2005	2006	2007	2008	2009
Existing Budget – No Increase[1]	44.17	44.17	44.17	44.17	44.17	44.17
Projected Snow and Ice Costs[2]		46.5	49.0	51.6	54.3	57.2
Estimated Financial Gap[3]		2.3	4.8	7.4	10.1	13.0

1 Normalized cost of 2004 snow and ice budget (based on winter severity index).

2 Based on 5.4 percent annual cost increase. Annual increased was based on historical increases in main component costs, change in volumes, and additional system miles due to construction and bus shoulder lanes.

3 A portion of the snow and ice gap is based on equipment cost. The depreciation cost (equipment) is also included in the fleet measure. These will be reconciled in future plans.

D. Implementation Strategies

Snow and ice removal is critical to user mobility and safety in Minnesota. As such, it is a high-priority for users as well as Mn/DOT. It is a very labor and equipment intensive activity, and it is an activity that has a significant amount of variability due to unpredictable weather events. The strategies for improving snow and ice removal activities include the following:

- Continue to pursue pre-wetting and anti-icing strategies to make existing chemical use more effective, thereby reducing amount of materials needed to deliver same level of service.
- Continue pursuing equipment innovations to make plowing more effective and efficient. This would include adding more underbody blades and pre-wetting equipment to the snowplow fleet to improve snow and ice removal capabilities.

[45] Regain time is the time from the end of the snow event until "bare lanes" are achieved in wheel tracks.

[46] Calculated by taking annual rate of increase for each component times the percentage of that components cost of the total snow and ice cost. These individual components are then summed. For example: labor increased at 4.7 percent annually; this is multiplied by 21 percent (labor makes up 21 percent of the overall snow and ice costs); this yields a component increase of 0.98 percent. Other component increases are salt (0.88 percent) and equipment (3.8 percent), system change (1.0 percent). These components total 6.9 percent annually.

[47] The 1.5 percent efficiencies is an estimated value. More work should be done to confirm and track efficiencies.

- Continue to advance use of Automated Vehicle Location (AVL) technologies to track time, chemical and material usage, to log problem areas, provide better communication with supervisors and dispatchers on what has been plowed and routes remaining to be plowed, and finally to reduce administrative efforts of coding timesheets (logging how much material and time was spent on different roadway segments).
- Use Maintenance Decision Support System (MDSS) or other similar systems to advance best management practices and/or improve weather severity index.
- Continue to explore new other chemicals or methods that are less expensive and/or have less impact on the environment
- Explore ways to increase efficiency of operations (i.e., plow routes, equipment modifications, starting times); For example, due to traffic volume increases should more clean-up operations go to night work? Can more efficiency be generated by sharing routes with counties and cities?
- Continue to explore ways to minimize blowing and drifting of routes (natural snow fences) as a way to reduce costs. Work with ROW agents, soil and water conservation offices to address problem areas.
- Assess impacts of internal shared work force (many non-maintenance workers also are used to plow snow). This means other work that they are doing will be impacted. What is this impact and is this the best use of time?
- Continue to evaluate ways to track overall level of effort – total man hours, total plow hours. Track over time to see if more effort is expended each year. Track costs with respect to advance purchases of salt and sand.
- Evaluate snow and ice severity index. Is this a good way of comparing events or overall winters? How are the statewide averages generated?
- Continue snow fighting training activities to continue to have highly trained and effective workforce; continue biannual management and supervisory meetings to debrief previous winter events, evaluation of past strategies and set goals and objectives for next season.

3.5 SAFETY

Reducing the risk of crashes and improving safety is an ongoing challenge for Mn/DOT and all government agencies. Mn/DOT's Statewide Transportation Plan identified a number of policies whose outcomes enhance traffic safety. The main policy is Policy 7 "Increase the Safety and Security of Transportation Systems and Their Users." The desired outcome is to reduce number and severity of crashes.

Striping, signing, and guardrail are some of the most beneficial maintenance activities that are targeted directly at safety. They guide and direct motorists to minimize vehicle conflicts and they reduce the severity of crashes should the vehicle leave the roadway in a hazardous location. These three areas are discussed below.

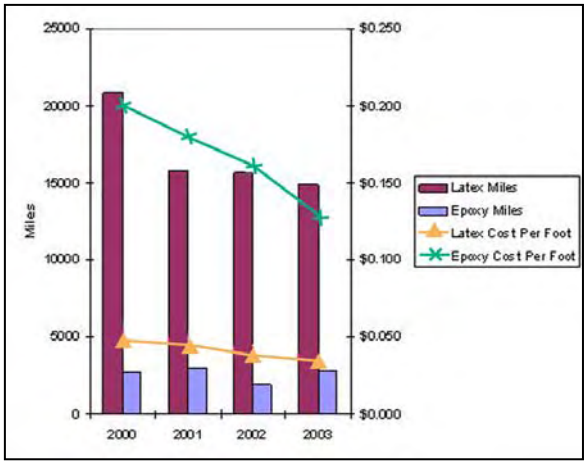
3.5.1 PAVEMENT STRIPING

A. Introduction and Background

Pavement markings have an important function to perform in managing, directing, and controlling traffic. In some cases, they are used to supplement the regulations or warnings of other devices, such as traffic signs or signals. In other instances, they are used alone and produce results that cannot be obtained by the use of any other device. Pavement markings provide the best vehicle guidance to the motorist, especially in low visibility conditions, thereby minimizing the risk of motorists of leaving their travel lane. Mn/DOT has made, and continues to make, a significant investment towards maintaining year-round pavement markings. This effort is especially difficult in Minnesota due to the seasonal conditions that not only limits the time that pavement markings can be installed and maintained, but also reduces the visibility or retro-reflectivity of the markings. In addition, snow and ice control operations affect the life of the pavement markings through abrasive materials and snow plowing operations.

Pavement striping operations were centralized on a statewide basis from 2000 to 2001 to improve efficiencies and reduce costs. This change has required some improved planning by the Districts to schedule striping crews and work around weather issues. As part of this centralization, the striping unit was set up to run more like a private business (the cost per linear foot includes all labor and material costs and the cost for replacement of capital equipment). Overall costs have been reduced by being able to centrally manage all of the striping requests and reduce the number of overall striping units statewide from ten to seven. In addition, the number of staff on each of the striping crews was reduced from five to four on latex crews, and from eight to five on epoxy crews. Since the initial year (2000), latex striping costs per linear foot have decreased by 30 percent from $0.05 per linear foot to $0.035 per linear foot (Figure 3-30). Total expenditures for striping have decreased by 34 percent from $7.1 million, in 2000, to approximately $4.8 million, in 2004.

Figure 3-30
Total Striping Miles and Cost per Foot



A significant portion of this decrease was a result of a $750,000 budget cut in 2003. This cut was achieved by reducing the thickness of the painted lines for both latex and epoxy and reducing the number of glass beads in the epoxy paint. The impact of changing the line thickness for and reducing the number of glass beads is not fully known. It is thought that this change could affect the life-cycle (longevity) of the epoxy lines. Data was collected in 2004, and is currently being evaluated.

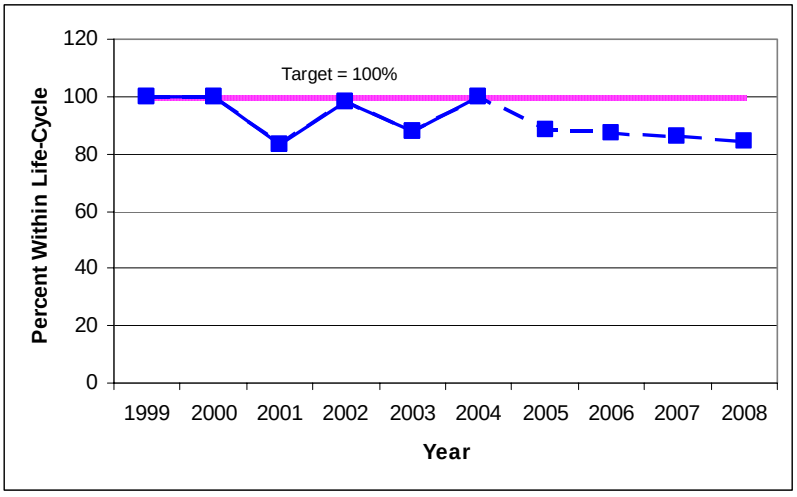
Source: Mn/DOT District Operations Performance Data Summary Report, 2004

B. Performance Measure

This is an emerging measure. The measure is based on the need to maintain visible stripe 365-days a year. In 1998 Mn/DOT conducted a pavement striping research study that focused on the public's perception of different pavement stripes. This study found that the threshold value of acceptable versus unacceptable stripe was a reflectivity between 80 to 120 Mcd[48]. As a result of this study, Mn/DOT established minimum targets for triggering stripe replacement (100 Mcd for white and 80 Mcd for yellow). Through research and experience, it has determined that latex lines have a life of approximately one-year before reaching this threshold; therefore, they are re-striped each year. Epoxy lines which are typically used on high volume roads, have an average life of three to four years[49]. Retro-reflectivity measurements are taken on epoxy stripes and evaluated each year to determine average life-cycle and to help determine the need for line replacement.

The measure for pavement striping is *the effective line miles striped each year, as compared to the total line miles of striping on the system.* Calculating the effective line miles striped each year is done by summing the different line miles striped times their life-cycle (e.g., number of epoxy line miles times three years). There are three components to this: latex line miles, epoxy line miles, and the number of line miles done through construction contracts. Summing these three components results in the total effective miles striped. The effective line miles striped are then compared to the total line miles on the system 37,000 to obtain a percentage or potential striping gap. Figure 3-31 shows historic and future trends in percent of line miles within life-cycle.

Figure 3-31
Percent of Line Miles within Life-Cycle



Source: Mn/DOT Pavement Marking

[48] Public Perception of Pavement Marking Brightness, (Market Research Unit, Minnesota Department of Transportation, 1998), p. 25.

[49] Mn/DOT uses laser-lux vans to measure retro-reflectivity (visibility) on 8,000 to 9,000 line miles of pavement strips or approximately 25 percent of the total line miles. This information is used to determine line life-cycle and line replacement needs. For this measure, the life-cycle of epoxy lines was reduced from 4-years to 3-years due to cost cutting measures in 2003 (epoxy line thickness was reduced and number of glass beads in paint were reduced). Information is being processed to confirm the life-cycle reduction change and retro-reflectivity loss. Life-cycle will be adjusted accordingly based on the results of this technical analysis in January 2005.

C. Policy Directions – Financial Implications

From a national perspective, development of pavement striping performance measures has been a long and difficult process. FHWA has been pushing for a retro-reflectivity requirement in the striping and signing area to improve the overall quality of signing and pavement markings. This is a very difficult issue because there have been few prior guidelines in this area, agencies are worried about liability issues, and these guidelines have a fairly significant management cost with respect to measuring and monitoring the system. The 1998 Mn/DOT research determined minimum thresholds for triggering line replacements.

Striping also has been caught up in another major policy discussion. There has been a renewed effort on both the national and state level to improve safety. One of the suggestions is to increase the width of the pavement stripes from a four-inch wide stripe to a six-inch wide stripe. Mn/DOT has estimated the additional cost of this change to be $1.3 to $1.6 million depending upon the assumed thickness of the painted line.

