HIGHWAY PROJECT COST ESTIMATING AND MANAGEMENT

FHWA/MT-08-007/8189

Final Report

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THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

in cooperation with
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

February 2009

prepared by
Sirous Alavi, Ph.D., P.E.
Michael P. Tavares, P.E.

Sierra Transportation Engineers, Inc.
Reno NV

RESEARCH PROGRAMS

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HIGHWAY PROJECT COST ESTIMATING

AND MANAGEMENT

FOR THE

MONTANA DEPARTMENT OF TRANSPORTATION

FINAL REPORT

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PREPARED BY:

SIERRA TRANSPORTATION ENGINEERS, INC.
1005 TERMINAL WAY, SUITE 125
RENO, NV 89502

PREPARED FOR:

MONTANA DEPARTMENT OF TRANSPORTATION
2701 PROSPECT AVENUE
P.O. BOX 201001
HELENA, MT 59620-1001

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16. Abstract
This report provides detailed information about the project objectives, deliverables, and findings. The project team thoroughly reviewed the Montana Department of Transportation (MDT) structure, operations, and current procedures as related to MDT highway projects cost estimation practices. This was achieved through a series of visits and a comprehensive set of interviews of MDT staff involved with highway project cost estimation. A literature review of the state-of-practice cost estimating procedures was also conducted and compared with MDT practices. This report contains the project team recommendations along with a series of strategic procedures to implement those recommendations. The report also provides a timeframe for the implementation of recommendations and strategic procedures.

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ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AGR	Alignment and Grade Review
BMS	Bridge Management System
CE	Construction Engineering Phase
CES	Cost Estimation System
CMS	Contract Management System
CN	Construction Phase
CMAQ	Congestion Mitigation and Air Quality Improvement Program
COMS	Congestion Management System
CTEP	Community Transportation Enhancement Program
DA	District Administrator
DESS	District Engineering Services Supervisor
DMS	Document Management System
DSS	Decision Support System
ER	Emergency Relief Program
FPR	Final Plan Review
HEAT	Highway Economic Analysis Tool
HPMS	Highway Performance Monitoring
HSIP	Highway Safety Improvement Program
IC	Incidental Construction Phase (Utilities)
IM	Interstate Maintenance
LES	Letting and Award System
MEPA	Montana Environmental Policy Act
MMS	Maintenance Management System
NEPA	National Environmental Policy Act
NH	Non-interstate National Highway System
PDM	Project Design Manager
PE	Preliminary Engineering Phase
PES	Proposal and Estimates System
PFR	Preliminary Field Review
PHF	Project History
PIH	Plan-In-Hand Phase
PNDS	Primary and National Highway Data Summary
PPMS	Program and Project Management System
RIMS	Road Inventory and Mapping Section
RW	Right of Way
RSAP	Roadside Safety Analysis Program
SFCP	State Funded Construction Program
SMS	Safety Management System
SOW	Scope of Work Phase
STIP	Statewide Transportation Improvement Plan
STPP	Surface Transportation Program-Primary
STPS	Surface Transportation Program-Secondary
STPU	Surface Transportation Program-Urban

ACRONYMS (CONTINUED)

SIAP	Systems Impact Analysis Process
TCP	Tentative Construction Program (also known as Red Book)
TDCS	Traffic Data Collection Section
UPWP	Unified Planning Work Program

EXECUTIVE SUMMARY

Cost overrun of infrastructure projects has become a common problem for transportation agencies. Federal, state, regional, and local transportation agencies are searching for ways to mitigate the discrepancy between budgeted costs and actual costs of projects they sponsor. The overall purpose of this project is to provide recommendations on how to enhance the current Montana Department of Transportation (MDT) highway project cost estimating practices. Sierra Transportation Engineers, Inc. (STE) was the hired consultant.

STE conducted a comprehensive review of the literature on cost estimating practices, which showed that many agencies are impacted by the adverse consequences of cost overruns including: a) disruption of plans, postponing, or canceling scheduled projects to satisfy budgetary constraints, b) reduction in project scope, resulting in projects that do not fully provide the service initially intended, c) extension in construction duration until additional funds become available, and d) the public losing faith in the agency's competency, or worse, trustworthiness. The results of the literature review and also the review of successful practices by other agencies revealed that many agencies are taking important steps to enhance their cost estimating practices. Those steps included developing a comprehensive cost estimating manual, developing a systematic approach for capturing risks, developing cost estimating training program, developing quality control and quality assurance programs for cost estimating, and establishing a standalone cost estimating department.

STE also reviewed MDT's current highway project cost estimating practices to develop specific recommendations for enhancement. STE worked with the various project development sections within MDT to better understand their organizational structure, methods of operations, and how each of these areas develops its cost estimates. This was accomplished with email surveys, interviews, conference calls, and meetings. Analysis of limited MDT data revealed that for the Statewide and Urban Section Projects initial and latest revised costs varied by 181%. For MDT highway projects, the analysis of limited data revealed that final construction costs were 46% higher than anticipated at the time of programming. With great assistance from project panel, STE developed a Cost Estimation Tracking System in MS Excel to be used for future data collection on project cost overruns. The use of the newly developed tracking system will ease the difficulty of gathering the historical cost data for future analysis. Eight risk factors namely insufficient knowledge of right-of-way, environmental mitigation requirements, unforeseen engineering complexities/constructability issues, changes in traffic control needs, increased stakeholders expectations, unforeseen events, changes in market conditions (inflation), and utilities were identified. A Monte Carlo simulation process was evaluated for project specific risk factors using the cost estimation tracking system database. The project specific risk factors can be used in lieu of unknown portion of contingency factors currently used at MDT.

The following recommendations are made based on STE's review of literature and evaluation of MDT's current practices: a) create a cost estimation section, b) routinely update unit cost data on MDT intranet, c) develop comprehensive cost estimating manual, d) develop quality control and quality assurance program for cost estimating, e) develop comprehensive system for capturing risk factors, f) create procedures for managing inflation, h) establish routine training program for staff involved in cost estimating. This report also contains a timeline for implementing the project recommendations.

1.0 INTRODUCTION

Sierra Transportation Engineers, Inc. (STE) is pleased to provide this final report for Montana Department of Transportation (MDT) contract number 308059, titled "Highway Project Cost Estimating and Management for the Montana Department of Transportation." This report provides detailed information about the project objectives, deliverables, and findings. The format of this report follows the MDT Research Section Report Requirements dated February 27, 2008.

1.1 PURPOSE

The overall purpose of this project is to develop a comprehensive document to determine the best practices of efficient highway cost estimating for MDT. Ultimately, MDT needs to have a cost estimating process and procedure that is rational and understandable to not only MDT personnel and management but also the numerous stakeholders outside of the MDT.

1.2 SCOPE

STE developed a detailed work plan that entails the scope of activities necessary to successfully complete the project objectives. The following specific activities were identified in the project work plan:

- Literature Review including NCHRP 8-49
- Review of MDT's Structure, Operations, and Current Process
- Develop Detailed Strategic Procedure & Recommendations
- Develop Implementation Plan

This final report describes work accomplished.

2.0 LITERATURE REVIEW

STE conducted a comprehensive review of literature on cost estimating practices including a thorough review of the National Cooperative Highway Research Program (NCHRP) Project 8-49 "Guidance for Cost Estimation and Management for Highway Projects During Planning, Programming, and Preconstruction."

The purpose of the literature review was to:

- Identify cost estimation problems (Problem Identification)
- Identify solutions to improve the cost estimation process (Solutions)
- Identify practices by other agencies for improving the cost estimation process (Best Practices)
- Recommend the best practices of cost estimation for implementation (Recommendations)

2.1 PROBLEM IDENTIFICATION

Cost overrun of infrastructure projects has become a common problem for transportation agencies. Federal, state, regional, and local transportation agencies are searching for ways to mitigate the discrepancy between budgeted costs and actual costs of projects they sponsor. This project is a good example of such an effort.

A recent study (Flyvbjerg et al. 2002) of infrastructure project costs sampled 258 projects worldwide worth $90 billion. The study revealed that costs are underestimated in 9 out of 10 transportation infrastructure projects. Actual costs are on average 34% higher than estimated costs for tunnels and bridges and 20% higher for road projects. The study also revealed that there is a lack of comprehensive project management plans to mitigate the occurrence of cost underestimation. The study concluded that agencies should develop institutional checks and balances for accountability by increasing transparency, using performance specifications, and developing comprehensive systems for the cost estimation process.

For a transportation agency, cost overruns can lead to adverse consequences, including:

- Disruption of plans, postponing, or canceling scheduled projects to satisfy budgetary constraints
- Reduction in project scope, resulting in projects that do not fully provide the service initially intended
- Extension in construction duration until additional funds become available
- The public losing faith in the agency's competency, or worse, trustworthiness.

In addition, inaccurate cost estimates lead to overloading the Statewide Transportation Improvement Program (STIP) with many projects that are underfunded. This often leads to misallocating design resources and creating false expectations with the public and other stakeholders. For example, in January 2001, Virginia's Joint Legislative Audit and Review Commission (JLARC) reported that the state's 6-year, $9 billion transportation plan may have understated the costs of projects by up to $3.5 billion (JLARC 2001). The report identified project scope expansion, lack of adjustment for inflation, and design errors and omissions as the most significant factors for underestimating projects costs. In a 2002 audit of the Springfield Interchange project in Northern Virginia, the Office of the Inspector General reported that Virginia Department of Transportation (VDOT) had to postpone or cancel 166 projects because costs due to lack of funding (FHWA 2002). Project cost underestimation was reported as a primary reason for funding issues.

In 2003 the General Accounting Office (GAO) reported to Congress that unreliable initial cost estimates have significantly contributed to the cost growth observed on major highway and bridge projects (US GAO 2003). Initial estimates were modified to reflect more detailed plans and specifications as projects were designed and the projects' costs were affected by, among other things, inflation and changes in scope to accommodate economic development over time.

NCHRP 8-49 cites four factors that create distinct challenges to the development of early and accurate project cost estimates (Anderson et al. 2007, pp. 1):

1. Difficulty in evaluating the quality and completeness of early project cost estimates
2. Difficulty in describing scope solutions for all issues early in project development
3. Difficulty in identifying major areas of variability and uncertainty in project scope and costs
4. Difficulty in tracking the cost impact of design development that occurs between major cost estimates

According to the findings in NCHRP 8-49, an agency should adopt a cost estimation process that effectively manages the internal and external factors causing cost escalation. These factors individually or in combination can increase project costs significantly. Internal factors are detailed in Table 2.1 and external factors in Table 2.2 (Anderson et al. 2007, pp. 13-18). Ineffective management of these factors comes from the following (Anderson et al. 2007, pp. 13-18):

- Lack of a thorough understanding of unknown (risk) factors
- Lack of realization that unknown (risk) factors change over time
- Lack of communication of information about unknown (risk) factors among the key stakeholders involved in various phases of project development
- Lack of common practices for cost estimation between bureaus/divisions/sections of an agency

Table 2.1 Internal Cost Escalation Factors.

Factors	Description
Bias	To insure a project remains in the program, project costs are purposefully underestimated. DOTs can mitigate bias by making the cost estimation process a priority and transparent.
Delivery/Procurement Approach	"The decision regarding which project delivery approach, (i.e.) design-bid-build, design-build, or build-operate-transfer, and procurement methodology, (i.e.) low bid, best value, or qualifications based selection effects the transfer of project risks. Lack of experience with a delivery method or procurement approach can also lead to underestimation of project costs." While these approaches may get projects constructed quickly, each comes with a set of risks "in terms of DOT responsiveness, expectations, and time."
Project Schedule Changes	Budget constraints or design challenges—e.g. change orders—will increase the construction duration, leading to increased inflation effects. "Estimators frequently do not know what expenditure timing adjustments will be made."
Engineering and Construction Complexities	Early design difficulties can lead to cost increases, lengthened schedules, and internal coordination errors between project components such as "conflicts or problems between the various disciplines involved (with) a project. Constructability problems… may also be encountered as the project develops."
Scope Changes	"Such changes may include modifications in project construction limits, alterations in design and/or dimensions of key project items such as roadways, bridges, or tunnels, adjustments in type, size, or location of intersections, as well as other increases in project elements."
Poor Estimation (errors and omissions)	"Poor estimation includes general errors and omissions from plans and quantities as well as general inadequacies and poor performance in planning and estimation procedures and techniques." DOTs can mitigate estimating errors by instituting a consistent process, including continuous monitoring, verifying, and correcting.
Inconsistent Application of Contingencies	"Misuse and failure to define what costs contingency amounts cover can lead to estimation problems. In many cases it is assumed that contingency amounts can be used to cover added scope and planners seem to forget that the purpose of the contingency amount in the estimate was lack of design definition."
Faulty Execution	"This factor can include the inability of the DOTs representatives to make timely decisions or actions, to provide information relative to the project, and failure to appreciate construction difficulties cause by coordination of connecting work or work responsibilities."
Ambiguous Contract Provisions	"When the core assumptions underlying an estimate are confused by ambiguous contract provisions," such as "providing too little information in the project documents," estimators cannot accurately forecast project costs or schedules.
Contract Document Conflicts	Conflicting documents "lead to errors and confusion while bidding and later during project execution they cause change orders and rework.

Table 2.2 External Cost Escalation Factors.

Factors	Description
Local Government Concerns and Requirements	Typically, scope changes are negotiated by either scaling down or scaling up a project.
Effects of Inflation	Projects with long development and construction durations can encounter unanticipated inflationary effects. DOT estimators should “think in terms of the time value of money,” including the inflation rate and expenditure timing. Inflation affects projects when: • Project estimates are not communicated in year-of-construction costs. • The project completion is delayed and therefore the cost is subject to inflation over a longer duration than anticipated. • The rate of inflation is greater than anticipated in the estimate.
Scope Creep	Similar to changes in scope by causing cost and schedule overruns.
Market Conditions	Changes in the regional, national or global economies can affect the costs of a project by causing unanticipated escalation in cost of asphalt, steel, and labor.
Unforeseen Events	Typically these are called “acts of God,” and may include fires, floods, hurricanes, tornadoes, earthquakes, terrorism, labor strikes, and sudden changes in financial or commodity markets. These acts can bring construction to a standstill and require extensive rework or repair.
Unforeseen Conditions	“There are a multitude of problems that are simply unknown during the planning stage” but “become apparent during construction.” For example, soil contamination, soil compaction factors, and utilities may not be accurately described on preliminary drawings.

In order to understand the internal and external factors that cause cost overruns of MDT projects, STE developed the following tools:

- Data Request Template
- Initial Risk Factor Rating
- Pre-Trip Questionnaire
- On-Site Interview Questions

2.1.1 Data Request Template

STE desired to review as much historical cost estimating data as possible to thoroughly understand the cost estimating strength and deficiencies and also to attempt to quantify the various uncertainties (i.e., risk categories) that impact a project cost.

A draft data request template called "MDT HPCE data request template" was created using Excel. STE provided an electronic copy of the template to MDT for review and comment on April 13, 2007. STE worked closely with the MDT project panel to customize the data request template to follow MDT practices. On July 3, 2007, STE finalized and submitted the data request template to MDT. This template is presented in Appendix A.

The data request template was expected to be populated with MDT project cost data, which could be under, over, and/or close to their original base cost and schedule. The template covered different types of MDT projects (i.e., new, rehabilitation, reconstruction, resurfacing, spot improvement), project categories (i.e., IM, NH, STPP, STPS, STPU, BR, Safety), project location (i.e., urban, rural), and various uncertainties (i.e., risk categories). The data request template was also designed to compare cost estimates at various phases within the MDT cost estimation process; namely, programming, award, and final cost.

Costs or schedule changes associated with potential risks were categorized in the data request template as:

- Insufficient Knowledge of Right-of-Way Factors
- Environmental Mitigation Requirements
- Unforeseen Engineering Complexities / Constructability Issues
- Changes in Traffic Control Needs due to Design or Traffic Growth
- Increased Local Government, Community, and Stakeholders Expectations
- Unforeseen Events
- Changes in Market Conditions
- Utilities
- Others

The risk categories were further broken down into subcategories that were specific to MDT as shown in Table 2.3.

Table 2.3 Risk Categories and Subcategories.

Risk Categories	Right-of-Way	Environmental	Engineering / Constructability	Traffic	Stakeholders	Unforeseen Events	Market	Utilities
Subcategories	Disagreement on freeway access	Permits or agency actions delayed or took longer than expected	Sufficiency of plans and specifications	Design change	Objections posed by local communities	Forest fires	Labor	Coordination with local utilities efforts
	Objections to RW appraisal	Agency disputes / disagreements not resolved in a timely manner	Change in seismic criteria	Traffic growth	Late changes requested by stakeholders	Weather related incidents (e.g., floods, wind, snow)	Fuel	Utility negotiations
	Acquisition problems	New information required for permits	Soil conditions	Land use changes / developments	Emergence of new stakeholders demanding new work	Earthquake	Materials	Delay
	Staffing issues	Environmental regulations change	Soil contamination		Threats of lawsuit	Man-made disasters (e.g., train derailments, vehicle accidents)	Land	Railroad involvement
	Volatile real estate market / rapid escalation	New issues in dealing with historic or archeological site, endangered species, wetland	Contractors / subcontractors capability		Stakeholders choose time and/or cost over quality	Change in state and national economic conditions / funding availability		
		Additional environmental analysis required	Work zone safety and mobility		Tribal Employment Rights Office (TERO) fee			
		Tribal issues	Site specific requirements		Overlapping Governmental Jurisdictions			
			Geotechnical conditions					
			Drainage / hydraulic issues					

2.1.2 *Initial Risk Factor Rating*

As stated earlier, the MDT cost estimation risk factors were defined based on the review of literature and also with consultation with the project panel. Recognizing that data gathering process by MDT would take time and effort, STE utilized a subjective methodology to assess the relative importance of the identified risk factors. STE developed and distributed a survey to MDT personnel to evaluate the role of risk factors on cost and schedule of transportation projects. A copy of this survey is presented in Appendix B.

STE evaluated the responses for the risk categories and subcategories using multivariate statistical methods known as principal component analysis for ordinal rates, also known as PRINQUAL. A detailed discussion of the procedure and findings are listed in Appendix C.

Based on this subjective survey, Table 2.4 lists the risk factors by order of significance from 1 to 8, where 1 is the most significant risk. It is important to recognize that delays in schedule can impact a project cost. For example, delay caused by environmental mitigation requirements, which is ranked as the number 1 risk factor for schedule delays, can be compounded by changes in market condition (inflation) to cause significant project cost increase.

The results of the survey suggest that the eight risk factors identified originally from the literature and discussions with the MDT project panel are all relevant to MDT cost/schedule overruns. The only way to quantify the historical risks is to gather MDT specific project data using the data request template.

Table 2.4 Ranking of Risk Factors by Order of Significance.

Risk Category	Ranking of Impact on Cost Increases	Ranking of Impact on Schedule Delays
Insufficient Knowledge of Right-of-Way Factors	4	2
Environmental Mitigation Requirements	5	1
Unforeseen Engineering Complexities / Constructability Issues	2	3
Changes in Traffic Control Needs due to Design or Traffic Growth	8	8
Increased Local Government, Community, and Stakeholders Expectations	3	4
Unforeseen Events	6	7
Changes in Market Conditions	1	5
Utilities	7	6

2.1.3 *Pre-trip Questionnaire*

NCHRP Web-Only Document 98, a supplement to NCHRP Project 8-49, provides guidelines and a sample questionnaire for collecting cost estimation information (Anderson et al. 2006). STE followed the guidelines to develop a questionnaire named “pre-trip questionnaire.” MDT personnel from planning, programming, and design were asked to respond to different portions of the questionnaire as deemed appropriate. A copy of the questionnaire is presented in Appendix D. The responses to the questionnaire provided information about MDT's current cost estimating practices, which are discussed in Section 3.0 of this report. The responses were also utilized by STE in its preparation for on-site interviews.

2.1.4 On-Site Interview Questions

NCHRP Web-Only Document 98, a supplement to NCHRP Project 8-49, provides examples of interview questions to capture the strengths and weaknesses of project cost estimating practices (Anderson et al. 2006). It states that the focus of the interview should be to assemble state of practice estimating information and to understand what factors cause estimating accuracy problems. The interviews are also designed to gain an understanding of how cost estimates are managed as the scope of a project develops. For example, based on interviews conducted in June and July of 2004, the strengths and weaknesses of the New York State Department of Transportation (NYSDOT) and the Kentucky Transportation Cabinet (KTC) were reported as follows (Anderson et al. 2006, pp. C2-C3).

Strengths of Estimating System

- Region Estimating System – In NYSDOT, projects are estimated at the local level which allows for the people doing the estimating to be in tune with the local project and political climate.
- Same Estimator throughout Project Life – In NYSDOT, the person that prepares the first estimate also prepares the estimates throughout the project life. This allows the person to become knowledgeable about all the details of a project.
- KTC has project identification forms that are used to document information about the project including changes.
- KTC has started a Project Manager's Academy to train the preconstruction engineers and project managers in cost estimating.
- For preliminary design estimates, KTC established trigger values for projects that exceed their budget.

Problems with Estimating System

- Preliminary estimating is difficult and not always accurate. NYSDOT started to utilize Trns*Port to help make estimating easier at the early phases.
- In NYSDOT, general guidelines are provided for early estimates in the design manual, however, methodologies vary throughout the state. There is a need to standardize some aspects.
- In NYSDOT, projects are tracked by the current system, but this is only on paper. The tracking system needs to be updated and refined.
- Accountability is an issue at KTC during the conceptual estimating phase.
- Change of scope and failing to make proper adjustment in cost is a major problem for KTC.
- KTC does not have formal estimating procedures or reviews for most of their estimates. Their long-range planning estimates rely on estimator's experience.
- KTC projects are routinely underestimated due to lack of attention to inflation.

It is important to state that the issues identified by KTC and NYSDOT are from the interviews conducted in the summer of 2004. Their current situations may be quite different.

STE followed the guidelines of the NCHRP 8-49 report to develop a set of interview questions for the MDT personnel. A copy of the on-site interview questions is presented in Appendix B. The results of the on-site interviews are discussed in Section 3 of this report.

2.2 Solutions Identified in Literature Review

Cost estimation is a complex practice impacted by the unique characteristics of an agency's organizational structure, policies, operational capabilities, and the level of training of its personnel. Those unique characteristics make the problems associated with cost estimation practices different among agencies. The solutions have to be tailored to address each agency's specific needs.

There is extensive literature on improving the accuracy of early cost estimation of transportation projects. The body of knowledge on how to enhance the cost estimation process of an agency can be divided into macro solutions that offer system-wide improvements and micro solutions that offer improvements to a specific problem similar to those listed Tables 2.1 and 2.2.

NCHRP 8-49 and FHWA report on "Major Project Cost Estimating Guidance" (FHWA 2007) provide comprehensive lists of strategies and principles for system-wide cost estimating improvements. In order to enhance an agency's cost estimation process, NCHRP 8-49 suggests the adoption of the following eight strategies (Anderson et al. 2006, pp. 57):

1. Management Strategy – Manage the estimation process and cost through all stages of project development
2. Scope/Schedule Strategy – Formulate definitive processes for controlling project scope and schedule changes
3. Off-Prism Strategy – Use proactive methods for engaging those external participants and conditions that can influence project costs
4. Risk Strategy – Identify risks, quantify their impact on cost, and take actions to mitigate the impact of risks as the project scope is developed
5. Delivery and Procurement Method Strategy – Apply appropriate delivery methods to better manage cost, as project delivery influences both project risk and cost
6. Document Quality Strategy – Promote cost estimate accuracy and consistency through improved project documents
7. Estimate Quality Strategy – Use qualified personnel and uniform approaches to achieve improved estimate accuracy
8. Integrity Strategy – Insure checks and balances are in place to maintain estimate accuracy and minimize the impact of outside pressures that can cause optimistic biases in estimates

To ensure consistent and accurate estimates, NCHRP 8-49 concluded that the following cost estimation management and practice principles should be followed by agencies (Anderson et al. 2006, pp. 125-126):

Cost Estimation Management

1. Make estimation a priority by allocating time and staff resources
2. Set a project baseline cost estimate during programming or early in preliminary design and manage to it throughout project development
3. Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline
4. Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate
5. Protect estimators from internal and external pressures to provide low cost estimates

Cost Estimation Practice

1. Complete every step in the estimation process during all phases of project development
2. Document the estimate basis, assumptions, and back-up calculations thoroughly
3. Identify project risks and uncertainties early and use these explicitly identified risks to establish appropriate contingencies
4. Anticipate external cost influences and incorporate them into the estimate
5. Perform estimate reviews to confirm the estimate is accurate and fully reflects project scope

The FHWA report on "Major Project Cost Estimating Guidance" (FHWA 2007) provides a series of key principles for successful cost estimating. Those principles are:

- Integrity – This principle discusses high standard of ethical integrity and a transparent cost estimating process.
- Contents of a Cost Estimate – This principle emphasizes the importance of a "complete" cost estimate, the equivalent of the total project purchase price. As such, the project cost estimate should include all costs including right-of-way, environmental mitigation, construction, public outreach, project management, etc.
- Year of Expenditure Dollars – This principle emphasizes the assignment of an inflation rate per year to the proposed midpoint of construction.
- Basis of a Cost Estimate – This principle discusses how a project cost should be developed based on best information available (e.g., bid based estimating is only good if the historic prices are for similar work and similar sized projects).
- Risk and Uncertainty – This principle states that costs should be determined for uncertainties within an estimate. To account for larger degree of uncertainty, early cost estimates can be expressed with an indication of the confidence level.
- Project Delivery Phase Transition – This principle emphasizes the importance of tracking cost estimates and changes throughout the life of the project and documenting assumptions and estimate information along the way.
- Team of Experts – This principle states that a skilled, interdisciplinary team should produce cost estimates using a clearly identified scope of work. For example, the right-of-way acquisition costs should be determined by the agency's right-of-way office.
- Validation of Estimates – This principle states that a competent unbiased team should validate the cost estimates.
- Revalidation of Estimates – This principle recognizes that situations may change over time and estimates need to be refreshed to account for those changes.
- Release of Estimates and Estimating Information – This principle emphasizes that only thoroughly reviewed, complete, and accurate cost estimates should be released to the public or be the basis for project approval.

Similar recommendations have been made by other research reports (TCRP 2006).

Based on its literature review, STE concluded that the most fundamental management policy is to make "estimation a priority." Allocating time and staff resources is the first step for implementing the strategies and principles discussed. One great way to make estimation a priority is to create a cost estimation department (group) with full time estimators. Other key practices that are necessary for the implementation of strategies and principles noted are:

- Development of a comprehensive cost estimating manual
- Development of a comprehensive system for capturing risk factors
- Establishment of a cost estimating training program
- Development of quality control program for cost estimating

These recommended solutions were compared with the ten cost estimation management and practice principles identified in NCHRP 8-49. Table 2.5 illustrates the applicability of the recommended solutions to the cost estimation management and practice principles.

Table 2.5 Comparison of Recommended Solutions.

Cost Estimation Management and Practice Principles	Solutions				
	Cost Estimation Department	Comprehensive Cost Estimating Manual	Comprehensive System for Capturing Risk Factors	Cost Estimating Training Program	Quality Control Program
Make estimation a priority by allocating time and staff resources	√			√	√
Set a project baseline cost estimate during programming or early in preliminary design and manage to it throughout project development	√	√	√		√
Create cost containment mechanisms for timely decision making that indicate when projects deviate from the baseline	√		√		√
Create estimate transparency with disciplined communication of the uncertainty and importance of an estimate	√	√	√	√	√
Protect estimators from internal and external pressures to provide low cost estimates	√			√	√
Complete every step in the estimation process during all phases of project development	√	√	√	√	√
Document the estimate basis, assumptions, and back-up calculations thoroughly	√	√		√	√
Identify project risks and uncertainties early and use these explicitly identified risks to establish appropriate contingencies	√	√	√	√	√
Anticipate external cost influences and incorporate them into the estimate	√	√	√		√
Perform estimate reviews to confirm the estimate is accurate and fully reflects project scope	√	√			√

2.3 Successful Practices by Other State Agencies

Many agencies across the nation have taken steps to enhance their cost estimation and management procedures. Perhaps the best example of a recent initiative by an agency is the ongoing efforts by the Minnesota Department of Transportation (Mn/DOT). According to Mn/DOT, escalations in the costs of transportation projects have resulted in the postponements of many important improvement projects. This situation impacts Mn/DOT credibility with many of its stakeholders. In 2007, Mn/DOT developed the following vision statement for their project entitled, "Cost Estimation Process Improvements and Organizational Integration" (Mn/DOT 2007):

> *"Mn/DOT will manage and control costs through a department-wide priority on cost estimating and cost management, reliable and accurate estimates, statewide uniformity and consistency, improved communication and credibility with external stakeholders, and clear accountability."*

Mn/DOT has identified the following key components for their vision statement (Mn/DOT 2007):

- Department-wide priority on estimating, managing, and controlling costs
    - Fully developed and integrated policies, processes, and tools for cost estimation, management, and control
    - Baseline estimates that align with early project scope development and include an initial assessment of risk and uncertainty
    - Clearly defined and documented cost management approval processes to authorize changes in scope and cost after the baseline estimate is established
    - Dedicated resources that are focused on effective scoping, project cost estimating, and cost management

- Reliable and accurate estimates
    - Well-documented and complete cost estimates
    - Clearly spelled out assumptions and risks that can be easily communicated

- Statewide uniformity and consistency
    - Uniform application and consistent statewide use of well-documented processes and tools
    - Use of process and tools during planning, scoping, design, and letting phases

- Improved communication and credibility with external stakeholders.
    - Consistent and clear communication of cost estimates to external stakeholders at milestone points
    - The ability to communicate cost estimates with confidence, leading to stronger relationships with external stakeholders, greater possibility for collaboration, and increased funding support of transportation initiatives

- Clear accountability.
    - Accountability for cost estimating and cost management at all levels of the organization
    - Defined roles and responsibilities for every person involved
    - Accountability that is tracked at key points in the process

A review of Mn/DOT's vision statement and its components clearly shows that its steps are in agreement with recommendations made by NCHRP 8-49 and FHWA principles stated in Section 2.2. Mn/DOT has recently restructured its organization and has established the Office of Project Scope and Cost Management, which will be responsible for project scoping, cost estimating, and cost management. Another significant step by Mn/DOT is a new requirement that an estimate should be expressed as a Total Project Cost Estimate (TPCE), which includes non-construction cost items such as right of way costs and contingencies.

There are a number of other agencies that have assigned resources to advance their cost estimation practices. The following sections contain examples of such agencies.

2.3.1 State of California

Currently, California Department of Transportation (Caltrans) Division of Design and Division of Engineering Services are performing a review of their cost estimating tools and practices. The Division of Design has established a website to disseminate information and provide updates on Caltrans' cost estimating practices. Caltrans has concluded that reasons for poor estimating include: estimates that are not updated and are old and out of date, estimates that are based on historic and not forecasted information, estimates that are prepared by staff with limited estimating experience, estimates that are based on low quality or high risk plans and specifications, estimates that are not tailored to project construction schedule, estimates that are prepared without quality control/assurance, and estimates that are constraints by programmed funding level (Caltrans 2006a).

To remedy poor cost estimation practices Caltrans is establishing cost estimating centers of expertise at each district, developing and implementing quality control/quality assurance processes at each district, utilizing consultant contracts for independent analysis of cost estimates at the districts, and making district directors accountable for accuracy of cost estimates (Caltrans 2006b).

2.3.2 State of Florida

In Florida, the Estimate Section of the Office of Specifications and Estimates sets policies and procedures for the statewide estimating process. The Estimate Section is responsible for reviewing the estimates for Florida's 5-Year Work Program, conducting post-bid reviews, publishing Florida's Basis of Estimates Manual, providing user support and training for the Long Range Estimates (LRE) and Trns*port estimating systems, and producing a variety of cost history reports.

2.3.3 State of Ohio

The Ohio Office of Estimating, a unit of Division of Construction Management, provides support, guidance, and training for project cost estimating. Ohio Department of Transportation (ODOT) has developed a cost estimating manual that contains its best recommended practices. It also maintains trends and forecast for inflation and historical bid item data on its website, which is available to ODOT estimators and also the public. ODOT's cost estimation procedure is a ten step process that provides guidance on critical issues such as contingencies, inflation, and quality review (ODOT 2008).

2.3.4 State of Washington

The Strategic Analysis Estimating Office (SAEO) of the Washington Department of Transportation (WSDOT) Design Office is tasked with providing technical support for estimating, risk analysis, value engineering, and project development. WSDOT has a well established cost estimating process that includes developing scope, base estimate, review of base estimate, analysis of risks and contingencies, communication, independent review of total estimate, and management endorsement.

WSDOT has also established Cost Estimating Guidelines that describe various steps of the cost estimation process. The guidelines clearly state that "the estimators should be shielded from pressures to keep estimates within programmed or desired amounts based on funding availability (WSDOT 2007a, pp. iii)." This is very much in line with NCHRP 8-49 recommendations of protecting the estimators from internal and external pressures to produce low estimates.

WSDOT also provides readily available cost estimating modeling tools (i.e., worksheets) on its website to be used by project estimators. The cost estimating methodologies supported in WSDOT guidelines are parametric, historical bid-based, cost based, and risk-based. WSDOT guidelines provide a comprehensive description of each methodology and describe the appropriateness of their use for various stages of project. For example, parametric methodologies (i.e., techniques that use historical data to define the cost of typical transportation facility segments, such as cost per lane mile, cost per interchange, cost per square foot, and cost per intersection) are used in planning, scoping, or early design stages (WSDOT 2007a, pp. 8-10). Historical bid-based methods are commonly used to develop WSDOT engineering estimates. Cost based estimates are very time consuming and require highly experienced estimators. WSDOT limits the use of cost based estimates to project items with the largest dollar value, typically 20% of items of work containing 80% of the project costs (WSDOT 2007a, pp. 8-10).

WSDOT policy requires a Cost Risk Assessment (CRA) workshop for projects over $25 million and a more detailed Cost Estimating and Validation Process (CEVP) workshop for projects over $100 million (WSDOT 2005). WSDOT developed the CRA and CEVP workshops to improve cost and schedule estimates by identifying and capturing risk events. Modeling techniques (e.g., Monte Carlo Simulation) are utilized to express cost and schedule estimates as a range of values rather than the conventional single point value. WSDOT's Policy for Cost Risk Assessment also suggests that other types of unique or unusual projects, or projects with certain attributes (e.g., projects with high degree of political interest, major structures, projects with multiple stages, etc.) that are typically over $5 million may benefit from a CRA workshop (WSDOT 2005).

2.3.5 Other DOTs

In 2006, the Project Delivery Subcommittee of the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Quality (SCOQ) conducted a nationwide survey to investigate the best practices for project cost and plan quality. Twenty agencies provided information on their project cost estimating practices. The survey results indicated that agencies all acknowledge the problems associated with developing early and accurate cost estimates. Table 2.6 illustrates examples of agencies that are taking definitive actions to improve their cost estimating practices (AASHTO 2006). The actions shown in Table 2.6 are in agreement with the recommendations presented in the literature review and summarized in Section 2.2.

Table 2.6 Agencies Taking Actions According to SCOQ National Survey.

Actions	Agencies
Developing Cost Estimating Manual	Maryland, Minnesota, Virginia, Washington, California
Developing Systems for Capturing Risk Factors	Washington, Florida
Developing Cost Estimate Training Program or Workshops	Virginia, Washington, Michigan
Establishing Cost Estimating Department	Louisiana, Nevada
Development of Estimate Quality Control Program	Indiana, Maine, Virginia, Washington, Wyoming

3.0 MDT'S STRUCTURE, OPERATIONS, AND CURRENT PROCESS

3.1 BACKGROUND

STE worked with the various project development sections within MDT to better understand their organizational structure, methods of operations, and how each of these areas develops its cost estimates. This was accomplished with email surveys, interviews, conference calls, and meetings. A typical MDT project can be divided into planning, nomination, programming, design, award, and construction stages. Table 3.1 describes the activities associated with each project development stage.

Table 3.1 MDT Project Development Stages and Activities.

Project Development Stages	Typical Activities
Planning	Purpose and need, improvement or requirement studies, environmental considerations, interagency coordination, asset management information, budgetary information
Nomination	Project nomination for programming
Programming	Project funding authorization
Preliminary Design	Right of Way (RW) development, environmental clearance, design criteria and parameters, surveys/utility locations/drainage, preliminary schematics such as alternative selections, geometric alignments, hydraulic studies/drainage design, bridge layouts, public involvement
Final Design	RW acquisition, Plan Specification & Estimate (PS&E) development – pavement and bridge design, traffic control plans, utility drawings, final cost estimates
Award	Prepare contract documents, advertise for bid, pre-bid conference, receive and analyze bids, determine lowest responsive bidder, initiate contract
Construction	Mobilization, inspection and materials testing, contract administration, traffic control, bridge, pavement, drainage construction

During various stages of a project's life cycle, cost estimates are revised as more information becomes available. Figure 3.1 presents the typical MDT project life cycle. The following sections describes MDT's cost estimation process and defines the terminologies used in the figure.

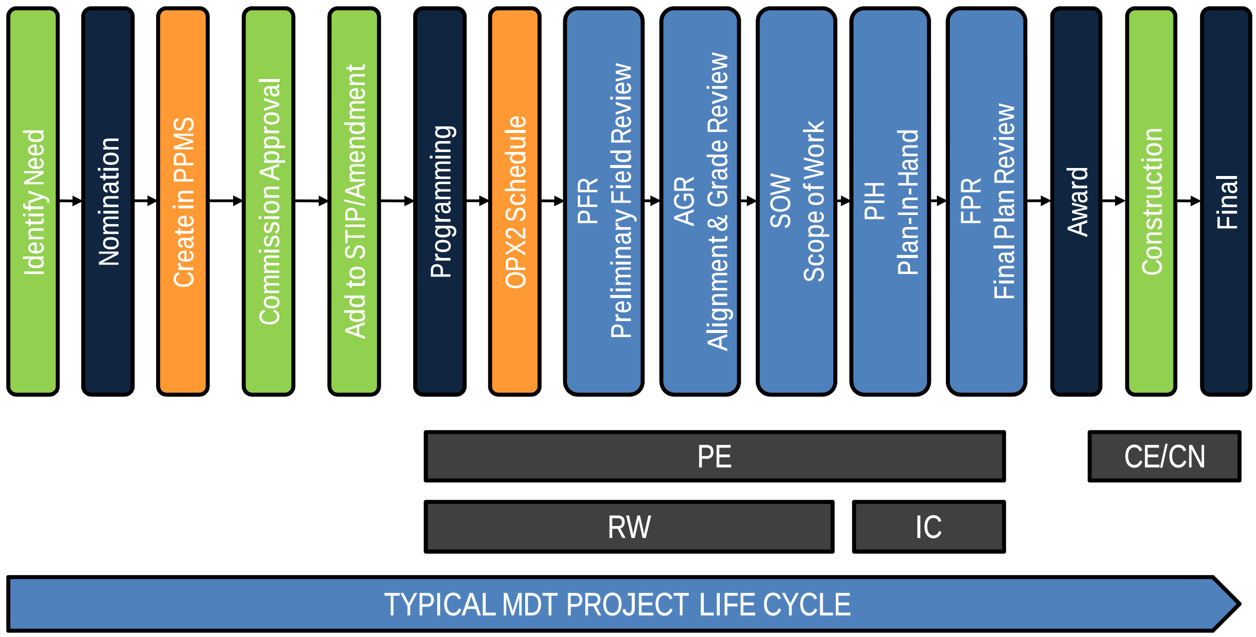

Figure 3.1 Typical MDT Project Life Cycle.

3.2 Planning Process

The Project Analysis Bureau in concert with the Statewide and Urban Planning Section develop the transportation program for Montana. This is accomplished by the implementation of a Statewide Long Range Transportation Plan (TranPlan 21) and the use of the Performance Programming Process (P3). TranPlan 21 establishes policies, goals, and actions for future system performance. The use of P3 ensures that the best system wide investment decisions are made given overall direction from MDT customers, available resources, and system performance monitored over time.

The Project Analysis Bureau is responsible for preparing the Statewide Transportation Improvement Program (STIP), which identifies transportation system improvement projects for all Montana jurisdictions receiving funding through the Federal transportation program. In addition, the Statewide and Urban Planning Section works closely with Metropolitan Planning Organizations (MPOs) in Billings, Great Falls, and Missoula in the development of their Transportation Improvement Programs (TIPs). TIPs are incorporated into the STIP by reference. The annual STIP identifies proposed transportation capital and operating projects for the next five years.

The Statewide and Urban Planning Section also works closely with Montana's fifteen urban areas to select urban highway improvement projects utilizing the Surface Transportation Program-Urban (STPU) funding.

3.3 Nomination Process

Every year the Project Analysis Bureau requests nominations from the districts that correspond to management system needs and available funds. For urban projects, the Statewide and Urban Planning Section works closely with local governments to identify priorities based on available funding. Funding levels are established by the Montana Transportation Commission (MTC) and distributed to the urban areas using a statutory population formula.

During the Nomination stage, the MDT Rail, Transit, and Planning Division (particularly, the Project Analysis Bureau and the Statewide and Urban Planning Section) provides budgetary information and management system guidance. MDT districts provide project scope, location, and cost estimates. Project information includes project number, route and reference post, estimated completion year, and a general description of the proposed scope of work. For urban projects, local governments also provide input.

3.4 Programming Process

In order for a project to be programmed, the Project Analysis Bureau, the Statewide and Urban Planning Section, the Fiscal Programming Bureau, and FHWA must come to an agreement. Programming information is included in the STIP. Montana is required to conduct a formal public involvement process for 45 days prior to submitting the STIP to the MTC for approval. The STIP is also posted on the MDT website for public viewing. Upon MTC's approval, the STIP is submitted to the FHWA and the Federal Transit Administration (FTA) for approval. Once formal approvals are obtained, projects are considered authorized and programmed.

3.5 Cost Estimation Process

MDT cost estimating procedures are described in a document entitled "Cost Estimation Procedures for Highway Design Projects." The objective of the procedures as stated in the document is to maintain consistency in cost estimation practices and "to develop estimates that more accurately reflect the final construction costs (Tribelhorn 2007)." Project cost deviations from the programming estimates impact the plans and priorities of the Tentative Construction Program (TCP, also known as Red Book). Project cost estimates are used by the Fiscal Programming Bureau and the districts to develop the 5-year Tentative Construction Program to ensure that sufficient funds are available for construction.

MDT's Tentative Construction Program is a project scheduling process, which identifies the general location of highway construction projects planned within the next five years. The Engineering Division uses the Tentative Construction Program to prioritize project design. The Tentative Construction Program is a balanced program and under estimation of costs can result in the change of scope, project postponement, or even complete cancellation. On the other hand, if initial cost estimates are unrealistically high, there will not be enough projects in the Tentative Construction Program, which can lead to loss of federal funding or a rush to get additional projects on board.

The current MDT cost estimation procedure emphasizes the need to document all steps and assumptions used in the cost estimation process. It also requires the cost estimates to be as complete and as detailed as possible using the best available information. To create consistency the current MDT procedure provides guidelines for reporting cost estimates and discusses rates for mobilization and construction engineering costs for various project types (e.g., reconstruction, interstate overlay, signal projects, etc.). Other items that are covered in the cost estimation procedure are various cost estimation methods, contingency, and inflation factors as shown in Table 3.2 (Tribelhorn 2007).

Table 3.2 Cost Estimate Summary During Various Stages of MDT Project Development.

Stage	Cost Estimating Method	Contingency	Inflation
Nomination / Preliminary Field Review (PFR)	Cost/mile Cost/yd^2 Estimated quantities (cost estimate spreadsheet) HEAT module Similar project comparison	10% - 25%	3%
Alignment & Grade Review (AGR)	Cost estimate spreadsheet Cost/mile Cost/yd^2	10% - 25%	3%
Scope of Work (SOW)	Cost estimate spreadsheet Decision Support System (DSS) bid history	10% - 20%	3%
Plan-In-Hand (PIH)	Cost estimate spreadsheet DSS bid history Estimator	5% - 10%	3%
Final Plan Review (FPR) / Contract Plans	Cost estimate spreadsheet DSS bid history Estimator	0% - 5%	3%

The following is a brief description of each cost estimating method used in the current procedure:

- Cost per mile – Use similar projects in region that were let in the past 6 to 12 months
- Cost per yd^2 – Part of the current Pavement Condition and Treatment report published by the MDT Pavement Analysis Section (PvMS)
- Cost estimate spreadsheet (estimated quantities) – Estimate the quantities for the major bid items and assign average bid prices
- HEAT module – Cost estimation tool
- Similar project comparison – This is done generally for small and specialized projects. Compare to similar projects that were let recently and adjust for differences in project scope, regional cost variations, constructability issues, etc.
- DSS bid history – Use the DSS (an AASHTO Trns*port module) bid history and refine bid prices for regional and availability cost factors
- Estimator – Can be used with discretion as a check on the cost estimate, especially for the larger cost items

The current procedure also recognizes the need for tracking the changes in costs estimates at different stages. It states that "the purpose of showing the changes along with an explanation is to track our estimate history and trends. By giving accurate accounts of our estimates, we will be able to improve our estimating abilities (Tribelhorn 2007)." However, the current procedure does not provide a unified format for reporting cost changes. MDT has recognized this issue by including the development of a tool to track historic cost estimates versus actual cost estimates in STE's deliverables.

As shown in Table 3.2, more than one cost estimating method can be used in each stage of project development. This is especially important in early stages of cost estimation as project specific quantities are not known. For more confidence in a cost estimate, the current process requires the estimators to use more than one method for cost estimation. It states that the estimators should "use the highest level of estimating accuracy possible given the amount of information available, document all assumptions, and provide a written estimate, which includes a list of the items considered in the estimate (Tribelhorn 2007)."

For projects over $15 million, the procedure calls for a creation of a Cost Estimate Review team at the Alignment & Grade Review stage. The team works with the Project Design Manager to "review the bid prices used and to evaluate the known and unknown issues as well as the potential for significant risk issues (Tribelhorn 2007)." The procedure discusses the team members and details their responsibilities. One issue that can be noted is that at the Alignment & Grade Review stage the project is already programmed into the Tentative Construction Program and any cost changes will have an impact on the balanced budget.

The following explains how the costs of construction, preliminary engineering, construction engineering, right of way, and incidental construction are handled:

- Construction (CN) Cost – For the Nomination and Preliminary Field Review, MDT design staff have been directed to think about all aspects of the project.

- Preliminary Engineering (PE) Cost – At Nomination, the district or the Project Analysis Bureau uses a percent of construction cost to estimate the preliminary engineering costs. After the Preliminary Field Review is completed, all of the functional design units estimate the hours of time needed to complete individual design tasks and those hours are used to adjust the preliminary engineering estimate.

- Construction Engineering (CE) Cost – At Nomination, the district uses a percentage of the construction cost to estimate the construction engineering cost. For the Preliminary Field Review report, the Project Design Manager uses a percentage of construction cost to estimate the cost of construction engineering following the guidelines described in the current MDT cost estimation procedure.