For Mn/DOT, between yellow centerline and white edge lines and lane lines there are a total of 37,000 lineal miles of striping on the 12,000-mile state highway system. A portion of these stripes is repainted as part of reconstruction contracts and a portion of them are repainted by Mn/DOT striping crews. Portions of the state system are painted with less expensive non-durable latex paints and others are painted with more expensive and more durable epoxy paints. While the initial cost of epoxy is three to four times more than latex, the life-cycle cost is comparable. The life-cycle of the pavement markings are dependent on many factors including pavement condition, pavement type, weather conditions when placed, the amount of traffic, and snow and ice control activities. While many of these factors, on a system level, are relatively constant, the amount of traffic on the state system has increased significantly and is anticipated to continue to increase as Minnesota adds over a million more residents by 2025. More traffic means more wear and tear on pavement markings.

Based on the average life-cycle of three years for epoxy (based on changes in line thickness, fewer beads, and fact that epoxy is being painted over in place epoxy and life may be less for this application), there is a $1.2 million funding gap with respect to providing a 365-day pavement stripe[50]. This gap is also based on the assumption that per linear foot costs will not be able to be reduced further (trend analysis shows that most of excess costs have been pulled out of the system and paint costs, fuel cost and labor costs are likely to minimize the ability to reduce costs further).

If a decision is made to go to a wider stripe (six-inch stripe) to improve safety, this gap will increase by another $1.3 to $1.6 million. The impacts of not meeting visibility or retro-reflectivity indicators means a higher percentage of the State highway system will not provide adequate visibility of pavement markings in which to guide the motorist. This has the potential to increase the risk of accidents, especially in low visibility conditions.

[50] An analysis was done to assess the current investment being made in striping as compared to the investment needed to achieve the established performance measure. The analysis tallied the number of linear miles striped using latex (one year life) plus the number of linear miles striped using epoxy times three (three-year life) and compares that to the 37,000 linear miles of striping on the system.

D. Implementation Strategies

Striping is one of the areas that has significantly reduced overall costs and increased efficiency. Supervisors are continuing to look at ways to reduce costs including reducing crew hours and reducing total paint crews from seven to six (possibly three latex and three epoxy crews). There is an optimal mix of latex and epoxy striping crews and Mn/DOT is working toward this as longer life-cycle stripes are placed. The percent of epoxy lines have been growing (15 percent in 1999 to 36 percent in 2004) while latex has been shrinking (62 percent in 1999 to 39 percent in 2004). Latex painting operations are less sophisticated and a faster (crews can achieve more production); however, these lines have to be painted every year while epoxy lines can be done less frequently thereby saving labor, fuel and other costs. Some discussion has also occurred with respect to leasing striping trucks in winter months to southern states to recoup greater proportion of depreciation and reduce storage costs.

There is a concern with respect to more durable striping products and the fact that the true cost of these items may be hidden in other maintenance work. For example, costs of seal coats and other preventive maintenance activities may not include protection and/or replacement of tape and/or expensive durable striping products. Mn/DOT should continue to evaluate this as well as continue to track striping costs (overall costs per line mile as well as component costs for labor, equipment and materials), crew efficiency measures (labor hours per line mile or similar measure), initial retro reflectivity and life-cycle of materials.

3.5.2 SIGNING

A. Introduction and Background

The function of highway signs is to provide regulatory, warning and guidance information to road users. Both word and symbols are used to convey messages to drivers to aid them in their trip. Regulatory signs give notice to traffic laws or regulations. Warning signs give notice of situations that might not be readily apparent. Finally, guide signs show route designations, directions, distances, services, points of interest, and other geographical, recreational or cultural information.

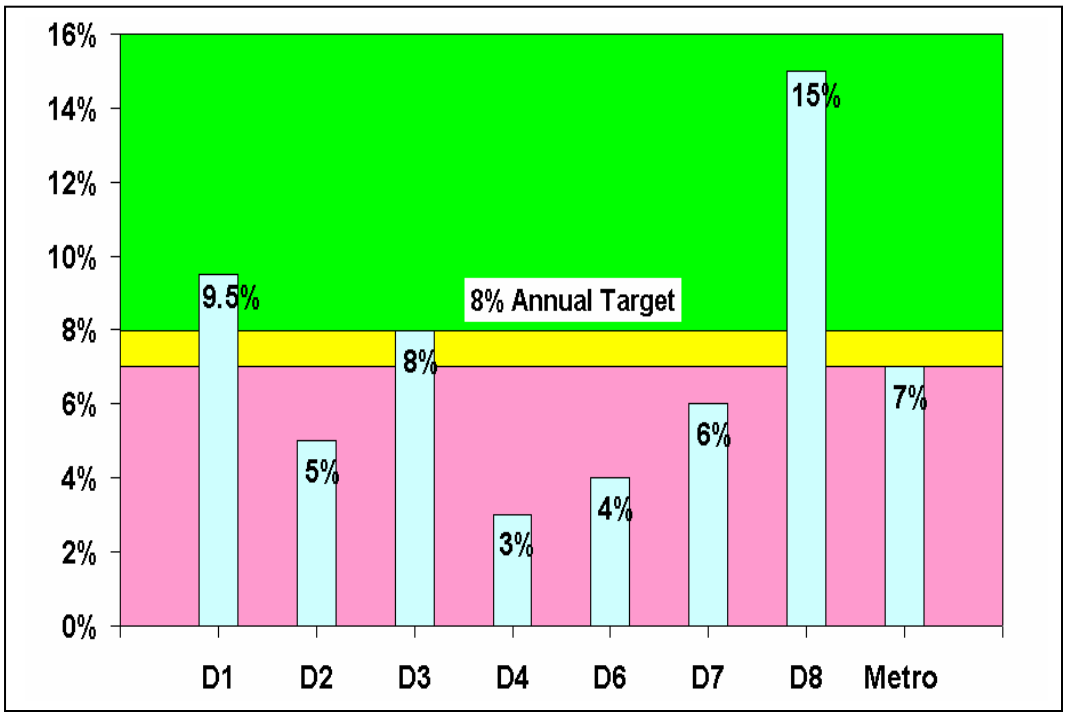
The basic requirements for signs are that they be highly visible in both day and night and that they be highly legible through adequate size letters and symbols and a short legend for quick comprehension. Providing these basic requirements allows the motorist to comprehend the intended message, determine course of action and react to the situation in a timely, safe and comfortable manner.

Highway Signs

B. Performance Measure

This is an emerging measure. While the life-cycle replacement measure has been in force for some time, the supporting data in this area is limited due to lack of sign management systems. There are an estimated 357,000 signs[51] on the state highway system that require life-cycle replacements due to deterioration of the sign face over time. In addition, signs periodically need timely repair and/or replacement due to wind and vehicle damage and vandalism. Based on field longevity tests and the types of sign face materials being used (high-intensity sheeting), signs last an average of 12 years before retro-reflectivity is lost and/or the sign legend becomes difficult to read. The performance measure for signs is *the percentage of signs replaced to meet 12-year life-cycle.* The performance target for this measure is to replace 8 percent of the total signs annually (Figure 3-32).

Figure 3-32
2003 Signing Replacement by District
(Percent of Total Signs to Meet 12-year Replacement Cycle)



Source: Mn/DOT District Operations Performance Data Summary Report, 2004

Based on 357,000 signs on the system and an eight percent life-cycle target, there is a need to replace approximately 28,560 signs per year. On a statewide basis Mn/DOT is only achieving approximately 85 percent of this life-cycle replacement target due to a number of factors including:

- The number and the size of the signing crews have been reduced.
- Increased traffic volumes and higher speeds result in additional time to perform sign replacements.

[51] This is based on estimates from each District. There is no uniform inventory system to identify the exact number of signs or their age. Districts have historically replaced signs based on a systematic corridor approach.

- Increased crashes result in additional knockdowns and damaged signs that take more time to repair/replace.

- Since inception of Gopher-1 Call notifications, significantly more coordination work is required. Up to three trips are needed per sign installation if new base posts are needed.

In addition to life-cycle replacement of signs, signs need maintenance and/or replacement due to vehicle and storm damage and vandalism, and others require replacement due to periodic changes in sign standards. Finally, as the highway system expands through improvements, such as turn lanes and new intersections, new signs are needed. New signs are added to Mn/DOT's system at a rate of about 1 percent or 3,500 signs per year. All of these types of repairs and/or installations are given priority over life-cycle replacements.

C. Policy Directions – Financial Implications

The cost to maintain the signs on the highway system will continue to increase and the gap between what is required to meet the target and can be accomplished within the budget and staffing constraints will increase as well. There is already an estimated backlog of 10 percent in the 12-year life-cycle replacement plan or 35,700 signs. Further, the average cost per sign is increasing due to increase in material and labor cost. Mn/DOT sizes sign legends (which affect sign sizes) according to class of highway (two-lane, four-lane, etc.) and posted speeds. In most cases, signs are not increased in size unless they are "undersized for legend" due to past legend sizes that have been modified over the years. Increase in letter and symbol size is not a general practice unless FHWA issues a new or updated sign size based on increased lettering or symbol sizes.

The financial impact to meet the current performance standard is broken into three areas[52]. These are described below:

- **Sign Maintenance Backlog**: There is a current sign maintenance backlog of approximately 10 percent of the total statewide signs. To catch-up to so that Districts are on 12-year replacement cycle, $1.4 million is needed annually (materials and installation).

- **Interstate System Replacement**: There are several locations in the state (e.g., Districts 1, 3 and 6) where overhead freeway signs are approaching 20 years old. The estimated replacement cost is $4 million or $1 million annually.

- **System Growth**: The sign system is growing by one percent annually. The cost of these signs (materials and installation) is $1.4 million annually.

To eliminate the backlog over the next four years on the targeted replacement cycle, replace old interstate signs and keep pace with the increases in system growth an additional $3.8 million per year is needed.

[52] Financial estimates of signing needs are based on information developed by HSOP Safety Committee, 2004.

D. Implementation Strategies

The current number of signs (non-interstate) that are out of the life-cycle was difficult to assess due to the lack of a physical sign inventory. Based on the analysis the following strategies are recommended:

- Mn/DOT should use percentage of signs replaced to meet 12-year life-cycle as the performance measure.

- If funding is restricted, Mn/DOT should consider prioritizing signs for replacement with regulatory and warning signs being the top priority, and guide signs being the last priority.

- Mn/DOT should continue to pursue the development of an automated sign inventory and management system to track the repair and maintenance of signing activities. The system must be easy to use and minimize the amount of field paperwork. This will become more important as the life-cycle of signs increase (anticipate 15 to 20 years with new sheeting). Several individual Districts are using programs today. Given that up to 5 percent of the signs are replaced due to vehicle damage, vandalism, and/or weather damage, the longer the life-cycle the more important it is to have a sign management system to identify which signs are nearing the life-cycle limit. For example, if one replaces 5 percent of the signs each year, over 15 years theoretically if no sign were replaced twice 75 percent of the signs would be replaced. Without a sign management system, it becomes more difficult to manage the system efficiently and ensure that signs are being replaced before the end of their useful life.