- Right of Way (RW) Cost – At Nomination, the district estimates costs for right of way based on knowledge of the project site. If requested by the district, the Right-of-Way Bureau may also provide information at the time of Nomination. Currently, MDT design staff do not include right of way cost estimates in the Preliminary Field Review report. MDT has not provided guidance to MDT design staff to estimate these costs. Sometime after the Preliminary Field Review, the MDT Right-of-Way Bureau estimates the cost per acre of the land to be acquired as well as the value of any improvements within the planned right of way. In addition, information on the cost to mitigate damages to the remaining property caused by the project is gathered. Those damages are generally due to irrigation facilities, water wells, springs, and septic systems that are impacted by the project. In May 2008, a parcel tracking system was created in the MDT Oracle database, which can be used to gather historical right of way costs for right of way cost estimating.

- Incidental Construction (IC) Cost – At Nomination, the district estimates costs for incidental construction based on knowledge of the project site. Currently, MDT design staff do not include incidental construction cost estimates in the Preliminary Field Review report. MDT has not provided guidance to MDT design staff to estimate these costs. A major part of incidental construction cost is the cost of utility relocation, especially for urban projects. The Utilities Section, which is a part of the Right-of-Way Bureau, acts as the liaison between MDT and the utility companies. The Utilities Section provides guidance on utility related issues and works directly with utility companies to determine relocation alignments and create agreements for cost sharing. The actual costs are determined at the later stages of a project development when right of way is established, scope of work is known, and project plans are developed.

3.5.1 Tracking Cost and Schedule Changes

The current MDT cost estimation process contains several mechanisms for tracking changes in project scope, cost, and schedule over time. These include the Document Management System (DMS), Program and Project Management System (PPMS), and OPX2. Based on discussions with MDT staff, STE concluded that as an institution MDT has excellent knowledge of those systems. However, the degree of knowledge and use of those systems greatly varies between individuals in charge of day to day cost estimation and scheduling activities.

A critical need is to provide systematic and routine training for MDT staff involved in the cost estimation and scheduling activities on how to effectively utilize the available tracking systems. There is also a need to establish policies to track and document scope, cost, and schedule changes for a project. This need is clearly apparent by the difficulties encountered in retrieving data on cost and schedule changes for STE's data request template.

The current DMS, PPMS, and OPX2 systems are described below:

DMS is an electronic file management system that contains project specific reports at various stages including Preliminary Field Review, Alignment and Grade Review, Scope of Work, Plan-in-Hand, and Final Plan Review. Chapter 3 of MDT Road Design Manual dated June 7, 2006 provides details on format and content of each report.

PPMS is an application used by MDT personnel to enter and track project data effectively and in a timely manner over the life cycle of a project. The PPMS application is Oracle based but has a user friendly web page front end. The PPMS application has the following elements:

- Four primary modules
    - Program Manager (PGM)
    - Project Manager (PM)
    - Report Manager (RM)
    - System Manager(SM)
- Linkage to OPX2 scheduling application

The Program Manager module is used to establish and maintain program level data, which includes creating the STIP. The Project Manager module is used to establish, maintain, or view all project level data. This includes project identification, attribute, and funding data. This module also is used to create project schedules in the OPX2 application. The Report Manager module is used for reporting various application data available in the PPMS database. A number of predefined reports have been developed, however, the user can customize the reports if needed. The System Manager module is used for overall application setup and maintenance, which includes the setup of global reference information, lookup tables, and all user privileges and security. Based on the MDT interviews conducted in September 2007, the Project Design Manager and personnel from the Project Analysis Bureau are authorized to update the PPMS with data on project related changes.

The cost estimates and any changes to the project scope can be updated in the PPMS at every project stage. PPMS is a good source of information for keeping tabs on all project cost information. MDT personnel involved in a project are able to see the most recent cost estimate and project scope changes in PPMS. However, during STE interviews, many MDT personnel were unaware of whether PPMS allows the tracking of historical cost and scope changes over time. They indicated that they have not been able to use the system to monitor the cost and scope changes for a project over time. Further discussions with MDT revealed that PPMS can track changes throughout the life cycle of a project and the problem is the lack of a training program.

OPX2 is a software developed by Planisware. MDT uses the software to track schedules and key milestones of a project. Data from OPX2 can also be viewed in PPMS. All project scheduling activities can be entered (i.e., start and finish date) into OPX2 by MDT personnel. There are two sides to the system, “Pro-Client” and “Browser”. Only a few people have Pro-Client access and the rest of the team runs the Browser application. The OPX2 user can view the schedule for a project and also see the most up-to-date estimate; however, the user cannot see the history of cost estimates.

3.5.2 Managing Cost and Schedule Changes

As discussed earlier, many projects experience cost and schedule changes during their development. In many cases, changes are based on requests from MDT functional units (i.e., right-of-way, utility, geotechnical, traffic, hydraulics, etc.) due to unforeseen complexities or more realistic estimating of quantities and costs. The MTC has established a policy on how to reapprove a project that experiences increased cost. Policy 12, adopted on December 10, 2004, has set thresholds for cost increases that would require MTC approval. For example, any project greater than $2 million experiencing more than 10% cost increase is required to be reapproved by MTC (MTC 2004). Cost increases that do not meet these thresholds are handled by MDT staff. District Administrators (DA), the Project Analysis Bureau, and the Statewide and Urban Planning Section work closely with the Engineering Division and local governments to manage scope, cost, and schedule changes. Often final decisions are not made until the annual Tentative Construction Program meeting in the fall, where the latest cost estimates are reviewed and compared to the actual federal funds. At that meeting, decisions such as moving a project earlier in the program, moving it out to a later point in the program, splitting it, downsizing it, switching priorities, etc. are made.

3.6 Issues Identified with Current MDT Cost Estimation Process

As stated in the literature review, the issues with developing accurate project cost estimates starts early in the process. All agencies are struggling with ways to increase the accuracy of their initial project cost estimation. The most common difficulty observed is simply the lack of adequate project information (i.e., quantities, right of way, knowledge of utilities, detailed scope, etc.) at the Planning and Nomination stages. However, project cost estimates at the time of Nomination have significant and direct impact on the development of the STIP and also on defining priorities in the Tentative Construction Program.

3.6.1 Total Cost Estimate

One lesson learned from the literature review is that the project cost estimate at the time of Nomination should be a "total" project cost estimate. The FHWA's principle on "Contents of a Cost Estimate" described previously in Section 2 defines the total project cost estimate as the "total project purchase price." The Nomination cost should reflect the cost from inception to the end of construction. As such the Nomination cost should be a complete cost and include all project related costs such as preliminary engineering, construction engineering, incidental (i.e., utilities, traffic control, lighting, mobilization, environmental mitigation, public outreach, etc.), right of way, construction, contingencies, risks, and inflation costs.

STE recommends that the MDT cost estimation procedure be revised to include a definition for total and complete project estimated cost. MDT should consider a policy statement to track and control the total project cost estimate throughout the life cycle of a project.

3.6.2 Documentation and Reporting for Nomination Stage

NCHRP 8-49 and other literature discussed in Section 2 emphasized the importance of document quality, estimate quality, and estimate transparency. The MDT Road Design Manual describes the reporting requirements from the Preliminary Field Review through the Final Plan Review (MDT 2006). Similarly, the MDT Cost Estimation Procedure provides estimating guidelines for those stages. However, the MDT Cost Estimation Procedure describes the Nomination and Preliminary Field Review together. There is no description or reference to a formal documentation process for the Nomination stage.

MDT should consider developing standalone cost estimation and reporting guidelines for the Nomination stage. The reporting guidelines should contain a quality control checklist to ensure that all the major project elements have been considered during the initial scoping process. Elements that can be considered include:

- Grading
- Aggregates
- Paving
- Bridge Approach Panels
- Mobilization
- Removal/Salvage
- Drainage
- Traffic Control
- Turf/Erosion
- Signing
- Lighting
- Temporary Construction
- Utilities
- Aesthetics
- Retaining Walls
- Noise Walls
- Bridges
- Signals/Traffic
- Management Systems
- Right of Way
- Project Development/ Delivery

3.6.3 Timing of Preliminary Field Review

By the Preliminary Field Review stage, the project has already been nominated and programmed. Given the fact that a significant majority of "nominated" projects are "programmed" in Montana, it would be a better practice to conduct a formal Preliminary Field Review during the Nomination stage and prior to establishing the project nomination costs. This is in line with the principle of making estimation a priority by allocating time and staff resources. By formally getting the MDT functional units (i.e., right-of-way, utility, geotechnical, traffic, hydraulics, etc) involved very early in the process, the nomination cost estimate can be more thoroughly developed.

Given the limitation of resources available thresholds can be set for this requirement based on project size or cost. For example, a policy can be developed to make the Preliminary Field Review a requirement during the Nomination stage for all projects that are expected to cost over $500,000. Nomination cost estimates for right of way, all incidental costs including utility relocation should be developed in consultation with appropriate functional units within MDT. This is particularly important for urban projects where insufficient knowledge of right of way and utility relocation have been major contributors to cost overruns. At the time of Nomination, other existing project studies (e.g., Environmental Impact Reports) should also be reviewed for possible useful data such as right of way cost.

3.6.4 Accuracy of Inflation Forecasting

At the time of this research study, the MDT Cost Estimation Procedure utilized a 3% inflation rate. In recent years construction industry has been impacted by significantly higher inflation rates. It is unrealistic to use a 3% fixed inflation escalation rate throughout the cost estimation process. MDT should revaluate the use of a fixed inflation rate for its highway construction projects. It should be noted that MDT is in the process of making changes to the way inflation is calculated. STE has provided further recommendations for inflation forecasting in Section 4 of this report.

3.6.5 Better Tracking of Cost and Schedule Changes

The MDT Cost Estimation Procedure emphasizes the need to document all steps, assumptions, and significant changes in cost estimates throughout the life cycle of a project. The significant changes in cost estimates are mainly due to changes in scope, incorrect initial cost estimates, and lack of thorough understanding of unknown (risk) factors.

During the course of this project, STE requested specific cost data from MDT using the project developed data request template. MDT spent significant effort trying to gather the information requested by STE. However, STE was informed that "there is no specific detail of project cost changes as they relate to a specific decision during the development phase." Attempts to contact the project managers were also unsuccessful as "many of the project managers of the time were no longer with MDT." This clearly shows that the current processes for tracking changes do not readily produce key data and information on cost, schedule, and scope changes.

Detailed historical data on cost, schedule, and scope changes are essential to thoroughly understand the underlying problems with MDT's existing project development process. The historical data is also critical for capturing risk (unknown) factors by project type and for each region. It should be noted that some MDT personnel have stated that the current PPMS has the ability to track project cost, schedule, and scope changes. They have stated that the issue at hand is a training problem and not a system deficiency. Whether through the use of PPMS or by using the tracking system developed during this project, MDT needs to systematically track all cost, scope, and schedule changes.

3.7 Evaluation of MDT Cost Data

MDT provided two sets of data to STE for analysis. One set contained cost information on seventeen urban projects and the other contained cost information on nine MDT highway projects. As stated earlier, the data provided did not have any detailed information on factors causing cost or schedule changes. However, STE has utilized the data received to make some general observations.

3.7.1 Statewide and Urban Section Projects

During STE project interviews, staff from the Statewide and Urban Planning Section identified scope creep, lack of early and accurate cost estimates for right of way and utility relocation, and changes in local governments' priorities as primary reasons for cost and schedule overruns. Other problems identified were unrealistic and low initial cost estimates either due to lack of adequate attention to project scope details or simply providing low costs to get a project nominated. Political and outside pressures can also contribute to optimistic bias in cost and schedule estimating. All issues identified here are very similar to problems described in the literature review and are not unique to Montana.

As stated earlier, data for seventeen projects was submitted to STE for analysis. The initial year of the estimate varied from 1989 to 2001. The total costs were broken down by preliminary engineering, right of way, incidental, and construction costs. For most cases at least three revised estimates were provided over the years. Several of the projects listed did not have any initial cost estimates for preliminary engineering, right of way, or incidental costs.

Due to the limited size of the data received, STE conducted a cumulative analysis of the data by combining all the initial costs into preliminary engineering, right of way, incidental, and construction costs and total categories. A comparison is made between the initial estimated cost in each category versus the last revised cost. The number of projects (i.e., sample size) varied for each category due to gaps in the data set. Table 3.3 shows the results of the analysis.

Table 3.3 Comparison of Initial and Latest Revised Costs per Category.

Categories	Initial Estimated Cost ($)	Latest Revised Cost ($)	Change in Cost ($)	% Change in Cost	Sample Size (# of Projects)
Preliminary Engineering	2,671,708	12,012,257	9,340,549	350%	12
Right of Way	941,200	6,191,929	5,250,729	558%	5
Incidental	424,695	7,742,867	7,318,172	1,723%	5
Construction	72,590,606	168,132,630	95,542,024	132%	17
Total	75,558,211	212,135,976	136,577,765	181%	16

From the analysis it is clear that there is a tremendous and significant increase in costs in all categories. Construction cost increase is the most significant factor in terms of dollar amount. Cumulative increase of construction cost for the seventeen projects analyzed is $95.5 million, which is 132% over the original estimate of $72.5 million. Scope creep and poor initial cost estimation are among the reasons for significant cost increases presented in Table 3.3.

There were fifteen projects in the data set that had complete cost data for all categories. Table 3.4 represents the cumulative cost data for each category. It shows that 70% of the total project cost is construction cost followed by right of way at 12%, incidental at 10%, and preliminary engineering at 8%.

Table 3.4 Latest Revised Costs Breakdown.

Categories	Latest Revised Cost ($)	% of Total Cost	Sample Size (# of Projects)
Preliminary Engineering	14,008,029	8%	15
Right of Way	20,810,479	12%	15
Incidental	18,257,255	10%	15
Construction	126,082,630	70%	15
Total	179,160,400	100%	15

3.7.2 MDT Highway Projects

MDT provided nine cost data sets to STE for review and analysis. Construction cost was the only common cost element. There was no information provided on cost or schedule changes. The notes provided with the data sets identified scope changes as the primary cause of cost increases. MDT reported the following general observations:

- Projects with fewer unknowns at the time of nomination, simpler in scope, and with limits on scope due to budget constraints are closer to the initial cost estimates than those that are more complicated.
- There are some projects that entered into the process at a much lower scope than realistically possible.
- Cost estimate errors do not appear to be due to estimators' inability to accurately estimate the known project work items. The errors are due to estimators' inability to adequately identify or account for the unknown/unforeseen project costs at the time of nomination.

A cumulative analysis of data received showed that the programmed construction cost was $32.5 million. The total construction cost as let (i.e., at the time of award) was $45.8 million and the final construction cost for all nine projects was $47.6 million. This results in a 41% increase of construction cost from the time of programming to award and 46% increase from the time of programming to final construction cost. The final construction cost was within 4% of the award cost. This limited analysis is in agreement with MDT's observation that scope creep or underestimating costs were the primary reason for cost increases.

The above analyses indicate that the cost escalation problems may be more significant for urban projects. A larger and more detailed data set is needed to validate this observation. STE's proposed cost estimating tracking system, which will be described later in this report, can be a great way for gathering this information.

3.8 MDT Staff Interviews

In most cases, the best source for identifying issues is to seek input from the staff directly involved with the process. STE spent the week of September 17, 2007 at MDT headquarters interviewing various MDT staff involved with the cost estimation process. Additional interviews were conducted during the interim visit on January 30, 2008. The main objective of these interviews was to capture how different areas deal with the unknown uncertainties (i.e., risks) during the life of a project. STE's objective was to learn how each individual or group changes project cost or schedule when confronted with previously unaccounted project events. As discussed in Section 2, STE followed the guidelines of the NCHRP 8-49 to develop its list of interview questions, which are shown in Appendix B.

3.8.1 Cost Estimation Problems Identified by MDT Staff

STE has categorized the issues identified by MDT staff into five areas; namely, Management, Risk, Process, Communication, and Data. In some cases, the issues are interrelated among categories. Detailed interview information is provided in Appendix E. The following presents the findings:

Management

- Cost/schedule overruns cause negative public perception.
- Over programming is an issue.
- There is no single standard procedure or format for estimating costs.
- There is no cost/schedule containment mechanism.
- There are difficulties in splitting out costs for different funding categories, counties, tribal boundaries, etc.
- There is a lack of adequate time to prepare projects cost estimates for programming purposes.
- Significant changes in overall funding levels and projects costs result in an inefficient (start/stop) design process.
- Staff workload does not allow adequate time and attention to cost estimating process.

Risks

- Project risks are not always accounted for properly.
- Utility relocation cost was identified as a major unknown risk.
- Early estimation of right of way cost was identified as a major unknown risk.
- Estimates are poor partly due to the use of an unrealistic and constant inflation factor (i.e., 3%).
- Unforeseen market events significantly affect the cost of major items.
- The contingency factor for right of way is set too low at the time of final plans (i.e., 0-5%). At that stage right of way negotiations may still be ongoing with potential for significant cost changes.

Process

- Projects costs are often underestimated.
- There is often project scope creep.
- Time span between project nomination and project delivery is too long at times, which adds to the risks.
- Not all factors are considered in the nomination costs.
- In the past historical cost data was not updated routinely.
- There are inconsistent initial cost estimation practices among districts and functional units.
- Cost estimates are constantly changing.
- There are too many tools in too many places.
- MDT staff need training to create consistency in estimates. Lack of training in Trns*port Estimator was particularly mentioned.
- The most difficult scheduling items are the purchase of right of way and relocation of utilities.
- Different groups want the cost information in different formats for reporting, some include indirect cost (IDC), others require traffic control or construction engineering to be separated out.

Communication

- There is a lack of an easy or reliable cost tracking system.
- There is a disconnect between the projected and exact letting dates.
- It is sometimes difficult to get a good estimate in a timely manner from another functional unit.
- There is not a one stop shopping area for cost estimation process.
- There is sometimes confusion on what the current project priorities are within the Department. Sometimes, functional units work on projects that have low priority.
- Lack of project knowledge and what is being asked for can result in unrealistic estimates.
- Large misunderstanding in the Department of what the information is needed for a project thus, the best information is not necessarily obtained by the right people.

Data

- Impacts of changes in market conditions (inflation) on materials, labor, fuel, land are not captured adequately.
- Inflationary factors are constant (3%), haven't been updated recently, and don't necessarily account for regional market impacts.
- There is not enough information available to perform cost based estimating.
- There are inconsistencies in unit bid price data.
- Unit costs used are often not current.
- A comprehensive database on cost that is current need to be available.
- Difficulties with using a 6 month history for bid items. If the quantity is small or large, it tends to skew the costs. Many items may not be used in the 6 month period so costs may be difficult to obtain.
- Geographic differences are difficult to quantify when there are very few projects let in some geographic areas.

3.8.2 Recommendations by MDT Staff

STE also asked if MDT staff had recommendations for improving the cost and schedule estimation process. STE has categorized the recommendations identified by MDT staff into five areas; namely, Management, Risk, Process, Communication, and Data. In some cases, the recommendations are interrelated among categories. Detailed interview information is provided in Appendix E. The following presents the findings:

Management

- Hire full time cost estimators within Preconstruction Engineering Section
- Allow a project to stay on schedule by preventing it from becoming derailed and delayed by other priorities
- Do not over program. It causes cost increases and project splits.
- Explore cost based estimating for big cost items
- Cost estimates at nomination need to be more realistic.
- Allocate adequate staff/time to the cost estimation at the time of nomination

Risk

- Improve risk analysis and management process
- Enhance available tools for justifying and tracking mobilization costs, traffic control, and construction engineering costs
- Develop risk factors for right of way and incidental costs including utility relocation costs, especially for urban projects

Process

- Improve guidelines for cost estimation at the time of nomination
- Keep cost estimating tools and software up to date
- Create quality assurance checks for validating estimates
- Move toward a more standardized cost estimation process that integrates as many inputs as possible
- The department should consider software that would handle the cost estimate for each project from nomination to contract letting and construction.
- Schedule ready dates should be revised based on funding levels on a quarterly basis to keep MDT priorities current.
- A one-stop-shop program that automatically calculates all the prices by region, scope, length, width, amenities, etc., using all of the existing tools and lists them side-by-side for comparison.
- Develop tracking ability to determine where the cost increases occur (materials, scope change, unknowns, etc.) for developing risk factors
- Create consistency in estimating costs for utilities, right of way, construction engineering, preliminary engineering and construction
- Create consistency in reporting format for cost estimation

Communication

- MDT should review projects with unusually high percentage of preliminary engineering, incidental, and construction costs. MDT should document reasons and evaluate the need for process changes.
- Create a cost tracking system that uses data already available in the Oracle database
- Keep design staff up to date with training
- Staff need to be trained on Estimator Trns*port.
- Communication and training would help the process.

Data

- Develop regional inflation rates and keep them up to date
- Provide readily available up to date unit price information based on today's market
- Develop external trend tracking sources, using non-MDT data, to help anticipate national and regional trends in costs of projects items
- Understand that 3% inflation is not realistic

3.9 Summary Recommendations

STE concludes that the most fundamental management policy that a department can make is to make "estimation a priority." Allocating time and staff resources are the first steps for improving the MDT cost estimation process. STE believes that the following recommendations address the issues identified by MDT staff and will improve the MDT cost estimating process:

- Create cost estimation section
- Routine updates of unit cost data on MDT intranet
- Develop comprehensive cost estimating manual
- Develop quality control and quality assurance program for cost estimating
- Develop comprehensive system for capturing risk factors
- Create procedures for managing inflation
- Establish routine training program for staff involved in cost estimating

These recommendations are thoroughly discussed in Section 4.0, Recommendations.

4.0 RECOMMENDATIONS

The following recommendations are made based on STE's review of literature and evaluation of MDT's current practices:

- Create cost estimation section
- Routine updates of unit cost data on MDT intranet
- Develop comprehensive cost estimating manual
- Develop quality control and quality assurance program for cost estimating
- Develop comprehensive system for capturing risk factors
- Create procedures for managing inflation
- Establish routine training program for staff involved in cost estimating

This section thoroughly discusses the recommendations and provides strategic procedures for successful implementation.

4.1 Create Cost Estimation Section

STE discussed the establishment of a cost estimation section with the MDT project panel. MDT stated that it was unlikely that it could establish a fully staffed section for cost estimating responsibilities in the immediate future. Although MDT is not creating a cost estimation section at this time, it is in the process of hiring two full time cost estimators. STE recommends that at least one of the two new hires be senior cost estimator or a cost estimator manager. STE also recommends that the two new cost estimators be responsible for the following activities:

- Routine (i.e., Quarterly) updates of unit cost data on MDT intranet
- Develop a comprehensive cost estimating manual with detailed procedures and standardized tools.
- Continuous update of the cost estimating manual
- Develop standardized formats for reporting projects cost estimates
- Develop quality control program for cost estimating
- Random cost validation checks (quality assurance checks) of project costs at the time of nomination
- Keep the cost estimating methods and tools presented in Table 3.2 current
- Maintain the historical cost estimation tracking system (including the Monte Carlo simulation process discussed later in this section)
- Provide training on cost estimation activities to MDT staff

As indicated by the activities listed above, the estimators will be the champions of promoting, enhancing, and advancing the cost estimation processes already in place at MDT. The estimators will act as a "hub" for disseminating information to and enhancing communication amongst current MDT staff involved in cost estimating.

4.2 Routine Updates of Unit Cost Data

As stated in Section 4.1 the cost estimation section (or new hired estimators) will be in charge of routinely updating (at least quarterly) and publishing the unit cost data on the MDT intranet. This used to be an issue at MDT but the practice of keeping the unit cost data current is now in place. It is important to ensure that all MDT cost estimators are using the most updated cost information in their analysis.

4.3 Develop Comprehensive Cost Estimating Manual

STE recommends developing a comprehensive cost estimating manual that contains the following elements:

- Estimating Policies
- Estimating Procedures
- Defining Contingency
- Risk Analysis
- Documentation of Estimates
- Defining Roles and Accountability
- Quality Control and Quality Assurance
- Approval of Estimates
- Training Tools

Some of these elements may already exist but they are not in an inclusive document.

Once the estimators are hired, the following steps should be considered to create a cost estimating manual with consistent tools and applications:

1. The estimators should visit with the district staff and administrators involved with the cost estimation process. They will need to create an inventory of all the programs, tools, and documents that are used by district staff to develop the initial nominated project costs.

2. The estimators should visit with staff at MDT headquarters including staff from Road Design, Urban Planning, Contract Plans, Safety, Right of Way, and Utilities to create a comprehensive inventory of all the programs, tools, and documents that are being use to create project related cost estimates.

3. A MDT cost estimation panel including staff from the districts, MDT headquarters, and the estimators should be formed to standardize the tools and programs that are being used for cost estimation. It is given that due to the evolving nature of cost estimation from nomination to award, various tools and applications will be used at different stages. For example, the existing cost estimation spreadsheets may continue to be used at the districts for project nomination while more powerful programs such as the Trns*port modules may be used for cost estimation at later stages at MDT headquarters. The importance of this step is that the tools and programs are all identified, accepted, and then routinely updated across MDT.

4. The list of methods and tools identified in Steps 1-3 should be incorporated into the existing MDT Cost Estimation Procedure for Highway Design Projects.

5. The MDT cost estimating panel should work with the estimators to develop new policies on cost estimation reviews. The frequency of reviews may be increased based on size and significance of the projects (i.e., projects that cost above a certain amount will be reviewed automatically, below a certain amount will be randomly reviewed).

6. The MDT cost estimating panel should also make policy decisions on the definition of total project cost and also on scheduling the Preliminary Field Review sooner in the project development (i.e., during the Nomination stage).

7. The MDT cost estimating panel should also consider developing standalone cost estimation and reporting guidelines for the Nomination stage.

8. As stated earlier, cost based estimating is very time consuming and require highly experienced estimators. MDT should consider WSDOT's policy of limiting the use of cost based estimates to project items with the largest dollar value, typically 20% of items of work containing 80% of the project costs.

4.4 Develop Quality Control and Quality Assurance Program

A Quality Control and Quality Assurance (QC/QA) Program should be developed to improve the cost estimation process. This program should be included in the MDT cost estimation manual. The quality control program should include a checklist of all items necessary for the estimate. A quality control checklist ensures that all the major project elements have been considered during the initial scoping process. The quality assurance program will describe the process and policies for cost estimation review and approval process.

4.5 Develop Comprehensive System for Capturing Risk Factors

STE recommends the development of a comprehensive system for capturing risk factors. As discussed previously, STE developed a data request template for MDT, which can be utilized to track cost and schedule changes throughout the life cycle of a project. This template shown in Appendix A can be the framework for an MDT cost/schedule tracking system.

The tracking system with the inclusion of an Excel based Monte Carlo Simulation Tool can be referred to as the new MDT Risk Analysis Program (RAP). The development of usable risk factors will take a few years. Data will be needed to generate Montana specific risk factors for various project types and categories. To implement the Risk Analysis Program, STE recommends the following steps:

Step 1. Make the cost estimating tracking system an integrated part of every project from the time of nomination to final project close out. The cost estimating tracking system can remain Excel based or it can become a PPMS module in the MDT Oracle database. STE believes that MDT Information Technology personnel can easily incorporate the cost estimating tracking system into the PPMS as a tracking module. On the other hand, STE has no reservation with recommending the proposed Excel spreadsheet as a standalone tool. However, the estimators need to make sure that for every project and at every stage, the tracking system is updated with "accurate" information.

Step 2. A commercial Monte Carlo simulation package such as @Risk or Crystal Ball should be purchased to support the simulation analysis. These readily available packages can be run as an add-on to an Excel spreadsheet and are reasonably priced (i.e., below $2,000).

The following example has been developed using @RISK. STE used randomly generated programming costs as well as cost overruns for each risk factor. The database format should closely resemble the example provided in Figure 4.1. Using @RISK, an estimator can fit a specific category's data to a statistical distribution.

In this example, Insufficient Knowledge of Right of Way data were fitted to a uniform distribution, Unforeseen Engineering Complexities were fitted to a normal distribution, and Changes in Market

Conditions were fitted to a triangular distribution. The @RISK data fitting graphs are shown in Figures 4.2, 4.3, and 4.4. In Figure 4.2, the data were fitted to a uniform statistical distribution with a mean of 11%. In Figure 4.3, the data were fitted to a normal statistical distribution with a mean of 5%. In Figure 4.4, the data were fitted to a triangular statistical distribution with a mean of 24%. In @Risk, data can be fitted to any of 38 statistical distributions, including the uniform, normal, triangular, exponential, logarithmic normal, and chi-square distributions. In this example, a 1,000 simulations were performed on each risk category. Based on the fitted distributions, an estimator can calculate a category's most likely risk factor.

	A	B	C	D	E	F	G	H	I
1		Range	Range	Range		Range	Range	Range	Range
2		7%-15%	5%-10%	3%-7%	3%-5%	7%-20%	10%-25%	10%-40%	3%-7%
3									
4	Proj. No.	Right-Of-Way Acquisition	Environmental Mitigation	Engineering Complexities	Traffic Needs	Stakeholders	Unforseen Events	Market Conditions	Utilities
5	1	12.0%	5.0%	4.0%	4.0%	12.0%	11.0%	25.0%	5.0%
6	2	10.0%	8.0%	3.0%	5.0%	9.0%	24.0%	32.0%	3.0%
7	3	14.0%	10.0%	7.0%	3.0%	8.0%	18.0%	22.0%	6.0%
8	4	12.0%	6.0%	6.0%	3.0%	11.0%	21.0%	34.0%	3.0%
9	5	13.0%	10.0%	5.0%	5.0%	7.0%	24.0%	19.0%	4.0%
10	6	8.0%	7.0%	5.0%	4.0%	13.0%	20.0%	26.0%	4.0%
11	7	7.0%	9.0%	3.0%	3.0%	8.0%	18.0%	23.0%	4.0%
12	8	12.0%	9.0%	7.0%	3.0%	10.0%	11.0%	35.0%	5.0%
13	9	9.0%	6.0%	6.0%	3.0%	12.0%	22.0%	26.0%	4.0%
14	10	10.0%	7.0%	3.0%	4.0%	9.0%	11.0%	29.0%	5.0%
15	11	12.0%	10.0%	5.0%	5.0%	11.0%	12.0%	22.0%	7.0%
16	12	10.0%	8.0%	7.0%	5.0%	12.0%	13.0%	14.0%	4.0%
17	13	9.0%	8.0%	6.0%	4.0%	17.0%	16.0%	34.0%	4.0%
18	14	8.0%	7.0%	3.0%	3.0%	17.0%	12.0%	23.0%	7.0%
19	15	9.0%	9.0%	4.0%	4.0%	8.0%	17.0%	25.0%	5.0%
20	16	7.0%	9.0%	7.0%	3.0%	14.0%	20.0%	21.0%	5.0%
21	17	9.0%	6.0%	6.0%	4.0%	12.0%	16.0%	34.0%	4.0%
22	18	11.0%	5.0%	3.0%	4.0%	8.0%	10.0%	24.0%	3.0%
23	19	8.0%	7.0%	6.0%	4.0%	16.0%	19.0%	11.0%	4.0%
24	20	14.0%	7.0%	5.0%	5.0%	10.0%	15.0%	27.0%	6.0%
25	21	7.0%	9.0%	6.0%	4.0%	11.0%	22.0%	23.0%	7.0%
26	22	14.0%	9.0%	3.0%	3.0%	9.0%	18.0%	17.0%	4.0%
27	23	7.0%	8.0%	4.0%	5.0%	16.0%	17.0%	13.0%	7.0%
28	24	15.0%	10.0%	4.0%	5.0%	19.0%	24.0%	13.0%	7.0%
29	25	13.0%	10.0%	5.0%	3.0%	12.0%	11.0%	30.0%	3.0%

Random Values / Monte Carlo Simulation

Figure 4.1 Format of Database Spreadsheet.

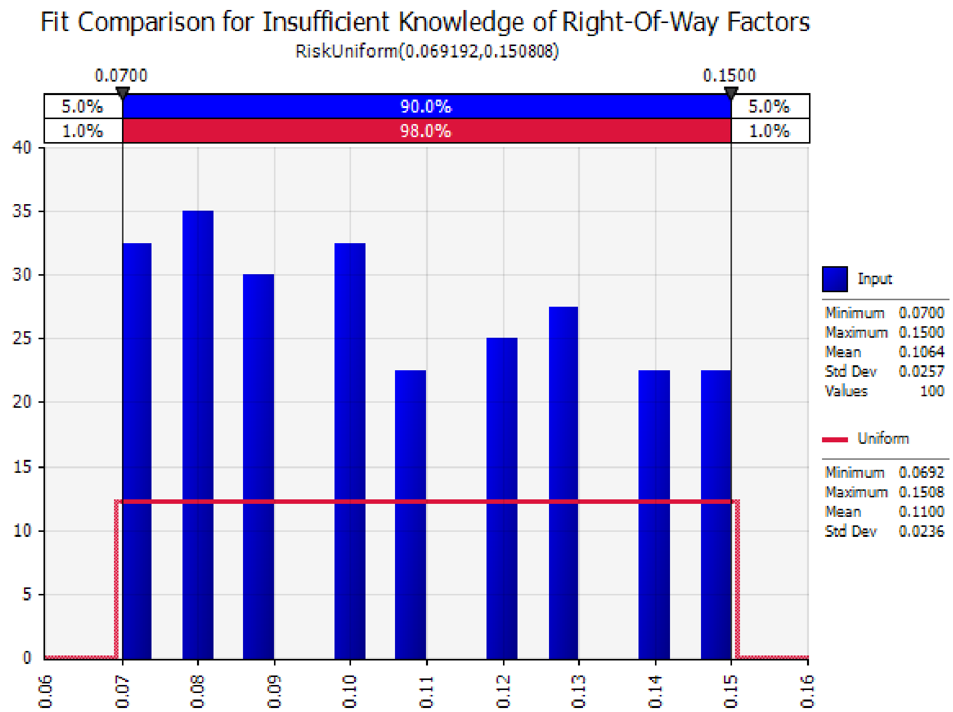

Figure 4.2 Data Fitting Curve for Randomly Generated Insufficient Knowledge of Right of Way Data.

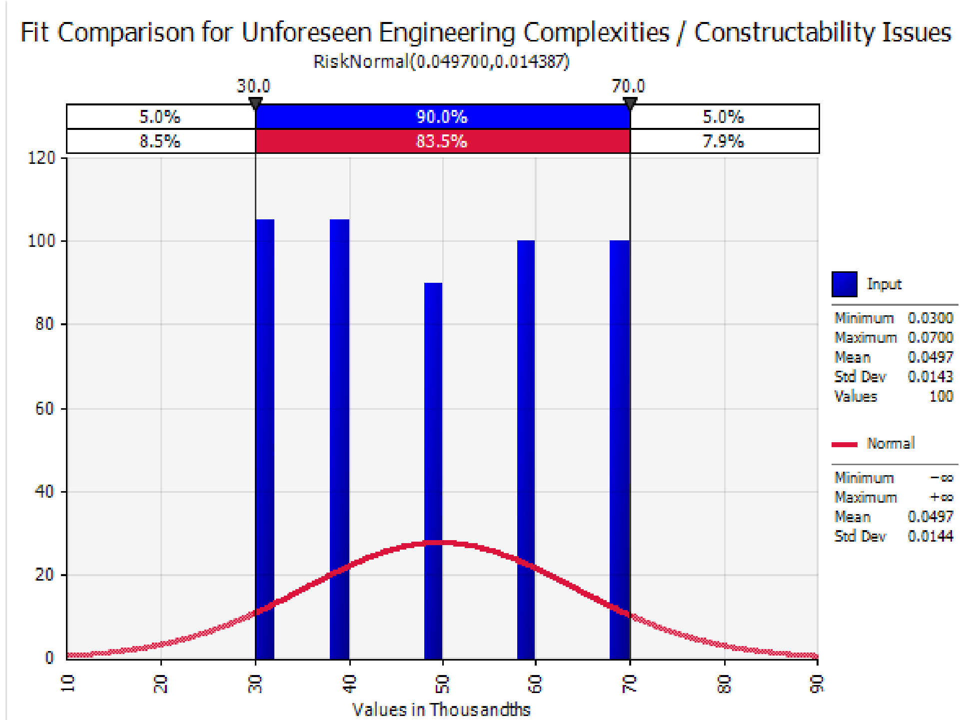

Figure 4.3 Data Fitting Curve for Randomly Generated Engineering Complexities Data.

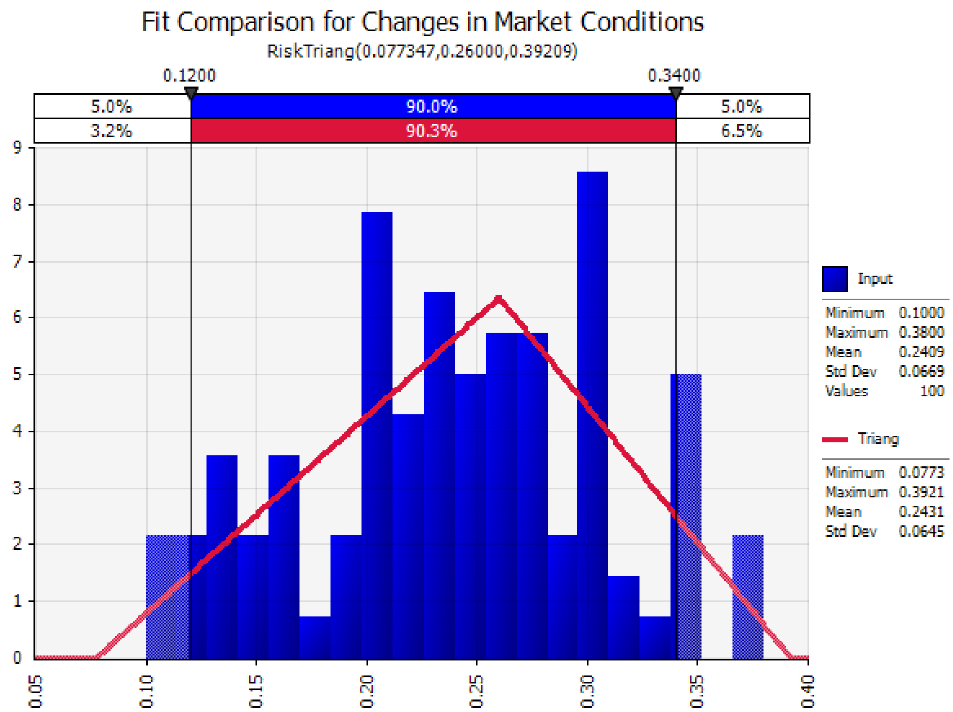

Figure 4.4 Data Fitting Curve for Randomly Generated Changes In Market Conditions Data.

Once the data have all been fitted to a statistical distribution, @RISK can be used to perform the Monte Carlo simulation. The Monte Carlo simulation process further refines the calculated risk factor. For example, a Monte Carlo simulation on the Changes in Market Conditions data gave a most likely value of 24.3% as shown in Figure 4.5.

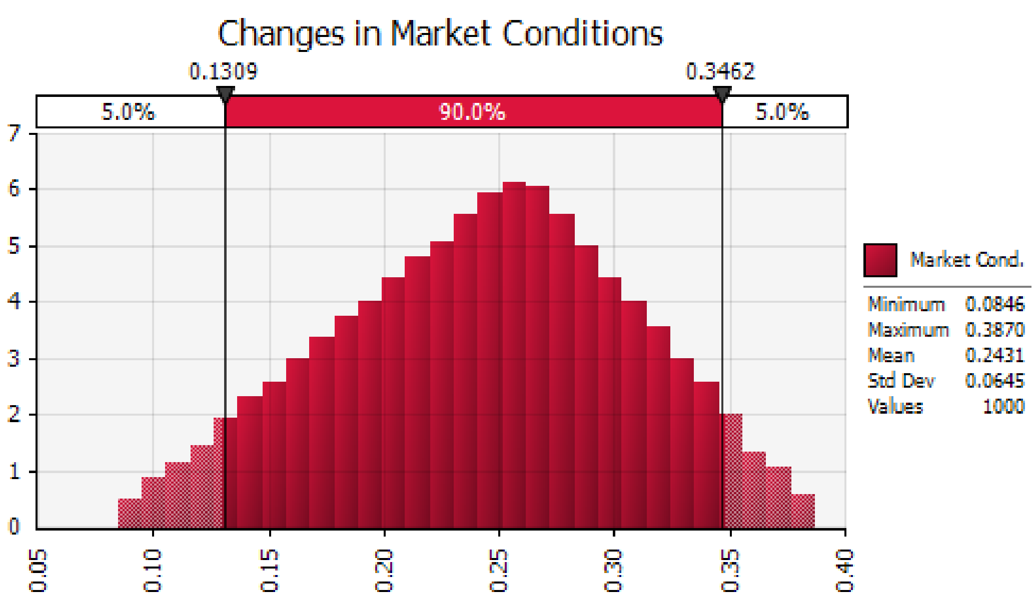

Figure 4.5 Monte Carlo Simulation Output.

Additionally, an estimator can calculate which category contributes most greatly to total project cost overruns. Calculated through Monte Carlo analysis, a tornado graph reveals which risk category contributes most greatly. For example, the randomly generated data was most influenced by Changes in Market Conditions as shown in Figure 4.6. Each risk category is ranked by its regression coefficient (R^2) value.

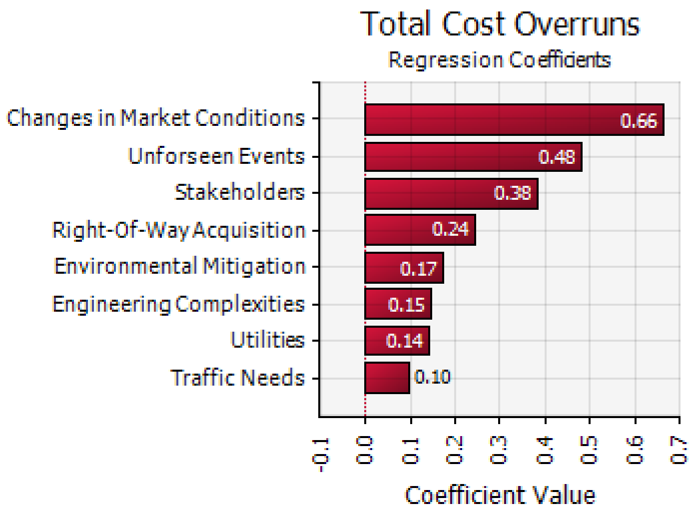

Figure 4.6 Total Cost Overruns Tornado Graph Based on Randomly Generated Cost Overrun Data.

Step 3. The risk factors obtained in Step 2 for each category and type of project can be used to replace the unknown portion of existing contingencies listed in the MDT Cost Estimation Procedure. Thorough and technical review of risk factors is necessary prior to any changes in the existing process.

Step 4. A yearly update of risk factors should be conducted using the most up to date data from the cost estimating tracking system.

STE envisions that the new estimators would be able to conduct the Monte Carlo simulation and report the newly established risk factors by project type and category. Regional differences can also be studied to see if risk factors need to be broken down further into regions or districts.

MDT should also investigate the use of Cost Risk Assessment (CRA) and Cost Estimating and Validation Process (CEVP) workshops to assess risks for its high profile and/or large projects. These workshops were described in the literature review section of this report. As stated earlier, WSDOT uses CRA workshops for projects over $25 million and CEVP workshops for projects over $100 million. WSDOT Policy for Risk Assessment also suggests that other types of unique or unusual projects, or projects with certain attributes (e.g., projects with high degree of political interest, major structures, projects with multiple stages, etc.) that are typically over $5 million may benefit from a CRA workshop. A CRA workshop is typically three days and can cost between $30,000 and $60,000 depending on project size and complexity. A CEVP workshop will typically takes five days and can cost $40,000 to $120,000 depending on project complexity and number of subject matter experts involved. STE has been told that the biggest project that MDT has ever awarded was less than $23 million and therefore, the use of those processes should be assessed carefully to maximize their benefits.

4.6 Procedures for Managing Inflation

As shown in Table 2.4, MDT staff ranked changes in market conditions as the most significant risk factor for cost overruns. Traditionally, MDT has used an inflation rate of 3% per year, compounded annually. MDT's current practice is to inflate the total estimated construction cost after adding in contingencies. Inflation is calculated up to the midpoint of construction.

A recent survey conducted by the WSDOT Office of Research and Library Services in February of 2007 showed that there is "no consistent approach to capturing inflation amongst agencies (WSDOT 2007b)." A copy of this survey is presented in Appendix F. The reported annual inflation rates varied from 3% to 6% and are estimated based on a number of different approaches. Producer Price Index (PPI), Consumer Price Index (CPI), FHWA Construction Cost Index, historical inflation trends, and commercial forecasting services such as Moody's and Global Insight are being used in various ways to forecast inflation by agencies around the nation. As stated earlier, there is no consistent approach to forecasting inflation. In addition, NCHRP 8-49 and other literature provide general discussions on inflation and lack specificity.

4.6.1 MDT Ongoing Analysis

There is a significant and ongoing effort at MDT to analyze historical cost trends to determine inflationary factors at the state level. A recently prepared MDT internal report entitled "Highway Construction Cost Trends" describes past and present inflation trends and a methodology for developing Montana specific highway cost indices (Fossum 2007). Figure 4.7, which is reproduced from the MDT report, shows the major increase in inflation trends in highway construction costs starting in 2004. Prior to 2004, Consumer Price Index-Urban (CPI-U) and Producer Price Index (PPI) for highway construction followed the same trend. Recent inflation trends in highway construction costs are captured in PPI for highway construction after 2004. The Global Insight baseline inflation projection of 2% for highway construction is shown on Figure 4.7 as well.

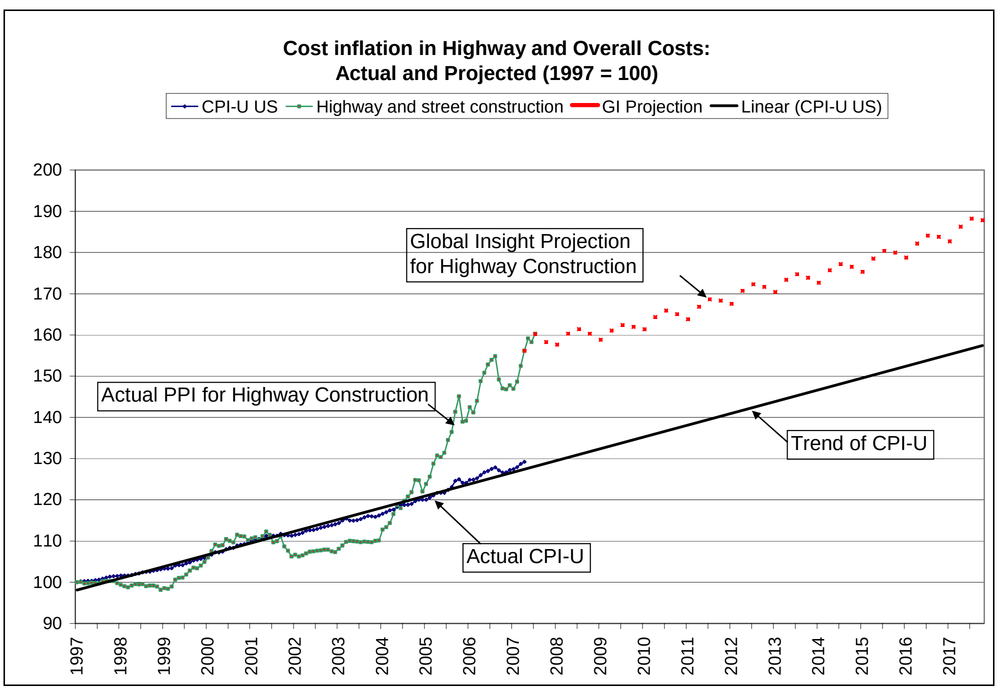

Figure 4.7 Comparison of Various Indices as Related to Highway Construction Costs (Fossum 2007).