- Mn/DOT should continue to evaluate sign life-cycle to assess replacement timeframes. Increasing replacement timeframes from 12 to 15 years would add 25 percent more life. This could potentially be a significant cost saving as long as inspection programs would ensure reflectivity and legibility.

- Larger interstate signs should be put into preservation funding program.

3.5.3 GUARDRAIL

A. Introduction and Background

Designing and maintaining a “forgivable roadside” is an important component in providing a safe highway. However, it is not always possible, feasible or affordable to design this type of facility where right-of-way is restricted. In these situations, the consequences of hitting a fixed object or running off the road can be reduced by the installation of guardrail. Past studies have concluded that properly located highway guardrails have a 94 percent success rate of preventing more serious accidents.

Guardrail Damage

When guardrail installation and repair are needed, there are two major concerns: public safety and repair crew safety. This is extremely critical on high volume and high-speed roadways that make up the vast majority of the Trunk Highway system. The time and cost to make repairs and replace deteriorated guardrail has and continues to increase due to material cost increases, increases in traffic control required, the limited work area and the difficulty of making repairs during the snow and ice control season (Table 3-15). On many occasions, especially during the winter, only temporary repairs can be made and permanent repairs are then made when conditions are more conducive to motorist and repair crew safety.

Table 3-15
Guardrail Material Cost History[1] – 1999 to 2004

Type of End Treatment	1999	2004
Repair 25-foot Plate Beam Guardrail	$1,433	$2,167
Repair ELT End Treatment	$1,500	$2,400
Repair ET 2000 End Treatment	$1,100	$1,700
Replace Nose – Crash Attenuator	$ 801	$1,600

[1] Includes traffic control

Overall cost for guardrail have been increasing substantially due to increasing costs as identified above, more guardrail being used to avoid right-of-way costs and/or make design more compatible with community and natural features (Metro District has 31 more crash attenuators than it did five years ago, a 20 percent increase), and more traffic hits are occurring due to increasing volumes and end treatments being closer to roadway (District 7 reported 20 percent increase in number of hits). For example, costs for guardrail repair in Mn/DOT's Brainerd District have risen 37 percent over the last two years ($110,600 to $176,700).

Finally, substantial increases are being added to the system in order to prevent or reduce cross-over accidents on high-speed divided highways. Significant median three cable guardrail is being added to facilities like I-94 from Maple Grove to Albertville. This will add to the number of repairs needed each year.

B. Performance Measure

This is considered a developmental measure. Guardrail is considered an essential safety element of the highway system. As such, damaged or non-functioning areas are typically flagged or temporary barriers provided until crews can schedule and make repairs. Repairs have to be coordinated with Gopher One-call and may also require scheduling of night work if they are located in high-volume areas.

Currently there are no established performance measures for guardrail repairs and replacement. Typically, repairs are made soon after notification of a problem. No reliable inventory system exists that quantifies the length of guardrail, crash attenuators and/or the condition of the specific guardrail elements. For the purposes of this report, estimates were made surveying maintenance engineers about guardrail maintenance issues. More work should be done to determine the appropriate performance measure for this area. For example, a potential measure may be the percentage of guardrail repair work that is completed within one week of the initial work order. Overall system condition type measures are difficult due to lack of information.

C. Policy Directions – Financial Implications

Guardrail and crash attenuators play a part in minimizing crash impacts. Based on the survey of maintenance engineers the estimated backlog in replacing deteriorated guardrail is approximately $663,000 with an annual deficiency due to cost increases of approximately $382,000. This backlog is primarily in the Twin Cities area where limited life-cycle replacement of guardrail is done (replacement is primarily due to vehicle hits).

The purpose of having guardrail is to protect the motorist from a hazardous object or condition. This protection needs to first minimize the severity of injuries to vehicle occupants, minimize the danger to other adjacent vehicles and then minimize the damage to the vehicle itself. Guardrail, like any other structural element, has a limited functional life. Beyond this period, it may not perform as intended.

D. Implementation Strategies

There presently is little information available to develop this measure. Guardrail is typically replaced with other preservation and/or improvement projects such as an overlay or pavement project, or it is part of an isolated repair project that is necessitated due to damage caused by vehicle crashes. In addition, there may be periodic upgrades to guardrail systems as a result of changes in standards (e.g., improved guardrail end-treatments). The overall strategy for guardrail maintenance is to develop a better inventory of potentially deficient guardrail areas and incorporate these areas into ongoing life-cycle replacement programs and/or other adjacent projects. In addition Mn/DOT should:

- Investigate reports of inventory issues due to number of different guardrail types being used.
- Identify potential solutions to better equip crews for obtaining parts.
- Provide additional training for different types of treatments to improve repair efficiency.
- Track material costs and number of reported guardrail hits on yearly basis. This is important to identify trends of increasing needs and/or unit cost factors that have direct budget implications.

Chapter IV
Summary of Performance and Funding Gaps

Previous chapters of this plan have discussed trends and influencing factors, developed a context for maintenance activities with respect to Statewide Transportation Plan policies, and have identified individual maintenance-operations performance measures. In addition, the plan has identified potential strategies for improving both the effectiveness and the efficiency of ongoing maintenance-operations activities and the potential funding gaps and strategies to close those gaps. These strategies were developed, for the most part as isolated work activities. That is to say, overall budgetary constraints were not applied, and, while conflicting goals and/or objectives may be identified in these measures, there was not a significant effort made to resolve the conflicts or mold the strategies into a unified plan. For example, the bridge preventive maintenance measure identifies a need for joint sealing, crack-sealing, flushing, and deck seals. These activities require a lane closure, which conflict with the need to maintain traffic flows and/or minimize disruption to users. These types of conflicts occur in many of the activity areas and will be resolved as part of the ongoing budget and work planning efforts.

This chapter summarizes these different work activities and provides a framework for ongoing biennial budget discussions and business planning efforts. In addition, it also provides input for discussion of long-term strategic direction of maintenance-operation activities.

Maintenance-Operations Investment-Decision Framework

Ongoing maintenance-operation costs are a reflection of five fundamental elements: 1) the size of the system or number of physical features/units that are maintained (e.g., number of miles of highway, number of buildings); 2) the number of different services provided (e.g., bridges, striping, signing, roadside maintenance); 3) the level of service or maintenance provided to users (e.g., number of bridge preventive treatments, hours of plowing, frequency of striping); 4) inflationary cost increases (e.g., fuel, labor, steel); and 5) efficiencies achieved through technology and/or improved methods or materials.

In addition to these five areas, the level of capital investment for rehabilitation and replacements also has a substantial impact on the condition of facilities and therefore the need for maintenance. If the systems or units are allowed to age without timely life-cycle replacement, they will require more maintenance over time. Furthermore, statutory requirements and/or executive orders also can increase costs by requiring special equipment, fuels and/or materials. The challenge is to find the optimum level of replacements (life-cycle improvements) and maintenance that will meet user expectations and minimize life-cycle costs.

A comparison done by the Minnesota's Legislative Auditor in 1997 found that the size of Minnesota's trunk highway system is typical when compared to other Midwestern states.[53] In addition, majority of the Minnesota's trunk highway system is legislatively designated. This makes the process more complicated for making system changes. Given these restrictions and the growth in demand for facilities, it is more likely that the number of lane miles and other infrastructure elements will increase not decrease.

Mn/DOT does have more control over the number of services it provides, and how it provides them. Generally, maintenance services are targeted at preventive maintenance (activities that reduce life-cycle costs), safety, and user mobility (Table 4-1). Because most of these services are core maintenance activities, they are inter-related (i.e., snow plowing activities improve safety and mobility). As a result, reducing service levels and/or services is generally difficult without affecting the user.

As costs of fuel, materials and labor have increased, Mn/DOT has looked at ways to prioritize activities, adjust service levels and increase efficiencies. It has reduced some bridge, pavement and roadside maintenance activities and absorbed annual inflationary costs. In addition, it has made a significant effort to increase efficiencies by promoting better equipment utilization, developing improved maintenance practices (e.g., snow and ice – anti-icing, pre-wetting, and underbody blades), increasing productivity (e.g., striping crews), and managing labor costs through strategic staffing. As Mn/DOT looks at all of its functions, it focuses its efforts and limited resources on preserving the functionality of the system. Investments and maintenance priorities generally follow the order below[54].

I. Legally Mandated Services[55]

II. Snow and Ice Removal

III. Infrastructure Life-Cycle Optimization (Preservation)

IV. Safety

V. Mobility

This begins with legally required or mandated services, then snow and ice removal which is the largest and most visible component of the maintenance budget (accounts for nearly one-third of all maintenance and operations expenditures). This activity, based on user surveys, is extremely important to users. Mn/DOT's approach has been to do whatever it takes to meet the overall performance targets for snow and ice (based on customer expectations). Budgets/expenditures are then adjusted for the remaining areas of preservation, safety, and mobility activities.

---

[53] Jim Nobles, Highway Spending: Report 97-06, (Office of Legislative Auditor, State of Minnesota, 1997).

[54] Activity areas are generally prioritized in the order shown; however, reduction in services and/or services levels should not increase liability risks. In addition, many of the areas are inter-related see Table 4-1.

[55] Services that Mn/DOT is legally obligated to provide (i.e., required by statute, executive order, federal rules, environmental permits, building codes). Also covers services that would reduce or avoid liability.

Table 4-1
Relationship between Maintenance Activities and Relevant Statewide Transportation Plan Policy Areas

		✓ Primary Purpose ✓ Secondary Purpose		
Category	**Maintenance Activity**	**Life-Cycle/ Preservation[1]**	**Safety[2]**	**Mobility[3]**
Infrastructure Maintenance and Preservation	Preventive Bridge Maintenance	✓		
	Preventive Pavement Maintenance	✓	✓	
	Pavement Patching	✓	✓	✓
	Traffic Signal and Lighting Maintenance	✓	✓	
Supporting Infrastructure Management	Building Maintenance	✓		
	Building Functional Adequacy	✓		
	Fleet Management	✓		
	Electronic Communications Coverage	✓	✓	
	Electronic Communications Maintenance	✓	✓	
User Mobility and Travel Time Reliability	Freeway Incident Management (Travel Time Reliability)		✓	✓
	Incident Response and Removal		✓	✓
	Planned Lane Closures		✓	✓
	Unplanned Lane Closures		✓	✓
	Signal Performance on Arterials		✓	✓
Snow and Ice	Snow and Ice Management		✓	✓
Safety	Striping		✓	✓
	Signing	✓	✓	
	Guardrail	✓	✓	

✓ Primary Purpose ✓ Secondary Purpose

[1] Life-Cycle/Preservation refers to Policy 1: Preserve Essential Elements of Existing Transportation Systems.

[2] Safety refers to Policy 7: Increase the Safety and Security of Transportation Systems and Their Users.

[3] User Mobility refers to Policy 3: Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers.