4.6.2 MDT Cost Indexing Efforts

Recently, MDT developed highway construction cost indices for major cost items that covered approximately 50% of total highway construction costs. The recently prepared MDT internal report entitled "Highway Construction Cost Trends" describes the methodology for developing Montana specific highway cost indexing as follows (Fossum 2007):

> *"Detailed item price data were extracted from DSS Trans*port from 2000 to most recent available. Representative item groups were identified, including: earthwork; aggregate; plant mix; asphalt; reinforcing steel; structural steel; concrete; and structural concrete. For each item group, the most common unit of measure (e.g., weight, volume, area, length) was selected, and comparably measured items in each group were extracted for analysis. In some cases – notably concrete – large numbers of empty cells (i.e., items not purchased consistently over the years) limited the field products to a few items for cost trend analysis. Within each year and product group, weighted average prices were calculated, and the percent of construction spending was totaled. Weighted average prices and percent of total construction spending were summarized in a table for each year and brought forward to a summary sheet. Prices were indexed by product group to make the differently measured units comparable. Weighted values were found by multiplying indexed prices by the percent of total construction spending represented by the sampled items. These weightings were applied and the product was totaled and indexed to 2004. The item groups were weighted by average percent of all purchases at the five-digit item group level between 2000 and 2007."*

Table 4.1 represents highway construction cost indices and inflation trends based on data received from MDT. STE calculated yearly inflation trends by evaluating the percent change in cost index from one year to the next.

Table 4.1 MDT Reported Highway Construction Cost Indices and STE Calculated Inflation Rates.

Year	Cost Index*	% Change (Inflation)
2000	75	
2001	82	9.16%
2002	79	-2.57%
2003	94	18.32%
2004	100	6.38%
2005	104	3.61%
2006	139	34.12%
2007	152	9.72%
	Average Inflation	11.25%

**Cost indices indexed to Year 2004.*

The inflation rates reported in Table 4.1 confirm that in recent years highway project cost estimates have been adversely impacted by higher than expected (i.e., higher than 3%) inflation rates. MDT's ongoing work suggests that inflation rates will be within 1% to 4.5% up to year 2013, 1.5% to 3% up to year 2015, and 2% to 3% up to year 2017. STE believes that these values are too optimistic given the recent past history of inflation trends in highway construction costs. STE proposes the following step by step approach to capture inflation:

Step 1. For long term planning beyond the framework of the Tentative Construction Program (i.e., five years and longer), use the national forecasted trends or MDT defined inflation (e.g., 3%).

Step 2. For short term planning of less than five years and within the framework of the Tentative Construction Program, capture the inflation trends for the most volatile highway construction items (e.g., earthwork, aggregate, plant mix, asphalt, reinforcing steel, structural steel, concrete, and structural concrete) utilizing the inflation rates established from cost indices as described in Section 4.6.2. There are two ways to achieve Step 2.

a. The first method is to develop an annual inflation rate for each volatile construction item individually based on year to year cost index fluctuations.

b. The second method (preferred for simplicity) is to calculate one "aggregate" inflation rate for "all" major construction items as shown in Section 4.6.2.

The results of both methods will be historical annual inflation rates that can be used to create a base for "short term" inflation rates. These rates can be applied to their appropriate cost items individually (or in aggregate, if that is the case).

Step 3. It is recognized that the inflation rates developed in Step 2 are historical and therefore, there is a need to forecast inflation into the future. However, it is also recognized that the future volatility in the market may have very little to do with the past and therefore simple curve fitting techniques will be ineffective. STE recommends the use of "exponential smoothing techniques" to develop inflation rates for the short term five year Tentative Construction Program cycles. This can be updated annually. Unlike single moving averages, where the past observations are weighted equally, exponential smoothing assigns exponentially decreasing weights as the observations get older. Using this technique recent observations are given relatively more weight in forecasting than the older observations.

Step 4. STE recommends that MDT continues updating and fine tuning its cost indices for volatile construction items annually.

Step 5. For the remaining 50% of the total highway construction costs, which contains less volatile items, MDT can choose to continue using the national forecasted or its current 3% rate for inflation.

4.7 Establish Routine Training Program

As discussed in Section 4.1, the cost estimating team will be in charge of developing and conducting a comprehensive cost estimate training program. The goals of a cost estimate training program are to:

- Improve the flow of information on factors affecting the cost estimation process among the MDT staff
- Introduce new practices of project cost estimation
- Reinforce the commitment of the department to the importance of improving cost estimation process

Due to the involved nature of cost estimating and the new recommendations discussed in this report, STE recommends that the training course be divided into 1) organizational information and 2) manuals, tools, & software instruction. The following describes the training course.

4.7.1 Organizational Information

The organizational information portion of the training course should be approximately one day and should focus on MDT's structure, operations, and current cost estimating process. STE believes that MDT staff should understand all project cost estimation and development stages and realize their interconnected roles in the cost estimating operation. Training materials should include background information on MDT organization and divisions and information on Statewide Transportation Improvement Program, Tentative Construction Program, Urban Projects, and MDT operations.

4.7.2 Manuals, Tools, and Software Instruction

The training needs to be comprehensive and cover all aspects of cost estimation including software, procedures, and reporting. The existing MDT cost estimation practices are quite advanced as compared to many other agencies and are comprised of written procedures (e.g., MDT Cost Estimation Procedures, Road Design Manual, software documentations), powerful programs (e.g., PPMS, OPX2, Trns*port), and tools (e.g., DMS, cost estimate spreadsheets). As mentioned previously, the degree of knowledge and use of these systems greatly varies between individuals in charge of day to day cost estimation and scheduling activities. STE recommends creating a training manual composed of materials from all the tools & software used by MDT cost estimating staff. This manual should explain how each tool/software operates and how to use it. Typically, these documents will describe features of a program and the various steps required to operate it.

STE envisions a two-day training seminar for manuals tools and software. The software training can be customized to emphasize applications that are more commonly used by individuals from various divisions and groups within MDT.

4.7.3 Review Training

STE recommends that the organizational information portion of the training course be conducted bi-annually. All estimators involved in the cost estimating operation should attend. STE recommends that the manuals, tools, and software instruction portion of the training course be conducted annually. All MDT staff using the cost estimating manuals, tools, and software should attend. The training course should also be routinely updated to reflect the latest cost estimation procedure, changes in software, and tools.

5.0 IMPLEMENTATION PLAN

The implementation plan and suggested timeline are described in Section 5.1. The performance measure indicators are described in Section 5.2.

5.1 IMPLEMENTATION PLAN AND TIMELINE

The following are the suggested timelines for implementing the recommendations and procedures described in Section 4 of this report.

- Create Cost Estimating Section
  - STE recognizes that MDT will be hiring two full time estimators, however, a standalone section is not anticipated.
    - Within the next 6 months MDT should finalize the roles and responsibilities of the two full time estimators and hire them.
    - Within the following six months the estimators should establish the framework for activities listed in Section 4.1.

- Develop a Comprehensive System for Capturing Risk Factors
  - Within the next 12 months MDT should complete and make operational the system for capturing risk factors as described in Section 4.5.

- Create Procedures for Managing Inflation
  - Within the next six months MDT should establish procedures for managing inflation based on recommendations described in Section 4.6.

- Establish Routine Training Program
  - Within the next 12 months MDT should establish a routine training program as described in Section 4.7. MDT should conduct the first round on training within a year from the completion of this report.

5.2 PERFORMANCE INDICATORS

The most significant performance indicator is to get cost/schedule estimates that more accurately reflect the final construction cost/schedule. This evaluation will take time as necessary data on cost and schedule have to be gathered. Using the risk analysis procedure, comparisons can be made over time between the programming, award, and final costs and schedules. STE anticipates that it will take a 5-year cycle of a Tentative Construction Program to gather enough information to conduct a full evaluation.

Another performance indicator is to see reductions in historical risk factors over time. STE believes that the implementation of its recommendations will result in across the board reductions in risk factors over time. Again, STE anticipates that it will take a 5-year cycle of a Tentative Construction Program to assess the improvements.

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APPENDIX A. DATA REQUEST TEMPLATE
(FUTURE COST ESTIMATING TRACKING SYSTEM)

Phrase / Word	Definition
Ad/Bid/Award Phase	Contract Plans processes
AGR	Alignment and Grade Review
BR	Bridge system
CE	Construction engineering phase
CN	Construction phase
Completion Date	Date that all construction is completed and contractor is off the project
Construction Phase	Construction processes
Final Cost	Total of all costs after all project phases (PE, RW, IC, CE, CN) closed
Final Design Phase	Plan-in-Hand (PIH) through Final Plan Review (FPR) and delivery of plans to Contract Plans
Finalized Date	Date that all phases are closed (PE, RW, IC, CE, CN)
FPR	Final Plan Review
IC	Incidental construction phase (Utlities)
IM	Interstate system
NH	Non-interstate national highway system
PE	Preliminary engineering phase
PFR	Preliminary Field Review
PIH	Plan-in-Hand
Planning Phase	MDT's nomination through Preliminary Field Review (PFR)
Preliminary Design Phase	Preliminary Field Review (PFR) through Scope of Work (SOW)
Programming Cost	Known cost at time of programming; may include contingency and inflation factors; includes all estimated costs (PE, CE, RW, IC, CN)
Project Category	IM, NH, STPP, STPS, STPU, BR, Safety
Project Completion Cost	Final cost of project as constructed
Project Development Phase	Scope of Work (SOW) to Plan-in-Hand (PIH)
Project District	MDT district (e.g., Great Falls, Billings, etc.)
Project Location	Urban or rural
Project Name/ID	Name or ID used by MDT
Project Type	N: New; R1: Rehabilitation; R2: Reconstruction; R3: Resurfacing Projects; SI: Spot Improvement
ROW	Right-of-Way
RW	Right-of-Way phase
Safety	Safety projects (Spot improvements not related to Emergency Relief Program)
SOW	Scope of Work
STIP	Statewide transportation improvement plan
STPP	State primary system
STPS	Secondary system
STPU	Urban system

Project Description	
Project Name/ID	
Project District	
Project Location	
Project Type	
Project Category	
Schedule and Cost Information	
Planning Schedule	
Date Project Programmed	
Expected Project Letting Date	
Date Project Awarded	
Number of Bidders	
Construction Schedule	
Starting Date of Construction	
Expected Construction Completion Date	
Construction Completion Date	
Finalized Date	
Project Cost	
Programming Cost Estimate	
Total Estimated Project Cost at the Time of Award	
Total Project Completion Cost (After All Phases Are Closed)	

Known Uncertainties Included in Programming Cost

Provide break down of uncertainties included in the programming cost:

Uncertainties	Considered	($)	(%)
a. Right-of-way			
b. Environmental			
c. Engineering			
d. Traffic			
e. Stakeholders			
f. Unforeseen events			
g. Market condtions			
h. Utilities			
i. Others (please specify)			

Provide break down of uncertainties included in the programming schedule:

Uncertainties	Considered	(months)	(%)
a. Right-of-way			
b. Environmental			
c. Engineering			
d. Traffic			
e. Stakeholders			
f. Unforeseen events			
g. Market condtions			
h. Utilities			
i. Others (please specify)			

Insufficient Knowledge of Right-Of-Way Factors

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Disagreement on freeway access		
b. Objections to ROW appraisal		
c. Acquisition problems		
d. Staffing issues		
e. Volatile real estate market/rapid escalation		
f. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Disagreement on freeway access		
b. Objections to ROW appraisal		
c. Acquisition problems		
d. Staffing issues		
e. Volatile real estate market/rapid escalation		
f. Others (please specify)		

Insufficient Knowledge of Right-Of-Way Factors

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Disagreement on freeway access		
b. Objections to ROW appraisal		
c. Acquisition problems		
d. Staffing issues		
e. Volatile real estate market/rapid escalation		
f. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Disagreement on freeway access		
b. Objections to ROW appraisal		
c. Acquisition problems		
d. Staffing issues		
e. Volatile real estate market/rapid escalation		
f. Others (please specify)		

Environmental Mitigation Requirements

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Permits or agency actions delayed or took longer than expected		
b. Agency disputes/disagreements not resolved in a timely manner		
c. New information required for permits		
d. Environmental regulations change		
e. New issues in dealing with historic or archeological site, endangered species, wetland		
f. Additional environmental analysis required		
g. Tribal issues		
h. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Permits or agency actions delayed or took longer than expected		
b. Agency disputes/disagreements not resolved in a timely manner		
c. New information required for permits		
d. Environmental regulations change		
e. New issues in dealing with historic or archeological site, endangered species, wetland		
f. Additional environmental analysis required		
g. Tribal issues		
h. Others (please specify)		

Environmental Mitigation Requirements

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
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a. Permits or agency actions delayed or took longer than expected		
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c. New information required for permits		
d. Environmental regulations change		
e. New issues in dealing with historic or archeological site, endangered species, wetland		
f. Additional environmental analysis required		
g. Tribal issues		
h. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Permits or agency actions delayed or took longer than expected		
b. Agency disputes/disagreements not resolved in a timely manner		
c. New information required for permits		
d. Environmental regulations change		
e. New issues in dealing with historic or archeological site, endangered species, wetland		
f. Additional environmental analysis required		
g. Tribal issues		
h. Others (please specify)		

Unforeseen Engineering Complexities / Constructability Issues

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	($)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Contractors / subcontractors capability		
f. Work zone safety and mobility		
g. Site specific requirements		
h. Geotechnical conditions		
i. Drainage / hydraulic issues		
j. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Contractors / subcontractors capability		
f. Work zone safety and mobility		
g. Site specific requirements		
h. Geotechnical conditions		
i. Drainage / hydraulic issues		
j. Others (please specify)		

Unforeseen Engineering Complexities / Constructability Issues

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Contractors / subcontractors capability		
f. Work zone safety and mobility		
g. Site specific requirements		
h. Geotechnical conditions		
i. Drainage / hydraulic issues		
j. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Sufficiency of plans and specifications		
b. Change in seismic criteria		
c. Soil conditions		
d. Soil contamination		
e. Contractors / subcontractors capability		
f. Work zone safety and mobility		
g. Site specific requirements		
h. Geotechnical conditions		
i. Drainage / hydraulic issues		
j. Others (please specify)		

Changes in Traffic Control Needs due to Design or Traffic Growth

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Design change		
b. Traffic growth		
c. Land use changes/developments		
d. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Design change		
b. Traffic growth		
c. Land use changes/developments		
d. Others (please specify)		

Changes in Traffic Control Needs due to Design or Traffic Growth

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Design change		
b. Traffic growth		
c. Land use changes/developments		
d. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Design change		
b. Traffic growth		
c. Land use changes/developments		
d. Others (please specify)		

Increased Local Government, Community, and Stakeholders Expectations

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Tribal Employment Rights Office (TERO) fee		
g. Overlapping Governmental Jurisdictions		
h. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Tribal Employment Rights Office (TERO) fee		
g. Overlapping Governmental Jurisdictions		
h. Others (please specify)		

Increased Local Government, Community, and Stakeholders Expectations

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Tribal Employment Rights Office (TERO) fee		
g. Overlapping Governmental Jurisdictions		
h. Others (please specify)		

	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Objections posed by local communities		
b. Late changes requested by stakeholders		
c. Emergence of new stakeholders demanding new work		
d. Threats of lawsuit		
e. Stakeholders choose time and/or cost over quality		
f. Tribal Employment Rights Office (TERO) fee		
g. Overlapping Governmental Jurisdictions		
h. Others (please specify)		

Unforeseen Events

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Forest fires		
b. Weather related incidents (e.g., floods, wind, snow)		
c. Earthquake		
d. Man-made disasters (e.g., train derailments, vehicle accidents)		
e. Change in state and national economic conditions / funding availability		
f. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Forest fires		
b. Weather related incidents (e.g., floods, wind, snow)		
c. Earthquake		
d. Man-made disasters (e.g., train derailments, vehicle accidents)		
e. Change in state and national economic conditions / funding availability		
f. Others (please specify)		

Unforeseen Events

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Forest fires		
b. Weather related incidents (e.g., floods, wind, snow)		
c. Earthquake		
d. Man-made disasters (e.g., train derailments, vehicle accidents)		
e. Change in state and national economic conditions / funding availability		
f. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Forest fires		
b. Weather related incidents (e.g., floods, wind, snow)		
c. Earthquake		
d. Man-made disasters (e.g., train derailments, vehicle accidents)		
e. Change in state and national economic conditions / funding availability		
f. Others (please specify)		

Changes in Market Conditions

		($)	
	Change in Project Cost		
	If available break down this cost in the following subcategories:		
	Subcategories	($)	(%)
	a. Labor		
	b. Fuel		
	c. Materials		
	d. Land		
	e. Others (please specify)		
		(months)	
	Change in Project Schedule		
	If available break down this schedule change in the following subcategories:		
	Subcategories	(months)	(%)
	a. Labor		
	b. Fuel		
	c. Materials		
	d. Land		
	e. Others (please specify)		

Changes in Market Conditions

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	($)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	(months)	(%)
a. Labor		
b. Fuel		
c. Materials		
d. Land		
e. Others (please specify)		

Utilities

		($)	
	Change in Project Cost		
	If available break down this cost in the following subcategories:		
	Subcategories	($)	(%)
	a. Coordination with local utilities efforts		
	b. Utility negotiations		
	c. Delay		
	d. Railroad involvement		
	e. Others (please specify)		
		(months)	
	Change in Project Schedule		
	If available break down this schedule change in the following subcategories:		
	Subcategories	(months)	(%)
	a. Coordination with local utilities efforts		
	b. Utility negotiations		
	c. Delay		
	d. Railroad involvement		
	e. Others (please specify)		

Utilities

	($)	
Change in Project Cost		
If available break down this cost in the following subcategories:		
Subcategories	**($)**	**(%)**
a. Coordination with local utilities efforts		
b. Utility negotiations		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		
	(months)	
Change in Project Schedule		
If available break down this schedule change in the following subcategories:		
Subcategories	**(months)**	**(%)**
a. Coordination with local utilities efforts		
b. Utility negotiations		
c. Delay		
d. Railroad involvement		
e. Others (please specify)		

APPENDIX B. STAFF INTERVIEW MATERIAL

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

	Rank According to Significance (with 1 being the most significant and 8 being the least significant)	
Categories	**Cost**	**Schedule**
Insufficient Knowledge of Right-Of-Way Factors		
Environmental Mitigation Requirements		
Unforeseen Engineering Complexities / Constructability Issues		
Changes in Traffic Control Needs due to Design or Traffic Growth		
Increased Local Government, Community, and Stakeholders Expectations		
Unforeseen Events		
Changes in Market Conditions		
Utilities		

Name	
Title	
Department/Division	
Phone	
E-mail	
Fax	

Q1.	Please describe your role in the cost/schedule estimation process. If not a direct role, what inputs do you provide that impact a project cost and/or schedule?
MDT RESPONSE	

Q2.	**When encountering a previously unaccounted project condition -**
Q2a.	**How do you communicate this information with the original estimators?**
M D T R E S P O N S E	

Q2b.	Do you follow a prescribed procedure to document and communicate those unforeseen conditions? If so, please describe the process.
M D T R E S P O N S E	

Q3.	How does your group seek additional funding and authorization for the necessary cost/schedule changes due to a newly discovered project condition? How has this cost/schedule overrun impacted other projects?
MDT RESPONSE	

Q4.	What management system(s) or planning/engineering software do you use to provide information for the cost/schedule estimation process?
M D T R E S P O N S E	

Q5.	What issues does your group face in providing information for the cost/schedule estimation process? Please provide as much detail as possible.
M D T R E S P O N S E	

Q6.	What recommendations/suggestions do you have for improving the cost/schedule estimation process?
M D T R E S P O N S E	

In the following worksheets, project risks are categorized into several groups. Based on your professional experience, please rate the significance of risks on past/current MDT projects from "high" to "low". Please note that this is a subjective survey and therefore provide your best opinion (i.e., rating) based on your own experience. You may leave the events that you have not encountered blank.

Insufficient Knowledge of Right-Of-Way Factors

Rate cost significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Disagreement on freeway access			
b. Objections to ROW appraisal			
c. Acquisition problems			
d. Staffing issues			
e. Volatile real estate market/rapid escalation			
f. Others (please specify)			

Rate schedule significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Disagreement on freeway access			
b. Objections to ROW appraisal			
c. Acquisition problems			
d. Staffing issues			
e. Volatile real estate market/rapid escalation			
f. Others (please specify)			

Environmental Mitigation Requirements

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Permits or agency actions delayed or took longer than expected			
b. Agency disputes/disagreements not resolved in a timely manner			
c. New information required for permits			
d. Environmental regulations change			
e. New issues in dealing with historic or archeological site, endangered species, wetland			
f. Additional environmental analysis required			
g. Tribal issues			
h. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Permits or agency actions delayed or took longer than expected			
b. Agency disputes/disagreements not resolved in a timely manner			
c. New information required for permits			
d. Environmental regulations change			
e. New issues in dealing with historic or archeological site, endangered species, wetland			
f. Additional environmental analysis required			
g. Tribal issues			
h. Others (please specify)			

Unforeseen Engineering Complexities / Constructability Issues

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Sufficiency of plans and specifications			
b. Change in seismic criteria			
c. Soil conditions			
d. Soil contamination			
e. Contractors / subcontractors capability			
f. Work zone safety and mobility			
g. Site specific requirements			
h. Geotechnical conditions			
i. Drainage / hydraulic issues			
j. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Sufficiency of plans and specifications			
b. Change in seismic criteria			
c. Soil conditions			
d. Soil contamination			
e. Contractors / subcontractors capability			
f. Work zone safety and mobility			
g. Site specific requirements			
h. Geotechnical conditions			
i. Drainage / hydraulic issues			
j. Others (please specify)			

Changes in Traffic Control Needs due to Design or Traffic Growth

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Design change			
b. Traffic growth			
c. Land use changes/developments			
d. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Design change			
b. Traffic growth			
c. Land use changes/developments			
d. Others (please specify)			

Increased Local Government, Community, and Stakeholders Expectations

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Objections posed by local communities			
b. Late changes requested by stakeholders			
c. Emergence of new stakeholders demanding new work			
d. Threats of lawsuit			
e. Stakeholders choose time and/or cost over quality			
f. Tribal Employment Rights Office (TERO) fee			
g. Overlapping Governmental Jurisdictions			
h. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Objections posed by local communities			
b. Late changes requested by stakeholders			
c. Emergence of new stakeholders demanding new work			
d. Threats of lawsuit			
e. Stakeholders choose time and/or cost over quality			
f. Tribal Employment Rights Office (TERO) fee			
g. Overlapping Governmental Jurisdictions			
h. Others (please specify)			

Unforeseen Events			
Rate cost significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Forest fires			
b. Weather related incidents (e.g., floods, wind, snow)			
c. Earthquake			
d. Man-made disasters (e.g., train derailments, vehicle accidents)			
e. Change in state and national economic conditions / funding availability			
f. Others (please specify)			
Rate schedule significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Forest fires			
b. Weather related incidents (e.g., floods, wind, snow)			
c. Earthquake			
d. Man-made disasters (e.g., train derailments, vehicle accidents)			
e. Change in state and national economic conditions / funding availability			
f. Others (please specify)			

Changes in Market Conditions

Rate cost significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Labor			
b. Fuel			
c. Materials			
d. Land			
e. Others (please specify)			

Rate schedule significance in the following subcategories:

Subcategories	High Significance	Medium Significance	Low Significance
a. Labor			
b. Fuel			
c. Materials			
d. Land			
e. Others (please specify)			

Utilities			
Rate cost significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Coordination with local utilities efforts			
b. Utility negotiations			
c. Delay			
d. Railroad involvement			
e. Others (please specify)			
Rate schedule significance in the following subcategories:			
Subcategories	**High Significance**	**Medium Significance**	**Low Significance**
a. Coordination with local utilities efforts			
b. Utility negotiations			
c. Delay			
d. Railroad involvement			
e. Others (please specify)			

APPENDIX C. RATING ANALYSES REPORTS

Because of the absence of data from previous MDT construction projects, STE asked the interviewees to:

1. Rate the eight risk categories according to their significance with “1” being the most significant and “8” being the least significant.
2. Rate the risk subcategories as having high, medium, or low significance.

As part of this analysis, STE evaluated each risk category and subcategory with respect to “Cost” and “Schedule.”

Objective and Methodology

STE evaluated the responses for the risk categories and subcategories using multivariate statistical methods known as principal component analysis for ordinal rates, also known as PRINQUAL. STE received 20 survey responses for the risk categories and 24 survey responses for the risk subcategories. This summary represents complete or partial survey responses.

The steps involved in the rating analysis were:

- Step 1: Created spreadsheet with risk categories in rows and respondent scores in columns.
- Step 2: Created a new column called “ID” by combining the two or three risk categories in the excel data file.
- Step 3: Deleted any columns with all missing rankings.
- Step 4: Converted data into SAS datasets.
- Step 5: PRINQUAL analysis:
    - Summarized the ordinal data using a principal component analysis for qualitative data.
    - Rankings were all related the first principal component.
    - Used PRINQUAL data transformation procedure using SAS software version 9.13.
        - Obtained linear and nonlinear transformations of variables by using the method of alternating least squares to optimize properties of the transformed variables' covariance matrix.
        - The ordinal variables were monotonically transformed by scoring the ordered categories so that order is weakly preserved and the covariance matrix is optimized.
- Step 6: Transformed standardized principal component scores into a user friendly scale.
    - From -2.5 (Highest ranking) & 2.5 (lowest ranking) to a score of 1 is considered as (Highest ranking) & 0 is considered as (lowest ranking).

Results

The risk categories and subcategories are ranked according to principal component. The principal component analysis is a multivariate technique for examining relationships among several quantitative variables. Three factors are presented, with Factor 1 being the most significant. Factor 2 and Factor 3 are ancillary factors. The shaded cells in the following tables represent large scores for Factor 2 and Factor 3 that indicate a few respondents rated these categories as more important than the other risk categories or subcategories.

Tables C.1 and C.2 present the analysis results of the eight risk categories with respect to cost and schedule. Similarly, Tables C.3 to C.17 present the analysis results of the risk subcategories with respect to cost and schedule.

Table C.1 Ranking of Risk Categories by Cost.

Risk Categories Rankings by Factor 1 Scores	Factor 1	Factor 2	Factor 3
Changes in Market Conditions	0.84671	0.41778	0.73916
Unforeseen Engineering Complexities / Constructability Issues	0.76486	0.54950	0.44075
Increased Local Government, Community, and Stakeholders Expectations	0.56523	0.65888	0.46897
Insufficient Knowledge of Right-Of-Way Factors	0.45253	0.20194	0.59512
Environmental Mitigation Requirements	0.39679	0.36366	0.01791
Unforeseen Events	0.32968	0.81159	0.60191
Utilities	0.29984	0.42380	0.38177
Changes in Traffic Control Needs due to Design or Traffic Growth	0.21970	0.32863	0.67386

Table C.2 Ranking of Risk Categories by Schedule.

Risk Categories Rankings by Factor 1 Scores	Factor 1	Factor 2	Factor 3
Environmental Mitigation Requirements	0.65994	0.50378	0.24261
Insufficient Knowledge of Right of Way Factors	0.65468	0.18494	0.58911
Unforeseen Engineering Complexities / Constructability Issues	0.65369	0.76832	0.37667
Increased Local Government, Community, and Stakeholders Expectations	0.64683	0.74276	0.44858
Changes in Market Conditions	0.61568	0.38440	0.73587
Utilities	0.38153	0.35844	0.42148
Unforeseen Events	0.29978	0.74236	0.79590
Changes in Traffic Control Needs due to Design or Traffic Growth	0.21252	0.55923	0.47033

Table C.3 Ranking of Right of Way Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
c. Acquisition problems	0.72179	0.96384	0.99750
e. Volatile real estate market/rapid escalation	0.61431	0.96837	0.71370
b. Objections to RW appraisal	0.53088	0.99714	0.80655
d. Staffing issues	0.41086	0.82994	0.78110
a. Disagreement on freeway access	0.26133	0.63232	0.55890
f. Others (please specify)	0.18875	0.52783	0.59110

Table C.4 Ranking of Right of Way Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
c. Acquisition problems	0.80893	0.99721	0.87132
e. Volatile real estate market/rapid escalation	0.52667	0.92091	0.50278
d. Staffing issues	0.47781	0.73963	0.71955
b. Objections to RW appraisal	0.46250	0.94526	0.57831
a. Disagreement on freeway access	0.30047	0.86610	0.87097
f. Others (please specify)	0.14026	0.48444	0.46361

Table C.5 Ranking of Environmental Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
g. Tribal issues	0.68145	0.70995	0.23698
f. Additional environmental analysis required	0.61110	0.70751	0.23164
a. Permits or agency actions delayed or took longer than expected	0.58127	0.73853	0.44847
b. Agency disputes/disagreements not resolved in a timely manner	0.49348	0.57540	0.48402
e. New issues in dealing with historic or archeological site, endangered species, wetland	0.46686	0.65405	0.54274
d. Environmental regulations change	0.46662	0.53762	0.34331
c. New information required for permits	0.45553	0.57311	0.48956
h. Others (please specify)	0.14026	0.48444	0.46361

Table C.6 Ranking of Environmental Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
g. Tribal issues	0.69691	0.72591	0.13448
a. Permits or agency actions delayed or took longer than expected	0.68018	0.87429	0.21504
f. Additional environmental analysis required	0.60836	0.70006	0.03923
b. Agency disputes/disagreements not resolved in a timely manner	0.60208	0.63226	0.09307
c. New information required for permits	0.5165	0.73873	0.17419
e. New issues in dealing with historic or archeological site, endangered species, wetland	0.49284	0.5576	0.26392
d. Environmental regulations change	0.47635	0.58586	0.14506
h. Others (please specify)	0.14026	0.48444	0.46361

Table C.7 Ranking of Unforeseen Engineering Complexities Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Sufficiency of plans and specifications	0.74984	0.27100	0.46135
h. Geotechnical conditions	0.71471	0.48782	0.23922
c. Soil conditions	0.70122	0.37640	0.39680
i. Drainage / hydraulic issues	0.65039	0.34708	0.49031
g. Site specific requirements	0.56874	0.32684	0.72473
d. Soil contamination	0.53645	0.38224	0.45581
e. Contractors / subcontractors capability	0.48286	0.15341	0.79735
f. Work zone safety and mobility	0.44001	0.33508	0.67046
b. Change in seismic criteria	0.32255	0.56479	0.46557
j. Others (please specify)	0.14026	0.48444	0.46361

Table C.8 Ranking of Unforeseen Engineering Complexities Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Sufficiency of plans and specifications	0.67947	0.15209	0.65055
h. Geotechnical conditions	0.63501	0.29955	0.31639
i. Drainage / hydraulic issues	0.60333	0.33748	0.39746
c. Soil conditions	0.60166	0.21964	0.55670
g. Site specific requirements	0.54814	0.34807	0.76090
e. Contractors / subcontractors capability	0.54021	0.07343	0.64687
d. Soil contamination	0.47778	0.15511	0.53359
f. Work zone safety and mobility	0.46777	0.26898	0.70469
b. Change in seismic criteria	0.34959	0.45714	0.55205
j. Others (please specify)	0.14026	0.48444	0.46361

Table C.9 Ranking of Traffic Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Design change	0.73261	0.27730	0.82948
c. Land use changes/developments	0.68892	0.41151	0.80566
b. Traffic growth	0.58942	0.43384	0.67526
d. Others (please specify)	0.17109	0.38342	0.76307

Table C.10 Ranking of Traffic Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Design change	0.67623	0.26930	0.88877
c. Land use changes/developments	0.65911	0.37181	0.68718
b. Traffic growth	0.58300	0.35100	0.75924
d. Others (please specify)	0.14026	0.48444	0.46361

Table C.11 Ranking of Government, Community, and Stakeholders Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Objections posed by local communities	0.71934	0.37822	0.68491
c. Emergence of new stakeholders demanding new work	0.66796	0.29518	0.38708
b. Late changes requested by stakeholders	0.66195	0.18610	0.62404
d. Threats of lawsuit	0.58330	0.48630	0.77601
e. Stakeholders choose time and/or cost over quality	0.47005	0.26582	0.61908
g. Overlapping Governmental Jurisdictions	0.44354	0.48826	0.48213
f. Tribal Employment Rights Office (TERO) fee	0.43486	0.45556	0.38116
h. Others (please specify)	0.14026	0.48444	0.46361

Table C.12 Ranking of Government, Community, and Stakeholders Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
a. Objections posed by local communities	0.77216	0.38186	0.40413
b. Late changes requested by stakeholders	0.71892	0.38787	0.63529
c. Emergence of new stakeholders demanding new work	0.64397	0.28249	0.36059
d. Threats of lawsuit	0.52941	0.49727	0.59974
g. Overlapping Governmental Jurisdictions	0.40222	0.58502	0.37519
e. Stakeholders choose time and/or cost over quality	0.40172	0.42956	0.46908
f. Tribal Employment Rights Office (TERO) fee	0.37789	0.41001	0.54343
h. Others (please specify)	0.14026	0.48444	0.46361

Table C.13 Ranking of Unforeseen Events Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
e. Change in state and national economic conditions / funding availability	0.76812	0.49535	0.51443
b. Weather related incidents (e.g., floods, wind, snow)	0.43854	0.37133	0.52232
a. Forest fires	0.39354	0.37698	0.46155
c. Earthquake	0.31637	0.56134	0.44520
d. Man-made disasters (e.g., train derailments, vehicle accidents)	0.28930	0.44115	0.48184
f. Others (please specify)	0.14026	0.48444	0.46361

Table C.14 Ranking of Unforeseen Events Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
e. Change in state and national economic conditions / funding availability	0.72878	0.29311	0.71873
b. Weather related incidents (e.g., floods, wind, snow)	0.47843	0.35713	0.30925
a. Forest fires	0.39003	0.39124	0.38143
d. Man-made disasters (e.g., train derailments, vehicle accidents)	0.31791	0.37852	0.46309
c. Earthquake	0.30118	0.46001	0.43472
f. Others (please specify)	0.14026	0.48444	0.46361

Table C.15 Ranking of Changes in Market Conditions Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
b. Fuel	0.86817	0.46717	0.58613
c. Materials	0.86018	0.50557	0.42015
d. Land	0.81536	0.54311	0.44378
a. Labor	0.67728	0.51511	0.52489
e. Others (please specify)	0.14026	0.48444	0.46361

Table C.16 Ranking of Changes in Market Conditions Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
c. Materials	0.61116	0.59225	0.45506
d. Land	0.56441	0.77023	0.59016
b. Fuel	0.52587	0.61550	0.60750
a. Labor	0.49062	0.55760	0.54492
e. Others (please specify)	0.14026	0.48444	0.46361

Table C.17 Ranking of Utilities Subcategory by Cost.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
c. Delay	0.70782	0.55198	0.16940
d. Railroad involvement	0.64937	0.40626	0.27649
a. Coordination with local utilities efforts	0.54540	0.48882	0.35215
b. Utility negotiations	0.50752	0.55146	0.39411
e. Others (please specify)	0.14026	0.48444	0.46361

Table C.18 Ranking of Utilities Subcategory by Schedule.

Subcategory Rankings by Factor 1 Score	Factor 1	Factor 2	Factor 3
c. Delay	0.73622	0.47899	0.04268
d. Railroad involvement	0.72690	0.50271	0.33936
a. Coordination with local utilities efforts	0.65839	0.45284	0.15875
b. Utility negotiations	0.53828	0.49391	0.26653
e. Others (please specify)	0.14026	0.48444	0.46361

Interpretation of Results

Although this analysis is not based on previous MDT projects in terms of cost and time, the results indicate how the MDT personnel feel about the risk categories and subcategories presented to them.

As shown in Tables C.1 and C.2, the ranking of the risk categories by cost indicated that Changes in Market Conditions and Unforeseen Engineering Complexities / Constructability Issues were the most significant. The ranking of the risk categories by schedule had a group of five with similar values; namely, Environmental Mitigation Requirements, Insufficient Knowledge of Right-Of-Way Factors, Unforeseen Engineering Complexities / Constructability Issues, Increased Local Government, Community, and Stakeholders Expectations, and Changes in Market Conditions.

For the Insufficient Knowledge of Right-Of-Way Factors Risk Category, the most significant subcategory for both cost and schedule was Acquisition Problems as shown in Tables C.3 and C.4. Although, there was some difference of opinion based on high values observed for Factor 2 and Factor 3.

For the Environmental Mitigation Requirements Risk Category ranked by cost, there was a group of three with similar values; namely, Tribal Issues, Additional Environmental Analysis Required, and Permits or Agency Actions Delayed or Took Longer than Expected as shown in Table C.5. Although, there was some difference of opinion based on high values observed for Factor 2. For the Environmental Mitigation Requirements Risk Category ranked by schedule, there was a group of four with similar values; namely, Tribal Issues, Permits or Agency Actions Delayed or Took Longer than Expected, Additional Environmental Analysis Required, and Agency Disputes/Disagreements Not Resolved in a Timely Manner as shown in Table C.6. Although, there was some difference of opinion based on high values observed for Factor 2.

For the Unforeseen Engineering Complexities / Constructability Issues Risk Category, the most significant subcategory for both cost and schedule was Sufficiency of Plans and Specifications as shown in Tables C.7 and C.8.

For the Changes in Traffic Control Needs due to Design or Traffic Growth Risk Category, the most significant subcategories for both cost and schedule were Design Change and Land Use Changes/Developments as shown in Tables C.9 and C.10. Although, there was some difference of opinion based on high values observed for Factor 3.

For the Increased Local Government, Community, and Stakeholders Expectations Risk Category, the most significant subcategory for both cost and schedule was Objections Posed by Local Communities as shown in Tables C.11 and C.12.

For the Unforeseen Events Risk Category, the most significant subcategory for both cost and schedule was Change in State and National Economic Conditions / Funding Availability as shown in Tables C.13 and C.14.

For the Changes in Market Conditions Risk Category ranked by cost, there was a group of three with similar values; namely, Fuel, Materials, and Land as shown in Table C.15. For the Changes in Market Conditions Risk Category ranked by schedule, the most significant subcategory was Materials as shown in Table C.16.

For the Utilities Risk Category ranked by cost, the most significant subcategory was Delay as shown in Table C.17. For the Utilities Risk Category ranked by schedule, there was a group of two with similar values; namely, Delay and Railroad Involvement as shown in Table C.18.

SAS output files generated when Ranking main categories by cost and schedule using SAS PROCS PRINRQUAL, FACTOR, and GPLOT.

PRINQUAL MTV Algorithm Iteration History					
Iteration Number	Average Change	Maximum Change	Proportion of Variance	Criterion Change	Note
1	0.43788	1.75256	0.29502		
2	0.08336	0.45381	0.61569	0.32068	
3	0.06835	0.32458	0.63095	0.01526	
4	0.05313	0.25509	0.64047	0.00952	
5	0.04060	0.20016	0.64605	0.00558	
6	0.03213	0.15277	0.64929	0.00324	
7	0.02563	0.11684	0.65128	0.00199	
8	0.02020	0.06371	0.65254	0.00125	
9	0.01604	0.04690	0.65332	0.00078	
10	0.01280	0.03846	0.65381	0.00049	
11	0.01032	0.03187	0.65412	0.00031	
12	0.00824	0.02633	0.65433	0.00020	
13	0.00647	0.02171	0.65446	0.00013	
14	0.00528	0.01917	0.65455	0.00009	
15	0.00427	0.01700	0.65460	0.00006	
16	0.00346	0.01484	0.65464	0.00004	
17	0.00282	0.01281	0.65466	0.00002	
18	0.00228	0.01094	0.65468	0.00002	
19	0.00185	0.00929	0.65469	0.00001	
20	0.00150	0.00786	0.65470	0.00001	
21	0.00121	0.00661	0.65470	0.00000	
22	0.00098	0.00554	0.65470	0.00000	
23	0.00080	0.00463	0.65471	0.00000	
24	0.00065	0.00386	0.65471	0.00000	
25	0.00053	0.00321	0.65471	0.00000	
26	0.00043	0.00266	0.65471	0.00000	
27	0.00035	0.00220	0.65471	0.00000	
28	0.00028	0.00182	0.65471	0.00000	
29	0.00023	0.00150	0.65471	0.00000	
30	0.00019	0.00124	0.65471	0.00000	

The FACTOR Procedure
Initial Factor Method: Principal Components

Eigenvalues of the Correlation Matrix: Total = 18 Average = 0.94736842				
	Eigenvalue	Difference	Proportion	Cumulative
1	5.31032459	2.07140632	0.2950	0.2950
2	3.23891827	0.65404168	0.1799	0.4750
3	2.58487659	0.80626286	0.1436	0.6186
4	1.77861373	0.47731166	0.0988	0.7174
5	1.30130207	0.28680541	0.0723	0.7897
6	1.01449666	0.12601338	0.0564	0.8460
7	0.88848328	0.26377515	0.0494	0.8954
8	0.62470812	0.22569484	0.0347	0.9301
9	0.39901329	0.05519276	0.0222	0.9523
10	0.34382053	0.05365677	0.0191	0.9714
11	0.29016376	0.19252950	0.0161	0.9875
12	0.09763425	0.01053720	0.0054	0.9929
13	0.08709705	0.05638514	0.0048	0.9977
14	0.03071191	0.02087602	0.0017	0.9995
15	0.00983589	0.00983589	0.0005	1.0000
16	0.00000000	0.00000000	0.0000	1.0000
17	0.00000000	0.00000000	0.0000	1.0000
18	0.00000000	0.00000000	0.0000	1.0000
19	0.00000000		0.0000	1.0000

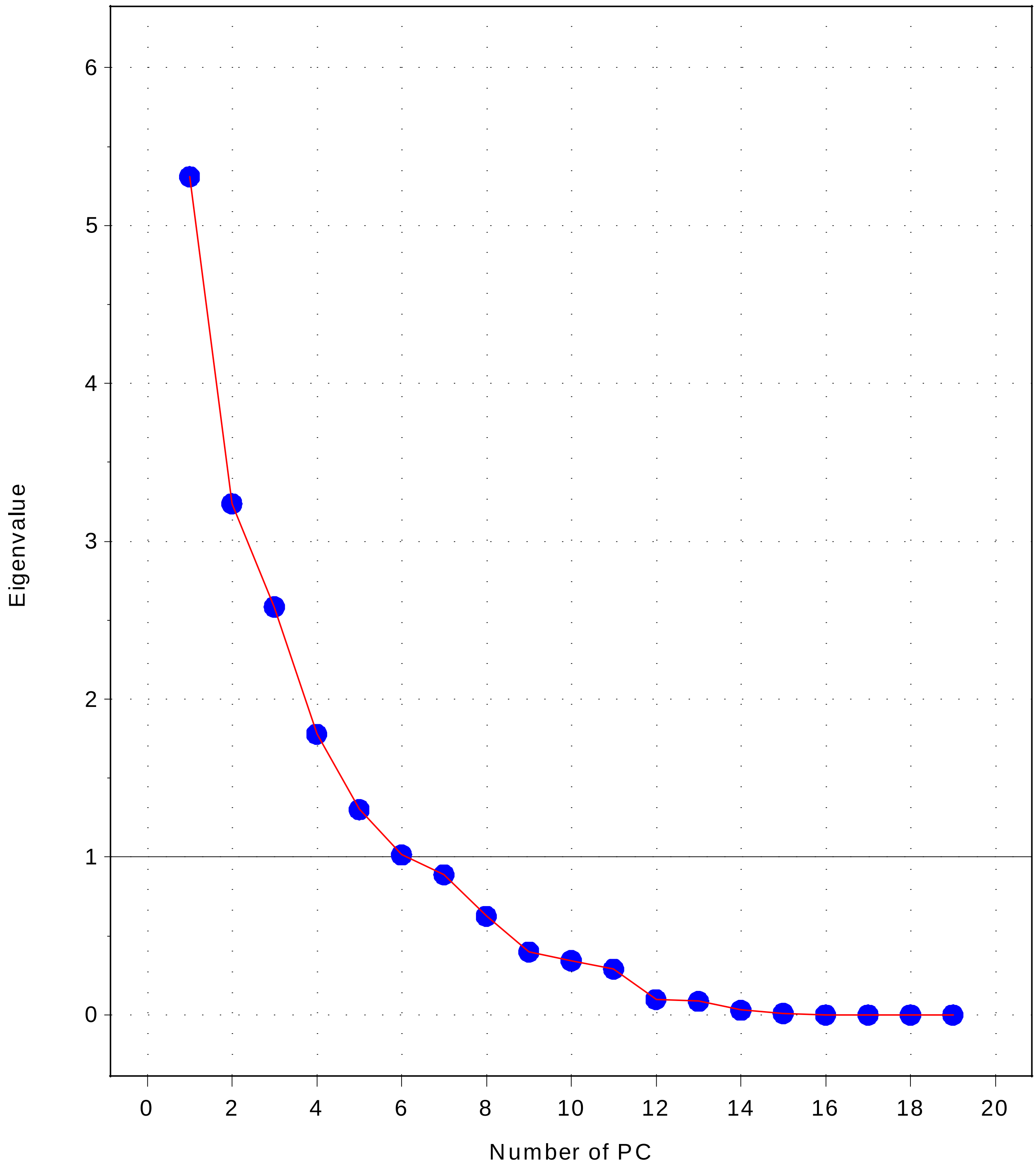
Eigenvectors				
		1	2	3
B	B	0.01547	-0.08396	0.04967
D	D	0.29891	0.03835	0.20035
E	E	0.18955	0.26676	0.38449
F	F	0.11328	0.22070	-0.46230
G	G	0.11079	-0.04345	0.42488
H	H	0.31830	-0.21273	-0.19450
I	I	0.00000	0.00000	0.00000
J	J	-0.02333	0.43312	0.29398
K	K	0.24105	-0.39163	0.16478
M	M	-0.07090	-0.25341	0.14098
N	N	0.25690	0.19054	0.19850
O	O	0.19357	-0.39674	0.08207
Q	Q	0.35632	-0.08795	-0.07982
R	R	0.19428	0.04248	0.25657
S	S	0.31568	0.05242	-0.30767
T	T	0.32568	-0.16231	-0.05957
U	U	0.28529	0.30851	-0.09841
W	W	0.26245	0.30172	-0.13313
X	X	0.24539	-0.02699	0.00842