Summary of Maintenance Performance Measures

The 1997 Legislative Auditor report recommended that Mn/DOT periodically prepare a report on its funding needs for the trunk highway system and define these needs in terms of specific performance measures. In addition, it recommended that these performance measures be tied to benefit-cost criteria and/or other applicable benchmarks. Developing measures for key activities and tying them to applicable standards and/or benefit-cost criteria was one of the primary purposes of the HSOP. While there is still more work to be done to improve the measures, this plan has made significant progress in better defining measures and data needs. In addition, it has provided guidance for ongoing work to further improve the effectiveness and efficiency of maintenance activities.

As the maintenance-operations plan was developed, each committee was asked to assess its respective area and determine: 1) potential impacts to services under a "Base-Level" funding conditions (no funding increase); and 2) the potential increase in funding required to meet performance targets identified in Chapter Three. These maintenance activities have been summarized and shown in Table 4-2. This table shows the performance measures, current performance levels, performance targets, explanation of performance gap, and identified funding gap needed to achieve performance targets.

The summary table shows funding gaps in both capital and operating areas for 2006 to 2009. Some of the maintenance areas are funded with capital funds (e.g., preventive pavement maintenance) and others are out of the maintenance-operation budget (e.g., snow and ice). Based on the work by the individual teams, an additional $120.46 million in capital funds and $106.71 million in operating funds are needed over the life of the plan to achieve the desired performance targets that were identified in Chapter Three.

The plan did not attempt to prioritize programs and service-level reductions to address funding shortages. However, information in this plan can be used during the investment-decision processes to evaluate overall investment priorities. In some instances there is currently a lack of data to fully quantify anticipated changes to current service levels; however, the teams did qualitatively identify potential impacts of funding shortfalls in individual areas. One example of this is pavement patching. Funding reductions or absorption of cost increases into the current patching budget would not mean that potholes would go unfilled, but the repair chosen may be a less cost-effective one that may not last as long and result in a more rapid deterioration of the pavement.

Table 4-2
Summary of HSOP Performance Measures

State Plan Policy	Category/Maintenance Activity		Performance Measure	Current Performance Level	Performance Target	Reasons for Performance Gap	Performance Implications of Closing Gap	Identified Budget Gap for First Biennium (2006-2007)		Identified Budget Gap for Second Biennium (2008-2009)	
								Capital	Operating	Capital	Operating
Policy 1 Preserve Essential Elements of Existing Transportation Systems	**3.1 Infrastructure Maintenance and Preservation**										
	3.1.1	Bridge Preventive Maintenance	Percentage of identified bridge preventive maintenance activities completed - Joint Repair (Strip and Poured Seals) - Deck Crack Sealing - Concrete Sealing (Deck and Railing Seals) - Flushing	94 percent - Strip Seals 72 percent - Poured Seals 86 percent - Deck Crack Sealing - Deck and Railing Seals[1] - Flushing[1]	96 percent - Strip Seals 77 percent - Poured Seals 80 percent - Deck Crack Sealing 74 percent - Deck and Railing Seals 87 percent - Flushing	- Bridge preventive maintenance has been low priority activity (minimal investments have been made in this activity)	- Expect a 4:1 return on investment		$6.6 million[2]		$6.6 million[2]
	3.1.2.1	Pavement Preventive Maintenance	-[3]	Not Applicable	Not Applicable	- Pavement preventive maintenance based on achieving minimum of 70% good pavement and 2% of poor pavement condition; performance varies depending on dollar investments in pavement preservation.	- Lower life-cycle cost - Increased Remaining Service Life - 8 to 1 return	$36.3 million[4]		$0 million[5]	
	3.1.2.2	Pavement Patching	Percentage of yearly dollars budgeted for patching that are spent.	$11 million spent in 2003; maintenance staff estimate that another 50 percent was needed.	To Be Developed	- Not enough investment in Capital Pavement Preservation - Funds diverted to Snow and Ice control	- Smoother Roads - Customer satisfaction		$11.0 million[6]		$11.0 million[6]
	3.1.3	Traffic Signal and Lighting Maintenance	Percentage of Priority 1 calls - repairs to begin within 20 minutes; Priority 2 and 3 calls - repairs to be completed within 1 to 3 days for signals and 1 to 3 weeks for lighting; Priority 4 and 5 calls to be repaired within four months.	To be Developed	To Be Developed	- Complexity of systems are increasing - Age of system is increasing - Two Electrician vacancies - Growth in number of lights (system) - Increase in power costs - Gopher One call peaks	- Fewer signal malfunctions - Less delay for drivers - More signal preventive work - Better response times to signal work - Fewer lighting outages - Replace knockdowns (per performance lighting goals)		$1.1 million[7]		$0.8 million[7]
	3.2 Supporting Infrastructure Maintenance and Management										
	3.2.1	Building Maintenance	Percentage of building replacement cost for annual maintenance.	1.5 percent	2.5 percent[8]	- Based on difference in spending as compared to State Facility Management Group standard (2.5% of facility value)	- Facilities meet design life - Lower life-cycle cost		$7.2 million[8]		$7.2 million[8]
		Building Functional Adequacy	Percentage of buildings (administrative and industrial) meeting functional needs.	78 percent	80 percent	- Large equipment and safety standards require upgrades - Gap based on physical and functional evaluation of building	- Reduce life-cycle cost	$25.0 million[9]		$25.0 million[9]	
	3.2.2	Fleet Management	Percentage of units within life-cycle. Percentage of units meeting utilization rate goals.	75 percent (life-cycle) 67 percent (utilization)	90 percent of units within life-cycle 95 percent units meeting utilization goals	- $1.7 Million budget reduction 2003-04 - Inadequate funding over a number of years has resulted in an older fleet; this will take time and more investment dollars to bring fleet back into efficient life-cycle.	- Reduce/optimize replacement/repair costs - Less demand on equipment maintenance and repair resources - Reduced fleet downtime and increased productivity	$5.8 million[10]		$5.8 million[10]	
	3.2.3	Electronic Communications Coverage	Measures statewide geographic coverage of communications systems (composite score)	77 percent	100 percent	- Industry trends toward digital technology - Lack of investment to keep current with technology migration - Need to maintain dual systems until conversion is complete	- Meet interim performance Targets - Increased system coverage	-$2.3 million[11]		$6.8 million	
		Electronic Communications Maintenance	Measures system reliability in terms of maintenance and repair activity	44 percent	94 percent	- Maintenance of multi-agency system	- Meet performance targets - Increased system reliability		$1.5 million		$1.3 million
	3.2.4	Information Technology (IT) Infrastructure Preservation	Percentage of servers and routers within industry recommended service life.	Servers - 54 percent Routers - 18 percent	90 percent of servers within service life 90 percent of routers within service life	- Reduced IT Funding - Lack of Budgeted Replacement Cycle - Server/Network expansions over the years - Previous replacement strategy not efficient	- Create consistent budget expectations - Maintain server performance - Maintain network uptime performance - Performance levels and feature needs met related to convergence		$1.2 million		$1.2 million
Policy 3 Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers	**3.3 User Mobility and Travel Time Reliability** (primarily in the Twin Cities Metropolitan Area)										
	3.3.1.1	Freeway Incident Management (Travel Time Reliability)	Percentage of the Metropolitan Urban Freeway System that is instrumented with cameras and pavement sensors.	82 percent[12]	100 percent	- Increasing congestion on more freeway miles will drive need to manage more freeway miles for greater number of hours - Traffic volumes expected to increase, incidents expected to take longer to clear due to increase in number and reduction of staff for response/clearance	Improved incident clearance, better traveler information to allow more efficient use of road network	$7.3 million[12]	$0.5 million[12]	$2.6 million	$1.2 million
	3.3.1.2	Incident Response and Removal	Percentage of the instrumented MUFS that is covered by a FIRST team.	70 percent	100 percent	FIRST staff levels have not grown to meet expanding need for incident response, State Patrol staff levels have declined as need has grown, RTMC Staff for maintenance, operations, and integration has declined	Improved safety, reduced congestion		$0.7 million[13]		$1.3 million
	3.3.2.1	Planned Lane Closures	Percentage of all planned lane closures done at night as part of normal maintenance operations activities.	To Be Developed	To Be Developed	- As volumes rise, more miles are subject to night-time work, which is more costly but has less impacts on users. - Planned maintenance lane closures in the Twin Cities Metropolitan Area are done primarily at night by night maintenance crews and are causing the addition more night maintenance crews.	Provides flexibility to perform needed infrastructure repairs on Metro area roadways where the LCM prohibits daytime lane closures. Also maintains safety of roadway appurtenances for motoring public.		$0.6 million[14]		$0.9 million[14]

Table 4-2 Continued
Summary of HSOP Performance Measures

State Plan Policy	Category/Maintenance Activity		Performance Measure	Current Performance Level	Performance Target	Reasons for Performance Gap	Performance Implications of Closing Gap	Identified Budget Gap for First Biennium (2006-2007)		Identified Budget Gap for Second Biennium (2008-2009)	
								Capital	Operating	Capital	Operating
Policy 3 Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers	**3.3 User Mobility and Travel Time Reliability - Continued** (primarily in the Twin Cities Metropolitan Area)										
	3.3.2.2	Unplanned Lane Closures	Identify, respond and clear unplanned lane blockages within two hours.	To Be Developed	To Be Developed	Many incidents (blow ups, barrier hits, flooding, truck overturns, etc) occur during a year on Metro area roadways. These require short term, emergency lane closures to maintain safety for the motorists. Have not authorized overtime for the purposes of responding to incidents, however, some weather/pavement conditions allow for reasonable anticipation of incidents occurring and data collected over the past several years shows us the likely locations.	Ability to respond to and repair emergency lane restrictions is enhanced and lane closure time is minimized (anticipated 1 hour time savings/incident).		$0.2 million[15]		$0.1 million[15]
	3.3.3	Signal Performance on Arterials	Average length of time between signal retiming evaluations	16 years	Four years	- Lack of capacity on freeways means arterials need to carry more traffic - Need better timing plans and system optimization - Better timing plans can reduce delays 10-15%	- Minimize congestion and delay - Reduced Maintenance costs - High benefit-cost ratio of 30:1		$0.5 million[16]		$0.5 million[16]
	3.4 Snow and Ice Management										
	3.4	Time to Bare Pavement by Route Type	Number of hours to achieve bare lanes after a weather event ends.	2.2 hrs Super Commuter 5.0 hrs Urban Commuter 7.0 hrs Rural Commuter 9.2 hrs Primary Collector 18.1 hrs Secondary Collector	1 to 3 hrs Super Commuter 2 to 5.0 hrs Urban Commuter 4 to 9 hrs Rural Commuter 6 to 12 hrs Primary Collector 9 to 36 hrs Secondary Collector	- New lane-miles - Increased number of lane miles in higher roadway categories - Labor intensive activity - increased labor costs - Inflationary pressures fuel, salt, steel (cutting edges) - Customer expectations have increased and it's a high priority for public	- Minimize budget impacts to other maintenance activity areas		$12.2 million[17]		$23.1 million[17]
Policy 7 Increase the Safety and Security of Transportation Systems and their Users	**3.5 Safety**										
	3.5.1	Striping	Percentage of pavement stripes that meet the minimum retro-reflectivity requirements.	95 percent	100 percent	- Thinner lines, less beads (03) - Move to more durable products	- Reflectivity targets will be met - Improved retro reflectivity and safety	$3.0 million[18] (6 inch stripe)	$2.4 million[19]	$3.0 million[18] (6 inch stripe)	$0 million[19]
	3.5.2	Signing	Percentage of signs replaced to meet the 12-year sign life-cycle.	85 percent	100 percent	- Meeting retro reflectivity standards - Growth in system size - District sign crews are being reduced. Insufficient capital dollars for interstate. - Backlog due to inadequate funding	No automated sign management system. Longer lasting VIP sheeting. Extend the cycle to 13-14 years and do a nighttime survey.	$3.4 million[20]	$4.2 million[20]	$0 million[20]	
	3.5.3	Guardrail	To Be Developed	To Be Developed	To Be Developed	- Growth in the number of installations, an increase in traffic volumes and a decreasing budget. - Lack of resources, the cost of materials, labor are increasing - No formal program to address/replace elements - just repair - Insufficient capital funds to replace existing deteriorated items	- Majority of backlog in Metro Area. - Guardrail is typically repaired and safety is maintained. - Guardrail is in place, functioning and provides necessary protection to drivers from roadside appurtenances.	$0.7 million Backlog	$0.8 million	$0.7 million Backlog	$0.8 million
							Total (in millions) =	**$77.88[18]**	**$50.68**	**$42.59[18]**	**$56.02**

Notes for HSOP

1 Due to limited data, current needs for these measures have not been established.

2 Based on seven preventive maintenance treatments with different life-cycles. Cost is $4.1 million per year with additional $134,000 per year catch-up.