Principal component analysis - qualitative rankings: -mdtmain

The FACTOR Procedure
Initial Factor Method: Principal Components

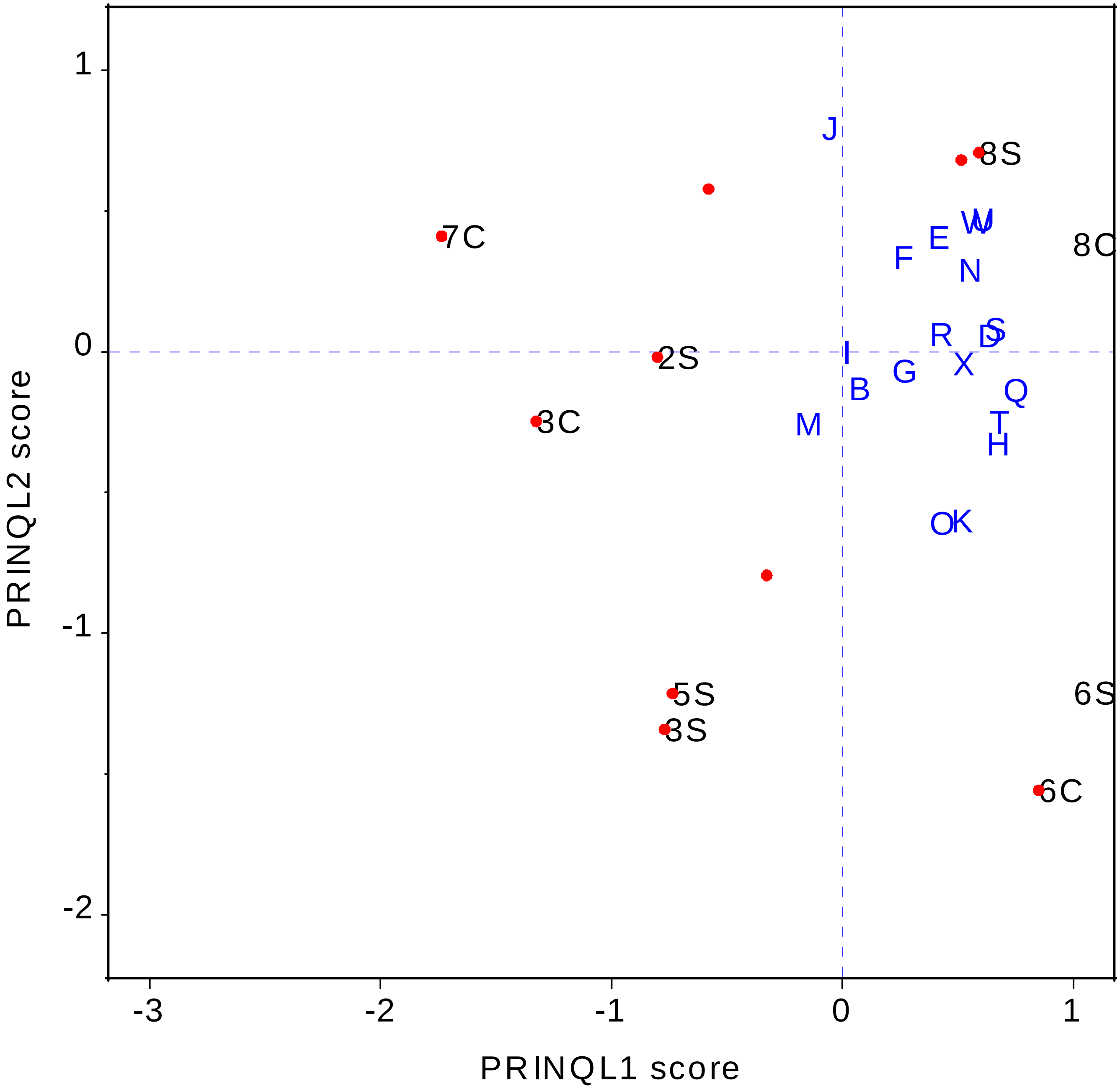
Factor Pattern				
		FACTOR1	FACTOR2	FACTOR3
B	B	0.03565	-0.15111	0.07985
D	D	0.68881	0.06901	0.32211
E	E	0.43680	0.48010	0.61816
F	F	0.26105	0.39720	-0.74327
G	G	0.25530	-0.07820	0.68311
H	H	0.73350	-0.38284	-0.31272
I	I	0.00000	0.00000	0.00000
J	J	-0.05377	0.77949	0.47265
K	K	0.55547	-0.70482	0.26492
M	M	-0.16339	-0.45606	0.22667
N	N	0.59201	0.34291	0.31914
O	O	0.44607	-0.71401	0.13195
Q	Q	0.82111	-0.15828	-0.12833
R	R	0.44770	0.07644	0.41250
S	S	0.72747	0.09434	-0.49466
T	T	0.75050	-0.29210	-0.09577
U	U	0.65743	0.55523	-0.15821
W	W	0.60478	0.54301	-0.21403
X	X	0.56548	-0.04857	0.01353

mdtmain:SCREE PLOT - Prinqual



mdtmain - Rank Scores

Obs	ID	FACTOR1	FACTOR2	FACTOR3
1	7C	-1.73356	0.41112	-1.19578
2	3C	-1.32432	-0.24750	0.29626
3	2S	-0.79972	-0.01890	1.28694
4	1S	-0.77340	1.57531	-0.44555
5	3S	-0.76843	-1.34161	0.61667
6	5S	-0.73414	-1.21379	0.25710
7	7S	-0.57842	0.57798	-1.17934
8	5C	-0.32613	-0.79439	0.15513
9	1C	0.23735	1.49032	-0.47561
10	2C	0.51603	0.68168	2.41044
11	8S	0.59234	0.70782	0.39258
12	6C	0.85159	-1.55794	-0.50957
13	8C	1.00079	0.38098	0.59116
14	6S	1.00110	-1.21179	-1.47952
15	4C	1.40150	0.85686	-0.86928
16	4S	1.43742	-0.29616	0.14837



J
8S
7C
W
U
E
F
N
8C
R
D
S
0
2S
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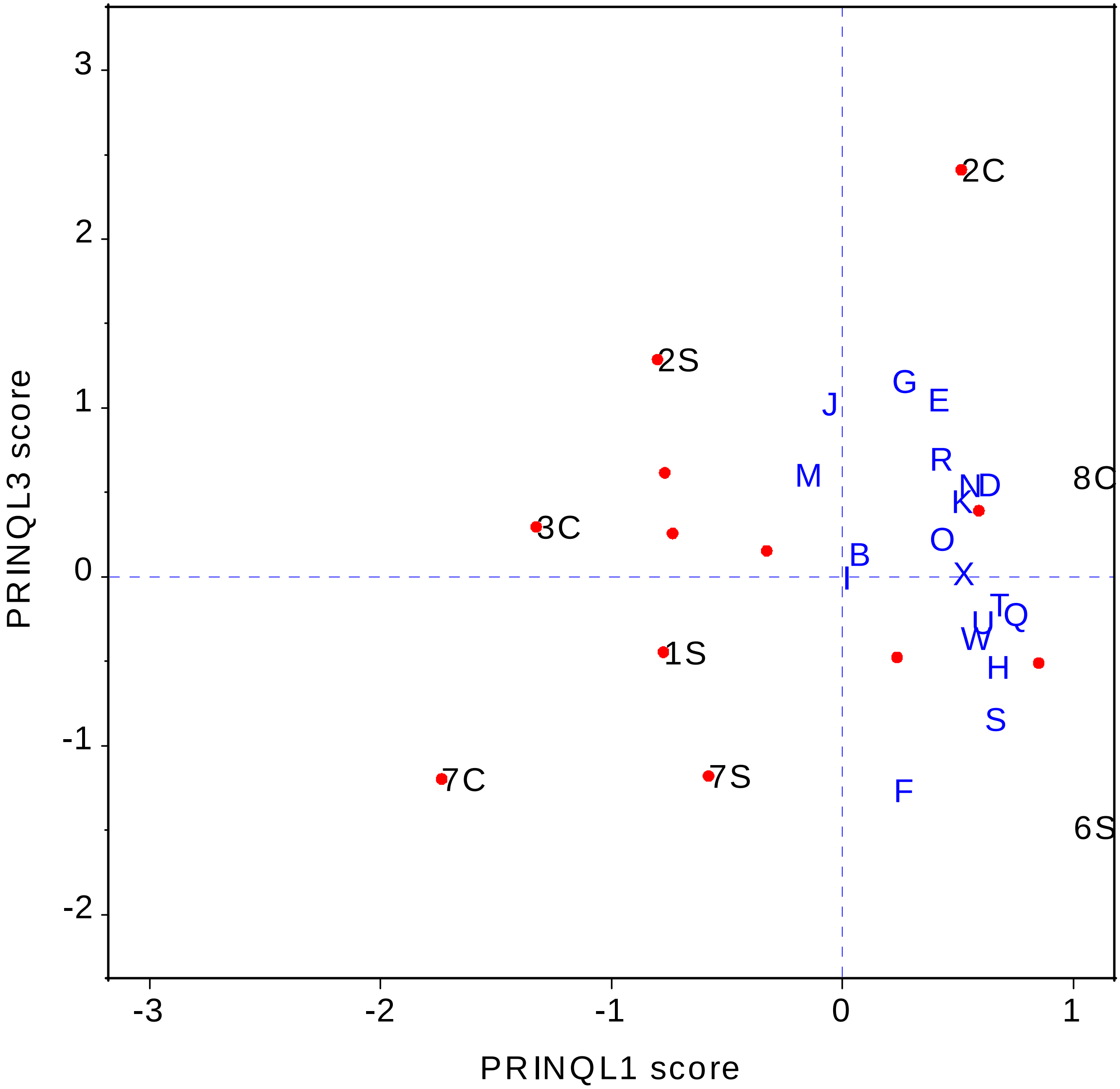
G
X
B
Q
3C
M
T
H
O
K
-1
5S
6S
3S
6C
-2
1
-3
-2
-1
0
1
PRINQL2 score
PRINQL1 score



3
2
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-2
PRINQL3 score
-3
-2
-1
0
1
PRINQL1 score
2C
2S
3C
1S
7C
7S
8C
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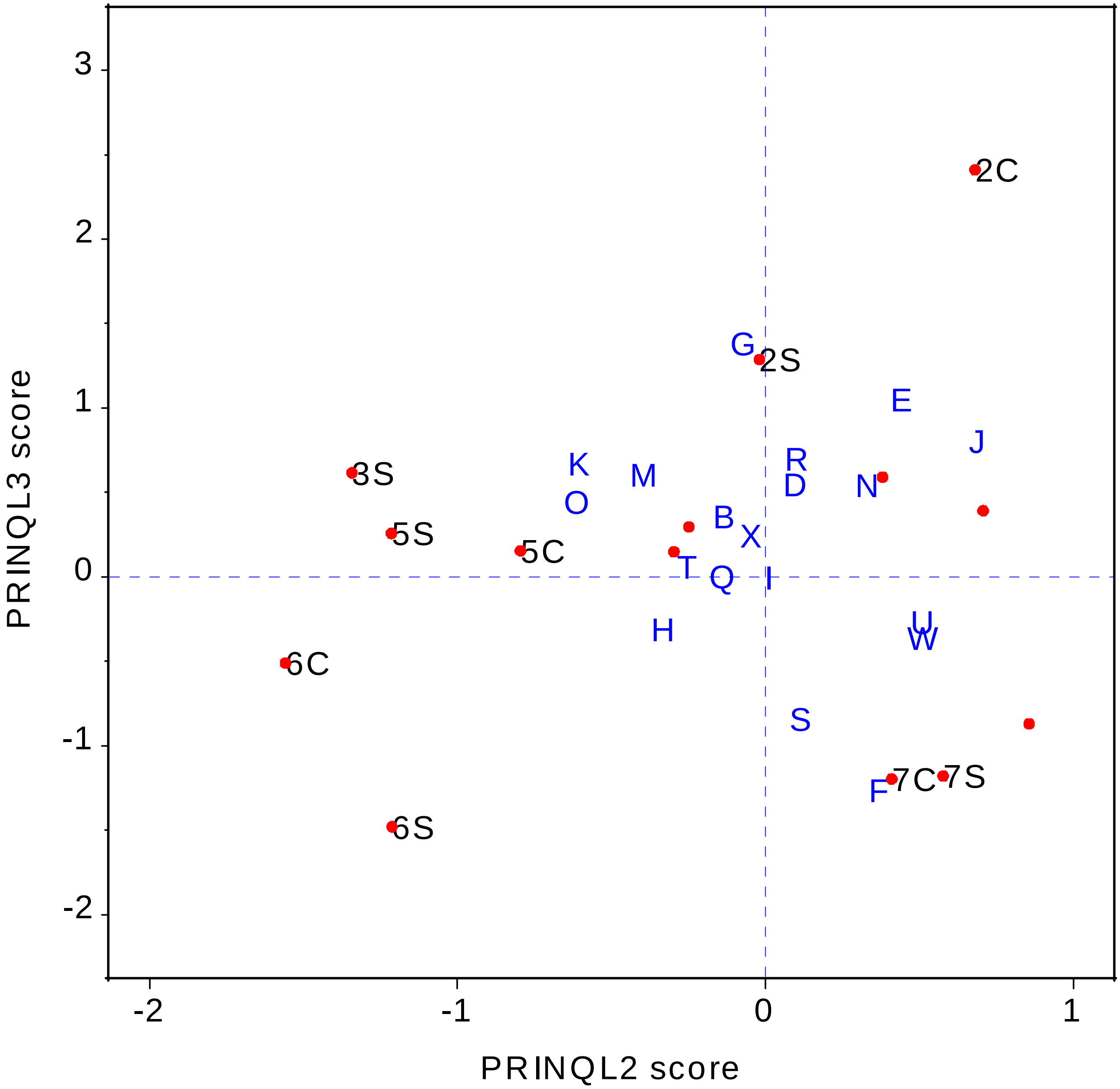

3
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PRINQL3 score
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PRINQL2 score
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6S

SAS output files generated when Ranking SUB categories within each main category by Cost and schedule using SAS PROCS PRINRQUAL, FACTOR, and GPLOT.

PRINQUAL MTV Algorithm Iteration History

Iteration Number	Average Change	Maximum Change	Proportion of Variance	Criterion Change	Note
1	0.55792	3.35737	0.42232		
2	0.12780	0.40536	0.89970	0.47738	
3	0.10053	0.31859	0.93719	0.03749	
4	0.07649	0.24474	0.96139	0.02421	
5	0.05700	0.20436	0.97621	0.01482	
6	0.04207	0.16875	0.98502	0.00881	
7	0.03110	0.14287	0.99020	0.00519	
8	0.02312	0.11801	0.99328	0.00308	
9	0.01733	0.09588	0.99514	0.00186	
10	0.01299	0.08377	0.99629	0.00115	
11	0.00986	0.07993	0.99703	0.00074	
12	0.00760	0.07615	0.99753	0.00050	
13	0.00596	0.07251	0.99789	0.00036	
14	0.00476	0.06901	0.99816	0.00027	
15	0.00389	0.06567	0.99837	0.00022	
16	0.00325	0.06248	0.99855	0.00018	
17	0.00279	0.05943	0.99870	0.00015	
18	0.00244	0.05653	0.99883	0.00013	
19	0.00217	0.05375	0.99895	0.00012	
20	0.00196	0.05112	0.99905	0.00010	
21	0.00180	0.04860	0.99915	0.00009	
22	0.00168	0.04620	0.99923	0.00008	
23	0.00158	0.04391	0.99930	0.00007	
24	0.00149	0.04173	0.99937	0.00007	
25	0.00141	0.03966	0.99943	0.00006	
26	0.00134	0.03769	0.99949	0.00006	
27	0.00128	0.03581	0.99954	0.00005	
28	0.00122	0.03402	0.99958	0.00005	
29	0.00116	0.03232	0.99962	0.00004	
30	0.00110	0.03070	0.99966	0.00004	

Principal component analysis - qualitative rankings: -mdtsub

The FACTOR Procedure
Initial Factor Method: Principal Components

Eigenvalues of the Correlation Matrix: Total = 20 Average = 0.95238095				
	Eigenvalue	**Difference**	**Proportion**	**Cumulative**
1	8.44631817	6.49181735	0.4223	0.4223
2	1.95450081	0.83421740	0.0977	0.5200
3	1.12028341	0.11924665	0.0560	0.5761
4	1.00103676	0.03192611	0.0501	0.6261
5	0.96911065	0.10878912	0.0485	0.6746
6	0.86032153	0.08233924	0.0430	0.7176
7	0.77798229	0.03784992	0.0389	0.7565
8	0.74013237	0.11240402	0.0370	0.7935
9	0.62772835	0.08718035	0.0314	0.8249
10	0.54054800	0.03404211	0.0270	0.8519
11	0.50650590	0.05597965	0.0253	0.8772
12	0.45052624	0.01225769	0.0225	0.8997
13	0.43826856	0.14884672	0.0219	0.9217
14	0.28942183	0.01861511	0.0145	0.9361
15	0.27080672	0.02692714	0.0135	0.9497
16	0.24387958	0.01564032	0.0122	0.9619
17	0.22823926	0.03112816	0.0114	0.9733
18	0.19711110	0.01236253	0.0099	0.9831
19	0.18474857	0.03221869	0.0092	0.9924
20	0.15252988	0.15252988	0.0076	1.0000
21	0.00000000		0.0000	1.0000

Principal component analysis - qualitative rankings: -mdtsub

The FACTOR Procedure
Initial Factor Method: Principal Components

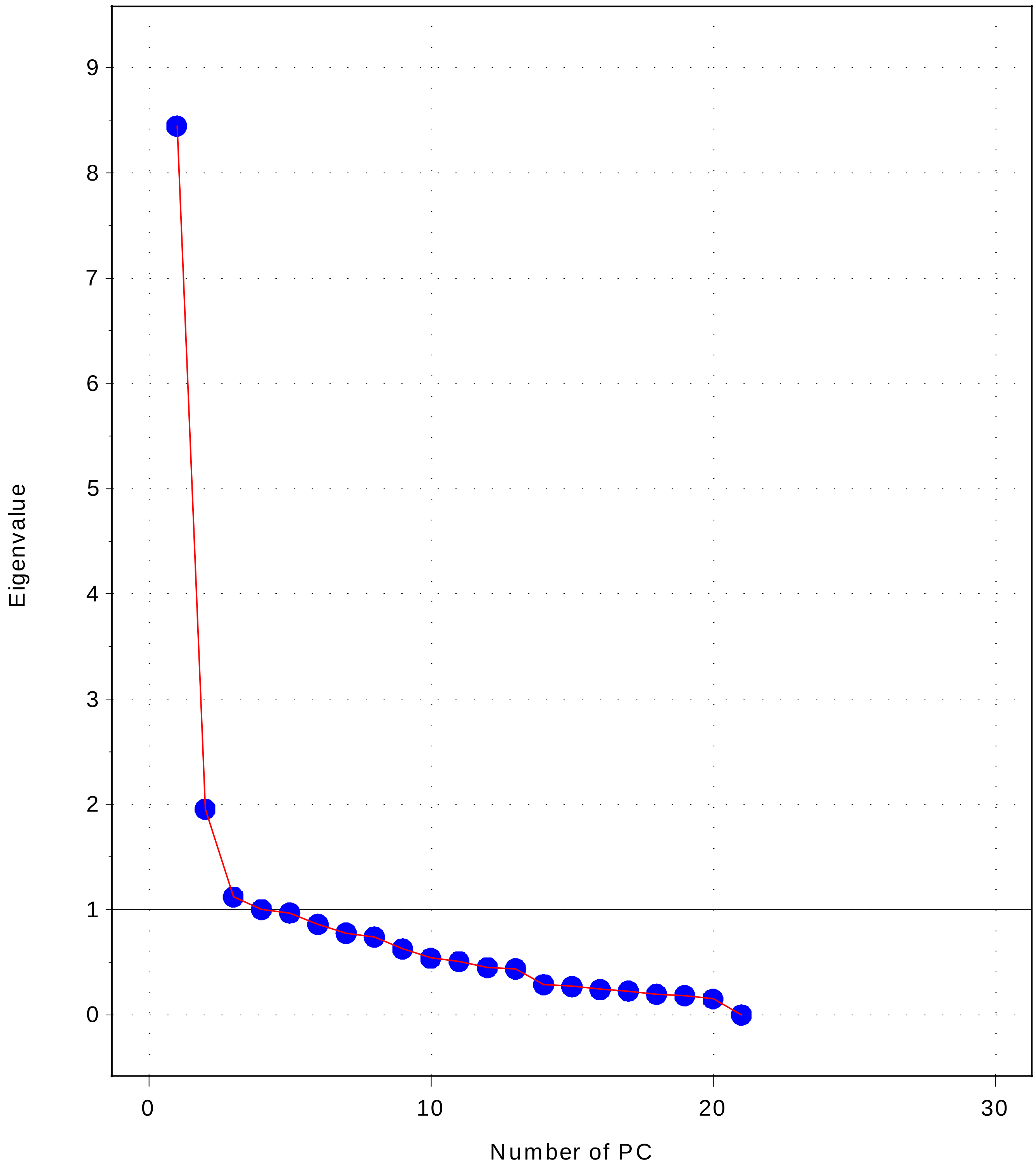
Eigenvectors			
	1	2	3
A	0.28803	-0.07941	-0.00950
B	0.13758	0.08814	0.19918
C	0.27799	0.13533	0.09410
D	0.23190	0.12003	-0.08058
F	0.26133	0.06217	0.03200
G	0.24624	-0.17806	-0.04531
H	0.27028	0.19818	-0.05688
I	0.00000	0.00000	0.00000
J	0.13392	-0.48206	0.30823
K	0.27733	-0.10181	-0.02582
L	0.18981	-0.28298	-0.18277
M	0.15071	-0.23753	0.53311
N	0.22331	0.09152	0.00598
O	0.22349	0.08928	-0.27938
P	0.19577	-0.28045	0.05868
Q	0.25693	0.12376	0.13709
R	0.24497	0.10544	0.23456
S	0.11481	0.29959	-0.02388
T	0.26211	-0.13230	-0.27556
U	0.25481	0.18794	-0.28345
W	0.02250	0.48487	0.46162