3 This performance measure is a spending or input measure. The outcome to be achieved is a smooth pavement measured in District and Statewide Plans.

4 Pavement preventive investment levels are based on Mn/DOT's previous $40 million per year spending target. Current preventive levels of investment for 2006-07 are $43.7 million. Therefore, the funding gap is $80-$43.7 million = $36.3 million

5 Spending levels for 2008-09 biennium are identified and fully funded in District Long-range Transportation Plans.

6 Budget gap based on maintenance staff judgment that budget should be 50 percent more in order to address patching needs ($5.5 million per year).

7 Cost are based on needs for the major components of signal and lighting systems, and traffic management systems (signal poles and equipment - $100,000, signal cabinets - $390,000, lighting poles - $200,000, and Greater Minnesota ITS maintenance - $320,000). In the first biennium, the District Plan does not account for lighting pole needs.

8 The Statewide Facilities Management Group initially made a recommendation for 2.5 percent of replacement value or $11.3 million annually. The Legislature initially funded this at 2 percent of replacement value as part of 1996 legislation. This was later reduced to 1 percent in 2003. The national standard is 2.7 percent based on Building Owners and Managers Association (BOMA). This analysis includes buildings at rest areas.

9 Budget estimate is based on what is feasible to replace given current staff, not based on need (functional problems). These capital needs are not considered part of the District Long-range Plans. Budget split: $10 million capital operating and $15 million capital construction per biennium.

10 Budget gap based upon maintaining life-cycle targets for most predominant vehicle types.

11 Analog to digital conversion costs for the 2006-07 biennium were estimated at $7.7 million. $5 million per year was funded through state road construction funds from FY 2006 to 2008 for the microwave conversion project. Therefore, there is an excess of $2.3 million ($7.7 - $10 million) in the first biennium.

12 Assumes 25 miles constructed in 2005; based on instrumenting the remaining miles of the urban freeway system. Additional staff required to maintain and repair system ($225,000 per year).

13 Two additional FIRST routes 2006 and one additional route in 2007. The cost is $150,000 per additional route.

14 Includes conversion of day to night crews -$133,200 for labor costs and $336,500 in one time equipment costs (per crew basis).

15 Overtime for approximately 20 incidents per year ($50,000) and one time equipment start-up (better distribution of equipment throughout region)

16 Signal retiming includes one additional staff person and $160,000 for signal retiming studies for a total of $250,000 annually. This would result in a 4-year signal retiming frequency.

17 A portion of the snow and ice gap is based on equipment cost. The depreciation cost is also included in the fleet measure. These need to be reconciled.

18 Costs for conversion of 4 inch edgeline stripe to 6 inch edgeline stripe is not included in overall HSOP cost totals.

19 Striping needs for 2008-09 are identified and funded in District Long-range Plans ($4.85 million excluding metro).

20 $3.4 million capital (interstate signs plus sign materials for system growth and backlog); $4.2 operating for installation of backlog and system growth. In 2008-09 needs are included in District Plans.

Grand Totals for 2006-09 (in millions)	
Capital =	**$120.46**
Operating =	**$106.71**

Chapter V
Future Direction, Findings and Recommendations

The findings and recommendations focus on the 2006 to 2009 timeframe; however, a number of the strategies identified provide direction beyond this timeframe. The recommendations and findings are listed below in no particular order of importance.

1. **Manage maintenance work and incidents to minimize impacts to road users.** *As roadways in the metropolitan areas become more congested, the ability to work in traffic during daylight hours will be limited. As a result, Mn/DOT will modify its current work practices and methods to safely conduct work and minimize delays to users. In addition, it will need to improve responses and removal of incidents to minimize delay and improve safety (reduce secondary crashes). These will be accomplished through the following:*

   - ✓ Shift more maintenance work to night crews (Twin Cities Metropolitan Area) to minimize impacts of lane closures during heavy travel times.
   - ✓ Increase instrumented system to full Metropolitan Urban Freeway System (MUFS); this will provide better response and monitoring of heavily used urban freeway system.
   - ✓ Increase FIRST coverage of MUFS to reduce user delays and improve safety.
   - ✓ Continue to explore ways to better coordinate work activities of different maintenance work groups as well as coordination between maintenance and construction to minimize lane closures
   - ✓ Continue to conduct non-essential snow and ice removal operations at night or in non-peak periods to reduce delays to users.

2. **Manage infrastructure assets for lowest life-cycle cost.** *It is critical to maintaining important facilities at the lowest cost. To accomplish this, infrastructure elements need to be monitored so that the right treatment is applied at the right time. In addition, agencies and policy-makers need to be able to pro-actively plan for changes in investment needs based on historic life-cycle patterns (e.g., freeway building era, large number of bridges reaching end of life).*

   - ✓ Continue to facilitate discussion between maintenance and construction to better manage investment allocations to minimize long-term life-cycle costs; better document the need to for investment level modifications to address historic infrastructure aging patterns (e.g., large number of bridges reaching design life).

- ✓ As funding becomes more complex (mixing of capital and maintenance funds), tracking of costs becomes more difficult. Continue to improve accounting methods and practices so that investments can be tracked by asset (e.g., pavement, bridges, signals, buildings) as well as activity (e.g., preventive maintenance, striping, signing).

- ✓ Increase preventive maintenance funding across all assets. Continue to develop and monitor performance measures.

3. **Continue to strive for improved efficiency and effectiveness in all maintenance areas.** *Mn/DOT's tools and available resources, as well as the conditions of assets, are constantly changing. As such, managers must periodically adjust maintenance practices and management strategies. To make good decisions, activities must be measured and evaluated with respect to the level of resources that are invested and the benefits received and/or levels of service that are provided for this investment. This process must continue to look at internal and external benchmarks, national standards, and internal best-management practices to improve efficiencies and effectiveness throughout the organization.*

   - ✓ Continue to initiate best management practice (BMP) meetings and peer-group reviews to evaluate efficiency of current practices and maintenance activities (e.g., snow and ice planning sessions and district comparisons, equipment utilization). In addition, Mn/DOT should find ways to implement the best management practices among various groups.

   - ✓ Seek and support technology enhancements that can improve effectiveness and efficiencies of maintenance activities, as well as better track inventories and condition of assets (e.g., sign management, AVL technology, weather systems, electronic time sheets and material usage).

   - ✓ Document efficiencies and develop a process for capturing and reallocating efficiencies gained to highest needs. Recognize achievements where efficiencies have been gained.

4. **Continually improve reliability and credibility of performance measures**. *The credibility of the measures is important in managing the asset and communicating the needs to the public and policy-makers. It is imperative that good, reliable measures are developed and that data is tracked over time to establish historic patterns. This data can be used to evaluate current practices as well as predict impacts of changing investment levels or resources.*

   - ✓ Continually improve data collection and methodology for performance measures (e.g., pavement patching, guardrail, signing, and preventive bridge maintenance). As part of this process, consider independent review and verification of data.

   - ✓ Track historic data trends and report measures over time. Build trend-line data sets.

- ✓ Forecast future performance and budget needs based on historic data.

- ✓ Work to better define "winter severity" index and relationship of index to overall snow and ice removal cost. Track information over time to better compare snow and ice cost changes.

- ✓ Compare standards and/or performance targets with applicable national standards from other available operations and maintenance plans.

- ✓ Establish periodic audits of HSOP performance measures encompassing both performance and financial data.

5. **Continually improve knowledge of transportation factors (indicators) that affect maintenance activities, costs and performance levels**. *Maintenance of the 12,000-mile trunk highway system is a very complex business. There are numerous factors that affect the ability to control costs and performance. Tracking these factors over time will provide better knowledge of external impacts on performance levels and costs.*

   - ✓ Identify and document budgetary shifts and their effects to activity levels and performance. Snow storms, tornados, crashes that damage lights or signals, pavement blow-ups, wind storms, or the amount of flooding that may cause unusual shifts in investments in a particular year. As these events occur, priorities may have to shift to respond to these events. In addition, as time goes on, public perceptions and priorities can change. Mn/DOT needs to have some flexibility to respond to these activities, but should track their impact on other budget areas.

   - ✓ Monitor inflationary impacts (cost of materials and equipment) on maintenance activities, budgets and performance levels.

   - ✓ Track changes in size of the system and number of maintenance activities (e.g., number of lane miles, signals, signs, lights, bridges, guardrails, interchanges; events or work orders).

   - ✓ Track influences of increasing traffic volumes on maintenance activities, budgets and performance levels.

   - ✓ Document and monitor impacts of regulatory requirements and/or mandates that change maintenance practices, and costs.

   - ✓ Track labor component of activities – consider impact of retiming workforce and training needs.

6. **Continue to develop strategies for improving individual maintenance activity areas.** *As part of the development of the plan, strategies were identified for individual performance measures.* The key strategies are summarized below and are described in more detail in Table 5-1:

- ✓ ***Bridge Preventive Maintenance*** – Focus bridge preventive maintenance investments on activities that provide highest benefit-cost with respect to extending bridge life (i.e., joint repairs, flushing, crack sealing, and concrete seals). Develop better consistency for preventive bridge programs statewide and continue to institute sharing of best practices and performance between Districts.

- ✓ ***Pavement Maintenance*** – Beginning in 2008, pavement strategies and investment levels will be data driven and guided by the pavement management system.

- ✓ ***Traffic Signal and Lighting Maintenance*** – Begin to track preventive maintenance work orders; correct chronic maintenance intersections (remove signal heads to back of poles); try and improve restitution recovery percentage.

- ✓ ***Buildings (Facility) Maintenance*** – Continue current inspection and prioritization process; current building maintenance practices and strategies to ensure that the most cost-effective practices are being employed; increase preventive maintenance to 2.5 percent.

- ✓ ***Building Functional Adequacy*** – Look for ways to improve partnering with local officials and other state agencies (consider building revolving loan fund).

- ✓ ***Fleet Management*** – Continue to institute management strategies and best management practices to increase equipment utilization and equipment within life-cycle.

- ✓ ***Electronic Communications*** – Continue working with other state and local agencies to develop a statewide shared digital system at lowest life-cycle costs. Continue to provide clear message of benefits and rationale for conversion from analog to digital systems. Continue to monitor and track performance measures and provide frequent updates to agencies.

- ✓ ***Information Technology Infrastructure Preservation*** – Continue to develop performance measure and data, track user impacts of server and/or router problems. Consider adding switches to measure for next HSOP plan.

- ✓ ***Freeway Incident Management (Travel Time Reliability)*** – Evaluate expansion of instrumented MUFS system; track benefits of instrumentation; provide more information using electronic message boards to motorists; and identify potential funding sources to expand the system.

Table 5-1
HSOP Performance Measures Implementation Strategies

State Plan Policy	Category/Maintenance Activity		Short-Term Strategies (1 -year)	Mid-Term and Long-Term Strategies	Data Collection Issues	Implementation Issues	Performance Measure Implementation Responsibilities	Department Level Measure Reporting Mechanism[1]	Responsibility for Implementation of Strategies and Actions
Policy 1 Preserve Essential Elements of Existing Transportation Systems	**3.1 Infrastructure Maintenance and Preservation**								
	3.1.1	Bridge Preventive Maintenance	Develop methods for tracking preventive work and reporting performance; Develop implementation strategies (address traffic control/lane blockage issues) based on funding received. Investigate ways to develop bridge management program (counter part to pavement manage) that could help define fixes and manage overall structure investments.	Track costs for each activity; compare to original estimates and re-evaluate b-c benefits. Set-up research comparisons with similar structures (leave some structures with no preventive maintenance); track conditions and maintenance/rehab costs over time on these two groups. Continue to develop preventive maintenance cost-benefit information and adjust practice accordingly.	How to track and report. PONTIS?	Feasibility of work in metro due to high volumes. Difficulty in keeping money in preventive programs where impact or benefits are long-term (more pressing issues siphon off funding)	**Data Collection/Reporting–**Office of Bridges and Structures **Measure Review/Concurrence**–MBMT **Implementation Group**–Bridge, MBMT, OIM, and Finance	1. Annual Highway System Performance Report to Commissioner Staff 2. Annual Maintenance Performance Report to Commissioner Staff 3. Annual District Operations Bridge Report	District Operations Division
	3.1.2.1	Pavement Preventive Maintenance	Use pavement management system to determine timing and appropriate treatments. Focus investments towards lowest life-cycle costs. Have to verify theoretical information with field reviews.	Refine strategies and treatments as materials and knowledge of treatments change.		Difficultly in keeping money in preventive programs where impact or benefits are long-term (more pressing issues siphon off funding)	**Data Collection/Reporting–**Office of Materials **Measure Review/Concurrence–** Office of Materials **Implementation Group–**Materials, MBMT, OIM, and Finance	1. Annual Highway System Performance Report to Commissioner Staff 2. Annual Maintenance Performance Report to Commissioner Staff 3. Annual District Operations Pavement Report	
	3.1.2.2	Pavement Patching	Develop better way to measure patching need; potential to tie to amount and severity of pavement distresses.		Little data; need to develop better methodology to assess need.	Defining need? Tracking work? Track changes to budget or - Tracking work is the easiest of the three.	**Data Collection/Reporting–**Office of Materials **Measure Review/Concurrence–**MBMT **Implementation Group–**Materials, MBMT, OIM, and Finance	Report to District Operations-Frequency TBD	
	3.1.3	Traffic Signal and Lighting Maintenance	Continue to evaluate relamping work (group contracts, better lamps to reduce frequency); Develop standards of practice with design group for location of light poles in areas less likely to be hit; define chronic maintenance issues and develop schedule for resolution; Define preventive maintenance program for signal systems (set-up control group to assess preventive benefits over time); Define criteria for signal life-cycle replacement program different levels of replacement (whole system, heads, wiring, etc.)	Continue to track elements affecting service levels and costs (material costs, labor costs by work type, work orders, backlogs). Develop internal benchmarks to identify performance standards (how long does it take to do different repairs, average response times). Track these over time. Determine potential strategies for increasing restitution ($ captured from vehicle damage). Establish group to investigate efficiencies and best practices for this area. Work to increase use of tower lighting and reduce placement of light poles in areas that are susceptible to knockdowns. Evaluate benefits of preventive treatments vs. no preventive treatments (over time).	Need to report performance, include work orders for preventive work.	Many different layers - MESU, CESU, RESU; organizational issues - who is responsible and owns assets? Review business model?	**Data Collection/Reporting–**Office of Traffic, Security and Operations (OTSO) **Measure Review/Concurrence–**OTSO **Implementation Group–**OTSO, Metro Traffic Engineering, OIM, and Finance	1. Report to District Operations-Frequency TBD 2. Report to Metro Traffic and Maintenance Operations and Safety-Frequency TBD	
	3.2 Supporting Infrastructure Maintenance and Management								
	3.2.1	Building Maintenance	Define targets for additional preventive maintenance dollars (where should this be focused). Investigate security issues; define what is needed.	Document where additional dollars were spent and how this helped extend building life (show that dollars were well spent). Divest of properties not used any longer.		Bridge crews do much of work; staffing may be an issue with greater bridge preventive maintenance work.	**Data Collection/Reporting–**Office of Maintenance **Measure Review/Concurrence–**Office of Maintenance **Implementation Group–**Maintenance, MBMT, OIM, and Finance	1. Annual Maintenance Performance Report to Commissioner Staff 2. Annual Report to District Operations	Operations, Safety and Technology Division
		Building Functional Adequacy	Continue to document building conditions and replacement needs. Investigate the issues and legislation required to establish building revolving loan fund. Consider reallocating or changing the way building funds are allocated to encourage good decision-making about space and facility needs. Continue monitoring of environmental regulations to anticipate influences or requirements that affect maintenance and building functional use.			Dollars limited by staff resources.			
	3.2.2	Fleet Management	Work with Equipment Utilization task force to look at measures and targets, define best practices and implementation strategies. Define timing and responsibilities for these strategies. Review methods and accounting practices for charging equipment costs to other activities (how should this be done).	Track progress towards utilization and life-cycle goals, monitor costs and regulatory issues that are affecting costs. Meet at least annually among districts to discuss best practices for equipment utilization.		Better utilization of equipment by sharing. Reconcile vehicle depreciation with snow and ice measure.	**Data Collection/Reporting–**Office of Maintenance **Measure Review/Concurrence–**MBMT **Implementation Group–**Maintenance, MBMT, OIM, and Finance	1. Annual Maintenance Performance Report to Commissioner Staff 2. Quarterly Fleet Report to District Operations	
	3.2.3	Electronic Communications Coverage	Continue to convert system over time. Monitor and track performance measures and provide frequent updates to agencies. Continue to provide clear message of benefits and rationale for conversion. Investigate security issues of facilities - define needs.	Define accounting methods and practices so that implementation costs and budget shifts can be tracked to this asset. Is there a way to simply track different agencies contributions as well as costs for supporting specialized applications. Agencies will ultimately want to know how their cost share was arrived at. Monitor changing technologies, look for ways to get competitive pricing for communications hardware.		Multi-agency system; different needs by different users will be challenge.	**Data Collection/Reporting–**Office of Electronic Communications (OEC) **Measure Review/Concurrence–**O**EC** **Implementation Group–**OEC, OIM, and Finance	1. Report to Mn/DOT Upper Management and Legislature as part of the Biennial Budget process 2. Annual report to customers (DOT, DPS, and DNR) as a component of annual capitol improvement plan	
		Electronic Communications Maintenance	Work on developing partnerships with local agencies to spread costs and benefits to larger group of users. Need to document costs and potential savings. Is there a way to establish a baseline of costs under old system?	Staff recommendations; significant increase in infrastructure suggest need for more staff. Monitor changing technologies, look for ways to get competitive pricing for communications software.		How does one capture savings to users of system? In five years, legislature will probably need reminding why consolidation of systems occurred? Impact to Mn/DOT budget is greater than other agencies.		Report to Mn/DOT Upper Management and Legislature as part of the Biennial Budget process	
	3.2.4	Information Technology (IT) Infrastructure Preservation	Continue to monitor network availability/capacity and implement the proposed replacement cycle on routers and servers. Track server/router downtime and issues similar to existing network availability measures. Limit expansion of applications and best utiiize existing infrastructure.	Continue to consolidate number of servers. Support the Drive to Excellence initiative to move towards networks and servers managed as a State Enterprise resource.			**Data Collection/Reporting–**Office of Information Technology (OIT) **Measure Review/Concurrence–**OIT **Implementation Group–**OIT, OIM, and Finance	Annual IT Performance Report to Commissioner's staff in October	

Table 5-1 Continued
HSOP Performance Measures Implementation Strategies

State Plan Policy	Category/Maintenance Activity		Short-Term Strategies (1 -year)	Mid-Term and Long-Term Strategies	Data Collection Issues	Implementation Issues	Performance Measure Implementation Responsibilities	Department Level Measure Reporting Mechanism[1]	Responsibility for Implementation of Strategies and Actions
Policy 3 Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers	**3.3 User Mobility and Travel Time Reliability** (primarily in the Twin Cities Metropolitan Area)								
	3.3.1.1	Freeway Incident Management (Travel Time Reliability)	Continue to monitor changes in congestion on system to define needs. Better define and quantify benefits of monitored system versus unmonitored system. Develop performance/benchmarks for maintenance staff (staff required)	Complete instrumentation of MUFS	Need better data on ability of this type of system to clear incidents faster; benefits to public.	Unpopular with some legislators.	**Data Collection/Reporting–**Office of Traffic, Security and Operations (OTSO) **Measure Review/Concurrence–**OTSO **Implementation Group–**OTSO, OIM, and Finance	Annual Highway System Performance Report to Commissioner Staff	District Operations Division
	3.3.1.2	Incident Response and Removal	Investigate sponsorship of FIRST units. Continue to track events or responses to incidents, benefits of units, letters of or customer response to units. Continue to work with DPS to identify and pursue strategies to reduce incident response and removal time.	Track and/or monitor factors that affect cost of FIRST units, size of system, hours of operation, labor costs, equipment costs. Complete full monitoring of FIRST routes.	Continue to log all responses. Track events on an hourly basis and on monthly basis to help determine staffing levels. Also look at activity levels with respect to weather events.				Operations, Safety and Technology Division
	3.3.2.1	Planned Lane Closures	Continue to monitor changes in congestion on system to define implementation schedule and needs. Continue to develop implementation strategies for coordinating work between day and night crews.	Monitor and evaluate effectiveness of work crew activities. Document amount of work that has been moved to non-peak travel times (number of hours or percentage of maintenance etc).	Continue to track traffic issues as well as night crew-vs.-day crew costs and efficiencies.	Need to work within labor agreements-semi dependent on hiring ability.	**Data Collection/Reporting–**Metro District Office of Maintenance Operations **Measure Review/Concurrence–**Metro Maintenance Operations **Implementation Group–**Metro Maintenance Operations, OTSO, OIM, and Finance	Report to Metro Management Team (MMT)	District Operations Division
	3.3.2.2	Unplanned Lane Closures	Identify characteristics for pavement blowups (days when crews would be held over). Test methodology (number of correct days - effectiveness of methodology). Refine and use as best practice. Better define response time savings of this practice.	Monitor and evaluate effectiveness of work crew activities. Document benefits of better response times to traveling public.	Time savings and benefit-cost not well documented.	Relatively low-cost activity.			
	3.3.3	Signal Performance on Arterials	Identify locations for signal timing upgrades. Document benefits of retiming (user efficiencies)	As program re-evaluates intersections for a second time, evaluate to see if benefits are at same magnitude (adjust accordingly).		Need to focus on growth areas; volumes or pattern changes.			
	3.4 Snow and Ice Management								
	3.4	Time to Bare Lanes by Route Type	Solidify miles in each plowing classification; Track system changes; Improve and/or confirm winter severity index by capturing Mn/DOT effort (hrs/cost) by storm event. Continue to develop and drive best management practices through organization; resolve discrepancies between WMS and costing systems.	Continue to track elements affecting service levels and costs (material costs, labor costs, equipment costs, system changes, and volume increases). Develop efficiency goals (pursue AVL, anti-icing, and pre-wetting).	Improve consistency of cost data and ability to compare between winters. Reconcile vehicle depreciation issue with fleet measure.	How to quickly drive "best practices" through whole organization is a function of dollars and training and acceptance.	**Data Collection/Reporting–**Office of Maintenance **Measure Review/Concurrence–**MBMT **Implementation Group–**Maintenance, MBMT, OIM, and Finance	1. Annual Maintenance Performance Report to Commissioner Staff 2. Mid-year and end of year reports to District Operations 3. Monthly Electronic reports	District Operations Division
Policy 7 Increase the Safety and Security of Transportation Systems and their Users	**3.5 Safety**								
	3.5.1	Striping	Define impacts of reduced line thickness and less beads on life-cycle. Better monitor and track construction striping. Continue to track and monitor new products, technology, and costs and efficiencies of striping crews.	Continue to investigate advantages (life-cycle) of new products and how they will impact retro-reflectivity.	Better accounting of construction lines in striping assessment.		**Data Collection/Reporting–**Office of Traffic, Security, and Operations **Measure Review/Concurrence–**MBMT **Implementation Group–**OTSO, Maintenance, MBMT, OIM, and Finance	1. Annual Maintenance Performance Report to Commissioner staff 2. Annual Striping report to District Operations	District Operations Division
	3.5.2	Signing	Investigate the potential costs, technologies, and implementation issues of a sign management system for state; continue to evaluate sign life-cycle based on reflectivity measures (determine if there should be a shift to 15 year cycle).	Implement sign inventory system or method for better tracking replacements	Need better inventory - field sign management system. No inventory; longer sign life complicates replacement process.	Concern about sign management system implementation cost; usability for crews, especially in metro.		1. Annual Maintenance Performance Report to Commissioner staff 2. Annual Signing report to District Operations	
	3.5.3	Guardrail	Investigate the potential costs and methods for establishing a guardrail inventory to better define needs and replacement timeframes. Look at opportunities to reduce the number of types of guardrail used (reduce parts inventory and training issues). Expand performance measure to include cable median barrier maintenance and repair.	Document material cost increases, and frequency of repairs (number of incidents). Can this be correlated to traffic volumes or changes in location.	No inventory; no systematic replacement program.	Size of exiting infrastructure is large.	**Data Collection/Reporting–**Office of Maintenance **Measure Review/Concurrence–**MBMT **Implementation Group–**Maintenance, OTSO, MBMT, OIM, and Finance	Annual Guardrail Report to District Operations (proposed)	

Notes

[1] Teams should report on measures, measure development, data, and strategies being pursued to achieve targets.

- ✓ ***Incident Response and Removal*** – Continue to pursue sponsorships to fund FIRST expansion; and track workloads, response times and responses per vehicle or route to provide a cost-effective service. Continue to work with DPS to provide coordinated incident response and removal services.

- ✓ ***Planned Lane Closures*** – To minimize user impacts, shift more maintenance work to night crews (track increasing traffic volumes on MUFS, document limited time periods for work using Lane Closure Manual).

- ✓ ***Unplanned Lane Closures*** – Track historic pavement blow-up areas, response, times to clear blow-ups, weather characteristics, and preparation of equipment, to evaluate ability to reduce user delays. Investigate ways to limit future pavement blow-ups or other emergency repairs that are necessary.

- ✓ ***Signal Performance on Arterial Routes*** – Increase frequency of signal retiming studies to three to four years, versus nine years today; document benefit-cost of timing studies.

- ✓ ***Snow and Ice Maintenance*** – Continue tracking of snow and ice costs; labor, equipment, materials versus regain time; correlate costs and regain time with severity index; increase efficiency efforts through pre-wetting, anti-icing, equipment modifications, and AVL technology. Continue to refine Winter Severity Index methodology.

- ✓ ***Pavement Striping*** – Continue to track striping costs for both epoxy and latex (overall costs per foot as well as component costs for labor, equipment, and materials), crew efficiency measures (cost per foot), initial retro reflectivity, and life-cycle of materials to reduce overall costs and increase efficiency.

- ✓ ***Signing*** – Develop an automated sign inventory system to track repair, maintenance, and replacement of signs to efficiently manage the system as well as ensure that signs are being replaced at the end of their useful life. Continue to correlate sign reflectivity and legibility with sign age as a proxy for sign replacement.

- ✓ ***Guardrail*** – Develop inventory of potentially deficient guardrail areas and incorporate these areas into ongoing life-cycle replacement programs and/or adjacent projects.

7. **HSOP Implementation.** *While roles and responsibilities for individual performance measures have been outlined in the implementation matrix (Table 5-1), overall strategic guidance and management are critical to the success of the plan. The figure below illustrates the relationships of Mn/DOT Divisions, Districts and functional areas to the plan.*

- ✓ ***District Operations Division*** is responsible for HSOP oversight. Duties include assuring that implementation assignments are carried out in a timely fashion, results are communicated to decision makers, and processes are put in place to secure and focus resources to areas that require them.

- ✓ ***Expert Offices*** will supply technical knowledge, data analysis, ongoing performance measure support, and data maintenance.

- ✓ ***Maintenance Business Management Team (MBMT)*** will act as the link between the plan itself and ongoing maintenance and operations activities as well as providing operational experience and feedback on current and proposed measures, including performance targets, data integrity and analysis, and best practices.

- ✓ ***Metro District Maintenance Operations*** will play a similar role to that of the expert office but for those measures specific to the Metro District (planned lane closures, unplanned lane closures, and signal performance on arterials).

- ✓ ***Office of Finance*** will assist in assuring financial consistency in the plan. The HSOP relied on various systems to analyze costs and report financial needs. Financial consistency is essential to the plan's success.

- ✓ ***Office of Investment Management*** will coordinate the HSOP with other planning and programming activities, and offer measurement reporting assistance and guidance.

- ✓ ***Other Functional Groups (PCMG, OMG, TEO, etc.)*** can review HSOP products, supply members to implementation groups, and communicate HSOP priorities and principles to their membership.

8. Issues to be addressed in future plans or requiring additional investigation. *Listed below are a few important maintenance and operations issues confronting Mn/DOT that were not fully addressed in this plan. The impacts of these issues are not entirely known at this time, but are likely to require substantial investigation and evaluation. It is recommended that Mn/DOT continue to work on these areas to assess potential impacts of these issues.*

- ✓ ***Develop performance measures for maintenance and operations activities not included in this initial plan*** – Mn/DOT conducts many maintenance and operations activities. Not all could be included in this plan. Listed below are current activities identified by Mn/DOT to be pursued in future plans.

  - Bridge Inspection
  - Bridge Repair
  - Shoulder and Edge Drain Maintenance
  - Traffic Information
  - Maintenance Project Work Zone Management
  - Construction Staging
  - Traffic Demand Management
  - Permitting
  - Snow Removal from Park & Ride Lots
  - Work Zone Management (mobility)
  - Work Zone Safety
  - Roadside Clear Zones
  - Roadway Sweeping
  - Edge Drain Cleaning and Repair
  - Noise wall Repair and Maintenance
  - Roadsides – Native Species
  - Clean Fuels

- ✓ ***Homeland Security*** (security issues were not thoroughly included in the HSOP analysis) – They were identified as part of building/site and other infrastructure discussions. These need to be further explored and separate investments need to be allocated towards these needs.

- ✓ ***Environmental*** – There are significant environmental regulatory issues that will impact Mn/DOT's operations. These regulations will affect storm water management (NPDES – Phase III), highway maintenance, and a number of building maintenance issues such as water re-use (wash bays). In addition, new diesel engine requirements are expected to add significant costs to diesel trucks in coming years. These elements need to be investigated and evaluated with respect to funding and impacts on operations.

- ✓ ***Roadsides*** – Historically, roadside maintenance has a limited affect on safety, mobility, and preservation of infrastructure assets. Also, from user perspective, roadside maintenance has been a low-priority when compared with safety, mobility, and preservation activities. On the other hand, cleanliness is important to the user as it affects the quality of their trip. The trade-off of providing increased roadside maintenance with respect to costs of this activity should be evaluated further during the budgeting process.

- ✓ ***Rest Areas*** – Rest areas are another component of the transportation system that Mn/DOT is responsible for in terms of infrastructure condition as well as operations. Building maintenance was covered under measure 3.2.1 "Building Maintenance," however, the replacement or adequacy of these facilities was not addressed. Future HSOP plans should analyze the rest area program to assess the performance levels and investment needs to meet customer expectations.

- ✓ ***Partnerships*** – Greater efficiency may be realized through continued and expanded use of shared facilities and fleet (e.g., Hutchinson Area Transportation facility). Mn/DOT should continue to investigate and pursue maintenance and operations partnerships with other public agencies, including DNR and DPS.

- ✓ ***Administrative Plan*** – Mn/DOT will consider developing a performance based plan to address administration and overhead activities not encompassed by either the District Long-Range plans or the Highway Systems Operation Plan.

9. **HSOP Plan Update.** *It is recommended that this plan be updated every two years to coincide with biennial budget discussions. The next update should include updates to data including financial numbers, performance measures and targets. In addition it should consider developing measures for areas identified in eight above.*

Appendix A
Acronyms and Definitions

AFMS: Automated Facilities Management System
AN: Asset Number
AVL: Automated Vehicle Location
ARMER: Allied Radio Matrix for Emergency Response
BARC: Bridge and Road Construction
BOMA: Building Owners Management Association
CESU: Central Electrical Services Unit
CFS: Commodity Flow Survey
CHAMP: Connecticut Highway Assistance Motorist Patrol
CIM: Communications Infrastructure Management
CIMC: Colorado Incident Management Coalition
C.S.: Condition State
DNR: Department of Natural Resources
DPS: Department of Public Safety
EER: Electronic Equipment Repair
EMS: Emergency Management System
EMS-M4: Equipment Management Information System
FCC: Federal Communications Commission
FHWA: Federal Highway Administration
FIRST: Freeway Incident Response Safety Team
FMP: Facilities Maintenance Program
FTE: Full Time Equivalent
FY: Fiscal Year
GAO: General Accounting Office
GHz: Giga Hertz
HATS: Hutchinson Area Transportation facility
HELP: Highway Emergency Local Patrol (New York)
HSOP: Highway Systems Operation Plan
INVC: Inventory Control
IRC: Interregional Corridor
IT: Information Technology
ITE: Institute of Transportation Engineers
ITS: Intelligent Transportation System
M4: Mn/DOT's Fleet Management System (Maximus Version 4)
MAP: Motorist Assistance Program (Houston, Memphis, and New Orleans)
Mcd: Millicandela

MDC: Mobile Data Computer
MDSS: Maintenance Decision Support System
MESU: Metro Electrical Services Unit
MHz: Mega Hertz
MUFS: Metropolitan Urban Freeway System
NOC: Network Operations Center
NPDES: National Pollution Discharge Elimination System
OEC: Office of Electronic Communications
OFGT: Office Management
OIT: Office of Information Technology
OMG: Operations Management Group
OTSO: Office of Traffic, Safety and Operations
PCMG: Preconstruction Management Group
PCS: Personal Communication Services
PM: Preventive Maintenance
PPM: Pavement Preventive Maintenance
PSR: Present Serviceability Rating
Recon: Pavement Rehabilitation and Reconstruction
RESU: Regional Electrical Services Unit
RTC: Regional Trade Center
RTMC: Regional Transportation Management Center
SFMG: State Facilities Management Group
SPSR: Shared Public Safety Radio
STIP: State Transportation Improvement Program
SUI: System Upgrade/Implementation
TBM: Tower/Building Maintenance
TCMA: Twin Cities Metropolitan Area
TCP/IP: Transmission Control Protocol/Internet Protocol
TEO: Transportation Engineers Organization
TOCC: Transportation Operations Communications Center
TSP: Transportation System Plan
TTI: Texas Transportation Institute
TTR: Travel Time Reliability
VHF: Very High Frequency
VMT: Vehicle Miles of Travel
WAN: Wide Area Network
WMS: Work Management System
WSI: Winter Severity Index

Annual Vehicle Miles of Travel: Annual vehicle miles of travel is calculated by taking the length of each highway segment times the average annual daily traffic volume times the number of days in a year.

Average Clearance Time: The amount of time between incident (see definition below) detection and total clearance. Average clearance time is a metric used by FHWA and other state departments of transportation.

Bare Lanes: When the "tire track" portion of the driving lane is clear of snow and ice.

Developmental Measures: These are measures for which neither data nor targets were previously developed.

District Long-Range Plan: Fiscally constrained report of capital programs and improvements of Mn/DOT projects for the next five years by individual Districts.

Emerging Measures: These are measures for which data exists, but targets have not been set previously.

Flushing: Flushing is to remove chemicals and material build-up through a rapid flow of water.

Indicator: A set of consistent trend data reported over time that provides information on a changing condition of strategic importance.

Incidents: Include all crashes, rollovers, spinouts and stalled vehicles blocking traffic.

Input Level: Measurement that relates to how many resources are consumed to provide the product or service. Resources generally consist of labor, equipment, materials, and dollars. Input measurements alone are important for fiscal and budgetary accounting purposes and are often monitored internally within the organization and by elected officials. When coupled with outcomes, they provide the customer an indication of the cost/efficiency of an organization. When coupled with outcomes, it provides an indication of the cost/benefit to the customer.

Interregional Corridors (IRCs): There are approximately 3,000 miles of Interregional Corridors within Minnesota. These are the important roadways linking regional trade centers levels 0 through 1 and 3 in the state.

Life-Cycle Cost: The amortized annual cost of a product or service, including costs associated with capital, installation, operations, maintenance, and disposal, discounted over the lifetime of the product[56].

[56] U.S. Department of Transportation

Mature Measures: These are measures for which baseline data exists and policy targets have been in use previously.

Mobility: Includes travel time and reliability. Reliability is also referred to as travel time variability or predictability.

Outcome Level: Measurement that relates to the *result* of the work done, i.e., how well the service is provided. Results are what the customer sees and/or measures. Results are what the customer believes or perceives as getting value from. Outcomes are quantitative as opposed to qualitative. Measurements that reflect smoothness of roads, bareness of pavement, brightness and legible of signs/markers, neatness of roadsides, reliability of signal lights, etc., are examples of outcome based performances in maintenance. Response time to repairing a defect is often an outcome measurement as well because it relates directly to a customer need.

Output Level: Measurement that relates to the *accomplishment* of the work done, i.e., how much of a product or service is provided. Outputs are important because they relate to productivity and efficiency. Measurements that reflect miles plowed, acres mowed, miles striped, bags of litter picked, etc, are examples of output-based performances in maintenance.

PONTIS: A federal bridge inventory/inspection program that tracks the conditions of individual bridge elements. It is also used to report the overall condition of bridges.

Present Serviceability Rating (PSR): The PSR rating is based both on a quantitative measure of highway ride quality (roughness) and a qualitative assessment or correlation of this ride roughness on a scale of 0 to 5.

Preservation: Maintain existing systems at a minimum level that will provide for the safe movement of people and freight. Focus is on activities that retain or restore the existing condition without necessarily extending the service life or adding capacity. "Preservation" includes traditional program categories of road repair, resurfacing, reconditioning and bridge repair. Transit projects considered under "Preservation" include operating assistance for existing transit service, bus rehabilitation/refurbishing, bus replacement with same size bus, bus replacement due to end of useful life and facility repair (garage, terminals, shelters)[57].

Primary Collector Route (PR): A roadway that carries between 800 and 2000 trips a day. Used for snow and ice removal purposes.

Principal Arterial Corridor: For purposes of defining levels of corridor management, a principal arterial corridor includes adjacent minor arterial(s) either side of the principal arterial facility, provided they function as alternate routes.

[57] 1999 STIP Guidance.

Replacement: Enhance economic development by replacing eligible system pieces or elements; reduce barriers such as weight restrictions, bottlenecks and system disruptions. "Replacement" includes traditional program categories of bridge replacement and reconstruction. Transit projects under "Replacement" include bus replacement with larger size bus[58].

Right-of-Way: A strip of land acquired by purchase, reservation, dedication, prescription or condemnation and intended to be occupied by a roadway, trail, water line, sanitary sewer, and/or other public utilities or facilities.

Rural Commuter Route (RC): A roadway that carries between 2,000 and 10,000 trips a day. Used to define snow and ice removal routes and targets.

Secondary Collector Route (SE): A roadway that carries under 800 trips a day. Used to define snow and ice removal routes and targets.

Structural Condition of Bridges: The structural condition is made up of three areas: deck condition, superstructure condition, and substructure condition.

Super Commuter Route (SC): A roadway that carries over 30,000 trips a day. Used to define snow and ice removal routes and targets.

Urban Commuter Route (UC): A roadway that carries between 10,000 and 30,000 trips a day. Used to define snow and ice removal routes and targets.

Weather Event: Time from the beginning of snowfall until three hours after snowfall has ended.

[58] 1999 STIP Guidance.

Appendix B
Minnesota Statewide Transportation Plan Policies and Outcomes

Statewide Transportation Plan Policy	Statewide Transportation Plan Outcomes
Policy 1 Preserve Essential Elements of Existing Transportation Systems	A. Optimize years of life and customer utility of facilities. Minimize life-cycle costs. B. All elements of Mn/DOT infrastructure will be maintained to the appropriate level for the function and use, and to meet customer expectations.
Policy 3 Effectively Manage the Operation of Existing Transportation Systems to Provide Maximum Service to Customers	A. Hours and days that service levels fall below performance targets due to maintenance, construction or regulatory procedures will be reduced. B. Hours and days that facilities do no carry full capacity or achieve target speeds due to weather, incidents or obstructions will be reduced. C. Use transit advantages, traveler information, TDM, and technology to maintain facility throughput and minimize downtime.
Policy 7 Increase the Safety and Security of Transportation Systems and their Users.	A. Crash rates, fatalities, and personal injuries will be continually reduced. B. The security of travelers, freight and transportation systems will be maintained.

Appendix C
HSOP Management Structure

Team	Members	Role
Steering Committee	Bob Winter Randy Halvorson Marthand Nookala Dick Stehr	▪ Provide strategic direction ▪ Guide policy decisions
Project Management Team	Gary Niemi–Chair Sue Mulvihill–Vice Chair Mark Wikelius Bernie Arseneau Jim Kranig Greg Ous Ed Idzorek Abby McKenzie Mark Larson Dan Dorgan Keith Shannon Dave Trooien (Liaison to DEs) Scott Peterson Brenda Wrobel Mitch Webster-Project Manager	▪ Design and lead process ▪ Manage consultant ▪ Synthesize results ▪ Identify policy issues for resolution
Work Teams **Supporting Infrastructure**	Mark Wikelius-Lead John Howard John Scharffbillig Robert Ellingsworth Randy Cameron Bob Lillevold Richard Post Curt Gobeli Andy Terry Michael Hogan Mike Barnes John Moreland	▪ Develop performance measures and targets ▪ Estimate cost to maintain current service levels ▪ Identify strategies and estimate cost to achieve targets ▪ Estimate performance under fiscally constrained scenario
Snow and Ice	Mike Tardy-Lead Dave Solsrud Rocky Haider	

Team	Members	Role
Pavement Maintenance	Jeff Vlaminck-Lead David Janisch Jim Curran	▪ Develop performance measures and targets ▪ Estimate cost to maintain current service levels ▪ Identify strategies and estimate cost to achieve targets ▪ Estimate performance under fiscally constrained scenario
Bridge Maintenance	Gordon Regensheid-Lead Gary Peterson George Welk Steve Kavanagh Craig Falkum Phillip Erickson Jim Lilly	
Safety Operations	Jerry Miller-Lead Bob Vasek Rob Ege Cassandra Isackson Craig Collison Curt Gobeli Brad Lechtenberg Jon Jackels Jack Pirkl Dave Schmidt Steve Skree Mike Weiss	
Traffic Operations	Sue Mulvihill-Lead Jim Kranig Bev Farraher Nick Thompson Norm Ashfeld Amr Jabr Brian Kary Cassandra Isackson Steve Misgen Timothy Bangsund Beryl Board Gene Lorentz Sue Lorentz Sean Bailey	

Team	Members	Role
Other Support	Deanna Belden Celine Carpenter Luann Cameron Dennis Herzog Jerry Holland Lawrence Moser Thomas Nelson Peggy Reichert Nan Swift Trent Weber Jerry Wood Heather Lott	▪ Develop performance measures and targets ▪ Estimate cost to maintain current service levels ▪ Identify strategies and estimate cost to achieve targets ▪ Estimate performance under fiscally constrained scenario
SRF Consulting Group, Inc.	Dave Montebello-Project Manager Praveena Pidaparthi Ferrol Robinson Rod Pletan (Sub-consultant)	