Principal component analysis - qualitative rankings: -mdtsub

The FACTOR Procedure
Initial Factor Method: Principal Components

Factor Pattern			
	FACTOR1	**FACTOR2**	**FACTOR3**
A	0.83708	-0.11102	-0.01005
B	0.39986	0.12322	0.21082
C	0.80791	0.18920	0.09960
D	0.67396	0.16780	-0.08529
F	0.75948	0.08691	0.03387
G	0.71564	-0.24893	-0.04796
H	0.78551	0.27706	-0.06020
I	0.00000	0.00000	0.00000
J	0.38920	-0.67394	0.32624
K	0.80599	-0.14234	-0.02733
L	0.55164	-0.39561	-0.19345
M	0.43800	-0.33208	0.56426
N	0.64900	0.12795	0.00633
O	0.64952	0.12482	-0.29571
P	0.56897	-0.39208	0.06211
Q	0.74672	0.17303	0.14511
R	0.71195	0.14741	0.24827
S	0.33366	0.41883	-0.02528
T	0.76176	-0.18497	-0.29166
U	0.74055	0.26274	-0.30001
W	0.06538	0.67787	0.48860

mdtsub:SCREE PLOT - Prinqual



mdtsub - Rank Scores

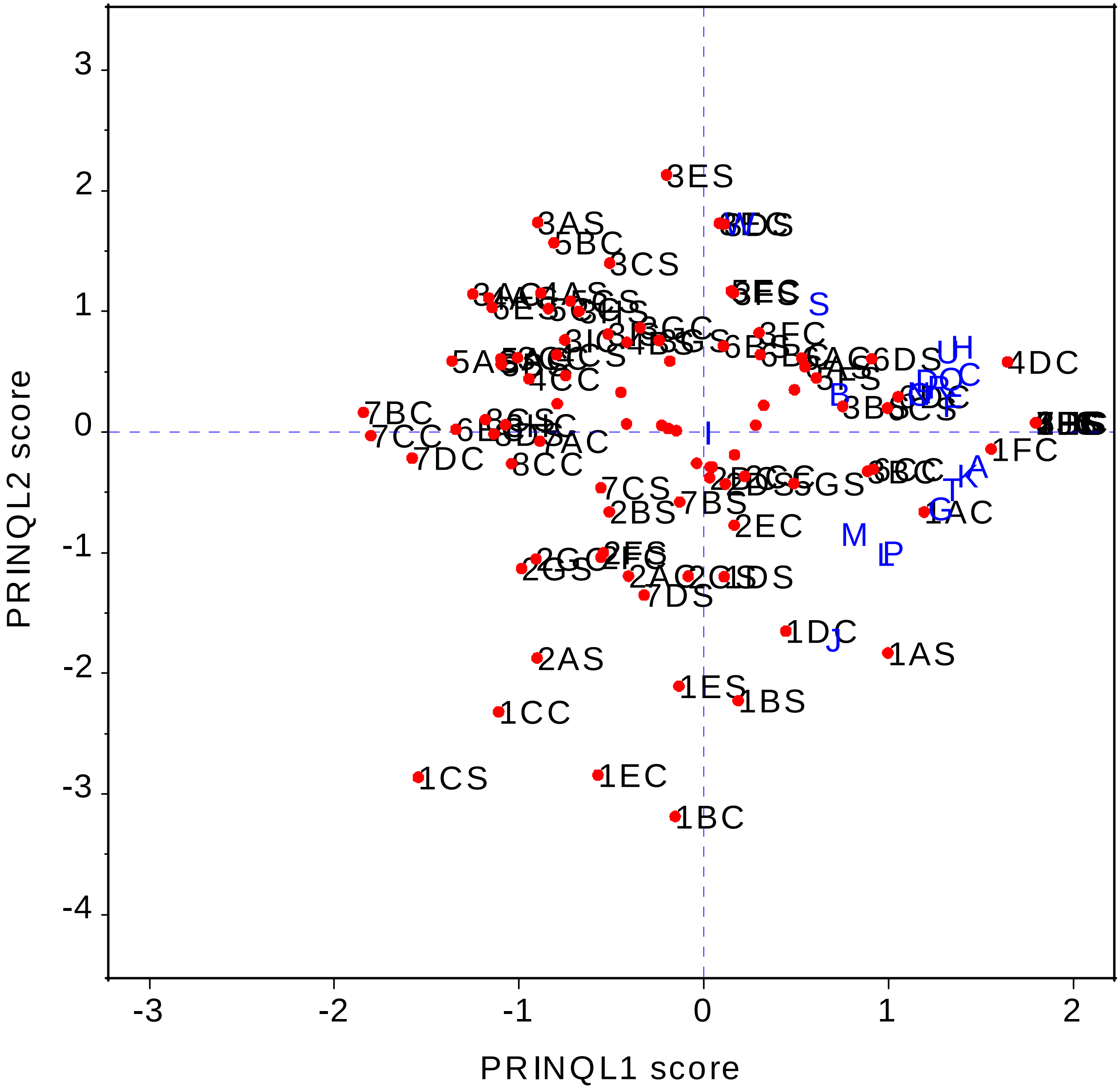
Obs	ID	FACTOR1	FACTOR2	FACTOR3
1	7BC	-1.84083	0.16413	-0.43067
2	7CC	-1.80091	-0.02784	0.39923
3	7DC	-1.57679	-0.21555	0.28109
4	1CS	-1.54463	-2.86052	-1.85659
5	5AS	-1.36080	0.59072	0.47933
6	6EC	-1.34062	0.02327	-0.07215
7	3AC	-1.24918	1.14499	0.19325
8	8CS	-1.18110	0.10503	2.28662
9	4AC	-1.16304	1.11350	-1.64738
10	6ES	-1.14392	1.03444	-1.09366
11	8DS	-1.13448	-0.01357	0.80318
12	1CC	-1.10897	-2.31922	-3.48752
13	5AC	-1.09672	0.60890	-0.92456
14	5BS	-1.09459	0.56066	-0.67647
15	3HC	-1.07355	0.06091	1.30389
16	8CC	-1.03911	-0.25992	1.65301
17	3CC	-1.00610	0.61799	0.51601
18	2GS	-0.98457	-1.12955	1.82761
19	4CC	-0.94460	0.44247	-1.52831
20	2GC	-0.90725	-1.04976	1.31512
21	2AS	-0.90091	-1.87146	1.42480
22	3AS	-0.89736	1.73954	-0.75273
23	7AC	-0.88640	-0.07555	-0.12447
24	4AS	-0.88116	1.15348	-1.94385
25	5CC	-0.83979	1.02409	0.56459
26	5BC	-0.80975	1.56951	-0.62018
27	4CS	-0.79557	0.64093	-0.93591
28	8AS	-0.79195	0.23581	1.70625
29	3IC	-0.75193	0.76462	0.04845
30	8DC	-0.74687	0.46870	1.11754
31	5CS	-0.71984	1.08755	0.69707
32	3HS	-0.67503	1.00225	0.91804
33	1EC	-0.57155	-2.84184	-1.06849
34	7CS	-0.55580	-0.46125	0.22468
35	2FC	-0.55551	-1.03753	1.34181
36	2FS	-0.54181	-1.00032	2.30386
37	3IS	-0.51666	0.81262	0.51272
38	2BS	-0.51041	-0.66128	2.03465
39	3CS	-0.50831	1.40178	-0.28350
40	4BC	-0.44711	0.33079	-0.87628
41	5DC	-0.41652	0.06848	-1.38004
42	4BS	-0.41499	0.74502	-1.29618
43	2AC	-0.40635	-1.19267	0.25766
44	3GC	-0.34372	0.86582	-1.12363
45	7DS	-0.32205	-1.35117	-0.45080
46	3GS	-0.24069	0.75964	-1.30448

mdtsub - Rank Scores

Obs	ID	FACTOR1	FACTOR2	FACTOR3
47	8AC	-0.22699	0.05588	0.73924
48	3ES	-0.20106	2.13286	-0.73435
49	8BS	-0.19138	0.03045	1.16735
50	3DC	-0.18223	0.58881	0.22093
51	1BC	-0.15442	-3.18569	-1.53275
52	5DS	-0.14707	0.01367	-0.49869
53	1ES	-0.13334	-2.10457	-0.01390
54	7BS	-0.12935	-0.57752	-0.53748
55	2CS	-0.08251	-1.19365	1.62907
56	8BC	-0.03758	-0.25730	0.52947
57	2BC	0.03261	-0.37701	0.07990
58	2ES	0.03579	-0.28802	1.18041
59	7AS	0.04690	-0.28799	-0.22461
60	3EC	0.08571	1.73296	-1.48676
61	6BS	0.10785	0.71436	0.95376
62	1DS	0.11095	-1.19817	-1.09775
63	3DS	0.11110	1.72444	-0.16793
64	2DS	0.11824	-0.42928	1.77470
65	5EC	0.14977	1.17092	-0.59542
66	3FS	0.16116	1.15510	-1.02344
67	2EC	0.16569	-0.77025	-0.21368
68	2DC	0.16689	-0.18812	0.78344
69	1BS	0.18750	-2.22628	-0.39153
70	2CC	0.22237	-0.36554	0.05221
71	5GC	0.28231	0.05868	0.08935
72	3FC	0.29994	0.82461	-0.85230
73	6BC	0.30728	0.64336	-0.11161
74	5FC	0.32568	0.22220	0.59422
75	1DC	0.44572	-1.64972	-1.40548
76	5GS	0.48889	-0.42511	0.62403
77	5ES	0.49139	0.35222	0.15460
78	6AC	0.53231	0.61510	0.19226
79	6AS	0.54987	0.54380	0.59285
80	5FS	0.61056	0.44993	-0.21715
81	3BS	0.75203	0.21432	-0.26023
82	3BC	0.88727	-0.32396	0.17213
83	6DS	0.91047	0.60739	0.18453
84	6CC	0.91814	-0.30672	0.27400
85	6CS	0.99412	0.19993	0.32638
86	1AS	0.99764	-1.83048	-1.85483
87	6DC	1.05350	0.29426	0.09080
88	1AC	1.19335	-0.66161	-0.29450
89	1FC	1.55625	-0.13914	-0.45552
90	4DC	1.64455	0.58289	-1.31537
91	1FS	1.79871	0.07781	0.18193
92	2HC	1.79871	0.07781	0.18193

mdtsub - Rank Scores

Obs	ID	FACTOR1	FACTOR2	FACTOR3
93	2HS	1.79871	0.07781	0.18193
94	3JC	1.79871	0.07781	0.18193
95	3JS	1.79871	0.07781	0.18193
96	4DS	1.79871	0.07781	0.18193
97	5HC	1.79871	0.07781	0.18193
98	5HS	1.79871	0.07781	0.18193
99	6FC	1.79871	0.07781	0.18193
100	6FS	1.79871	0.07781	0.18193
101	7EC	1.79871	0.07781	0.18193
102	7ES	1.79871	0.07781	0.18193
103	8EC	1.79871	0.07781	0.18193
104	8ES	1.79871	0.07781	0.18193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PRINQL1 score
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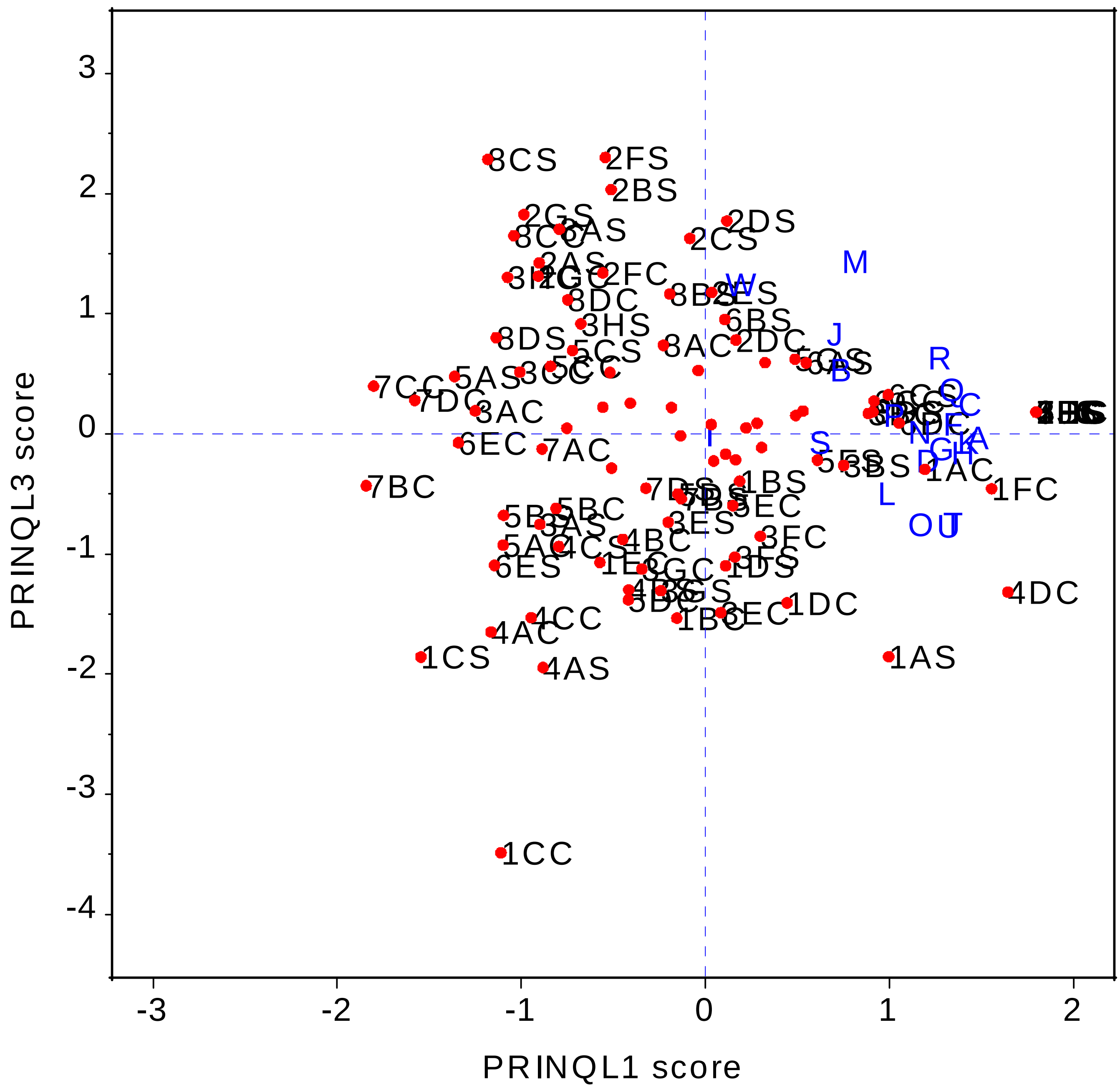
2
1
0
-1
-2
-3
-4
-3
-2
-1
0
1
2
3ES
3AS
5BC
3CS
4DC
1FC
7BC
7CC
7DC
8CC
7CS
2BS
7BS
2EC
1AC
2AS
1AS
1DC
1ES
1BS
1CC
1CS
1EC
1BC
7DS
2GS
4CC
6DS
3EC
5AS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PRINQL1 score
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2
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-1
-2
-3
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-2
-1
0
1
2
8CS
2FS
2BS
2DS
2CS
M
8DS
3HS
J
R
7CC
7DC
3AC
7BC
6EC
7AC
1AC
1FC
5BC
3ES
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4CC
4AC
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4AS
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1CC
L
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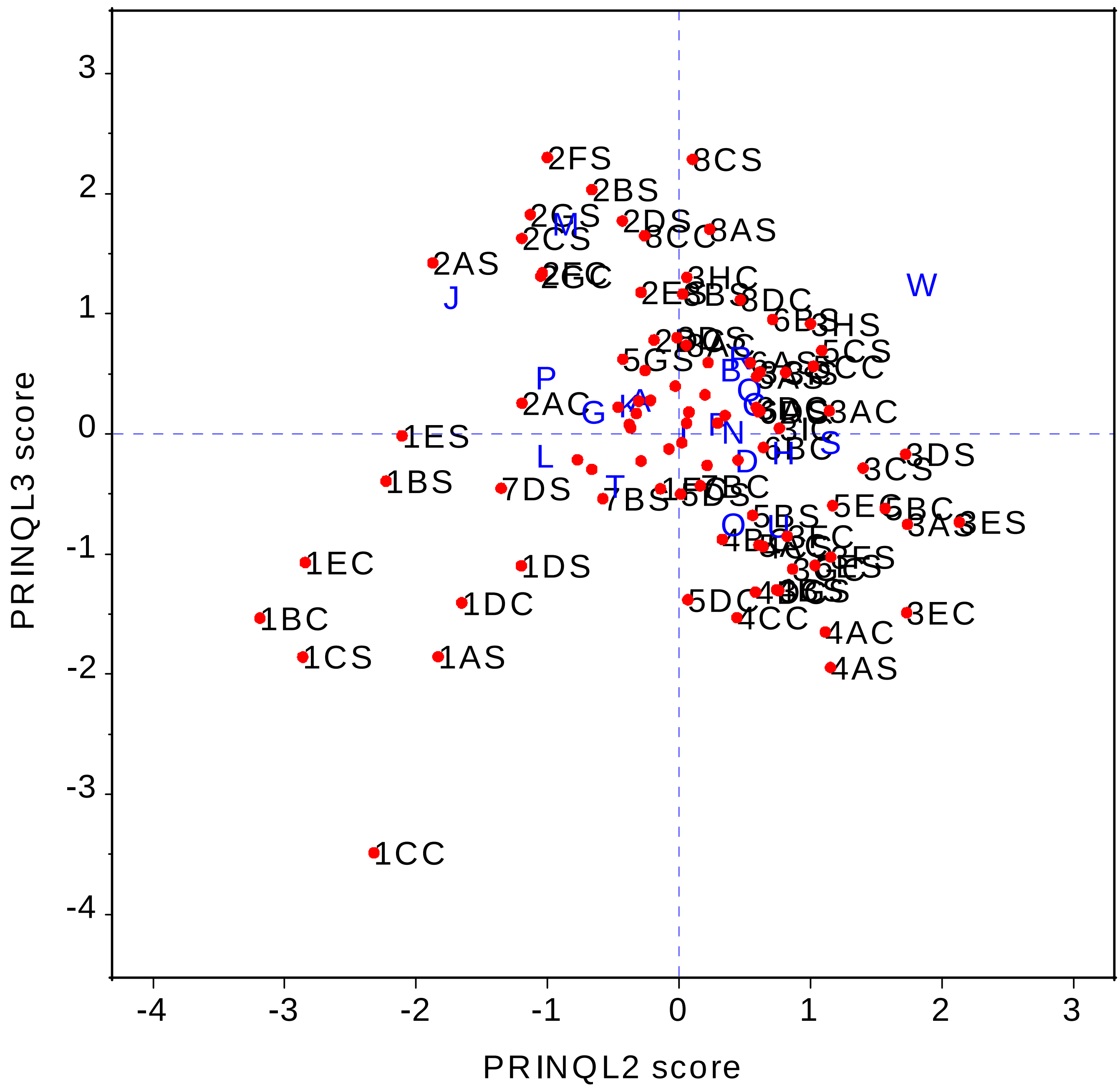
PRINQL3 score
PRINQL2 score
3
2
1
0
-1
-2
-3
-4
-4
-3
-2
-1
0
1
2
3
2FS
8CS
2BS
2DS
8AS
8CC
2AS
2CS
J
W
1ES
1BS
7DS
7BS
1EC
1DS
1DC
1BC
1CS
1AS
1CC
2AC
5GS
3AC
3DS
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APPENDIX D. PRE-TRIP QUESTIONNAIRE

Pre-Trip Questions and Surveys

PRE-TRIP QUESTIONS

Organizational Structure of MDT

1. Organizational Chart of MDT with a list of key tasks (roles) for each department/division.

MDT Response:

2. What departments/divisions/sections of MDT are involved in nomination phase of transportation projects? Please describe their roles.

MDT Response:

3. What departments/divisions/sections of MDT are involved in planning phase of transportation projects? Please describe their roles.

MDT Response:

4. What departments/divisions/sections of MDT are involved in programming phase of transportation projects? Please describe their roles.

MDT Response:

5. What departments/divisions/sections of MDT are involved in advanced planning/preliminary design phase of transportation projects? Please describe their roles.

MDT Response:

6. What departments/divisions/sections of MDT are involved in final design (PS&E) phase of transportation projects? Please describe their roles.

MDT Response:

Private Sector

1. Are there any private sector parties involved with MDT in the nomination phase of transportation projects? If so, please describe their roles.

MDT Response:

2. Are there any private sector parties involved with MDT in the planning phase of transportation projects? If so, please describe their roles.

MDT Response:

3. Are there any private sector parties involved with MDT in the programming phase of transportation projects? If so, please describe their roles.

MDT Response:

4. Are there any private sector parties involved with MDT in the advanced planning/preliminary design phase of transportation projects? If so, please describe their roles.

MDT Response:

5. Are there any private sector parties involved with MDT in the final design (PS&E) phase of transportation projects? If so, please describe their roles.

MDT Response:

SURVEY OF MDT PERSONNEL INVOLVED WITH COST ESTIMATING

Based on the NCHRP 8-49 report, we have prepared a series of survey questionnaires covering project development phases as described below:

PROJECT DEVELOPMENT STAGES AND ACTIVITIES	
PROJECT DEVELOPMENT PHASES	**TYPICAL ACTIVITIES**
Planning	Purpose and need; improvement or requirement studies; environmental considerations; interagency coordination
Programming	Environmental determination; schematic development; public hearings; ROW plan; project funding authorization
Advanced Planning/ Preliminary Design	ROW development; environmental clearance; design criteria and parameters; surveys/utility locations/drainage; preliminary schematics such as alternative selections; geometric alignments; bridge layouts
Final Design	ROW acquisition; PS&E development – pavement and bridge design, traffic control plans, utility drawings, hydraulic studies/drainage design, final cost estimates
Ad/Bid/Award	Prepare contract documents; advertise for bid; pre-bid conference; receive and analyze bids; determine lowest responsive bidder; initiate contract
Construction	Mobilization; inspection and materials testing; contract administration; traffic control, bridge, pavement, drainage construction

Source: NCHRP Web Only Document 98: Final Report for NCHRP Report 574, Table 1 of Appendix A. Interview Instrument, Published September 2006.

SURVEY #1

CONCEPTUAL ESTIMATES: PLANNING PHASE

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

A. Estimate Preparation

1. Describe policies, procedures, techniques, and/or standards used in preparing *planning conceptual estimates.* If these policies, procedures, techniques, and/or standards are formally documented (written), please provide either a copy or a website link.

MDT Response:

2. How do you ensure that conceptual estimates reflect all elements of project scope (e.g., related to design, construction administration, construction, right of way, environmental, etc.) as defined at the time conceptual estimates are prepared?

MDT Response:

3. What types of historical data do you use as a basis for preparing conceptual estimates? How is this data adjusted for time (schedule), location, and other project specific conditions?

MDT Response:

4. How are contingency amounts incorporated into the estimate? Are contingency amounts based on total estimated cost, identified project risks, or some other variables?

MDT Response:

B. Estimate Reviews

1. Is there a formal estimate review within MDT?

MDT Response:

C. Estimate Communication

1. Is there a systematic program that is used to standardize estimating procedures and train those responsible for assembling the estimates?

MDT Response:

2. Who approves the *planning conceptual estimate*? Once approved, is the planning conceptual estimate communicated to executive management and/or the public as a point estimate (one number) or as a range of values with an indication of reliability?

MDT Response:

D. Cost Estimating Management

1. Are there established mechanisms to control/track changes in project costs after planning conceptual cost estimates are prepared and submitted? If so, please describe these mechanisms.

MDT Response:

SURVEY #2

CONCEPTUAL ESTIMATES: PROGRAMMING PHASE

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

A. Estimate Preparation

1. Describe policies, procedures, techniques, and/or standards used in preparing programming conceptual estimates. If these policies, procedures, techniques, and/or standards are formally documented (written), please provide either a copy or a website link.

MDT Response:

2. How do you ensure that conceptual estimates reflect all elements of project scope (e.g., related to design, construction administration, construction, right of way, environmental, etc.) as defined at the time conceptual estimates are prepared?

MDT Response:

3. What types of historical data do you use as a basis for preparing conceptual estimates? How is this data adjusted for time (schedule), location, and other project specific conditions?

MDT Response:

4. How are contingency amounts incorporated into the estimate? Are contingency amounts based on total estimated cost, identified project risks, or some other variables?

MDT Response:

B. Estimate Reviews

1. Is there a formal estimate review within the MDT? If yes, go to 1a. If no, go to 1b.

MDT Response:

1a. Is there a set of formalized and institutionalized procedures for conducting such reviews? What are the milestones for these reviews? What personnel outside of those responsible for preparing the estimate are involved in the review?

MDT Response:

1b. How does MDT verify an estimate?

MDT Response:

2. Does project value or project complexity trigger additional reviews? If so, what are these trigger values?

MDT Response:

C. Estimate Communication

1. Is there a systematic program that is used to standardize estimating procedures and train those responsible for assembling the estimates?

MDT Response:

2. What formal mechanisms are used for capturing and transferring knowledge about cost estimating techniques?

MDT Response:

3. Who approves the programming conceptual estimate? Once approved, is the programming conceptual estimate communicated to executive management and/or the public as a point estimate (one number) or as a range of values with an indication of reliability?

MDT Response:

D. Cost Estimating Management

1. Are cost differences between *planning conceptual cost estimates* and *programming conceptual cost estimates* reconciled? If so, how is reconciliation performed?

MDT Response:

2. Are there established mechanisms to control/track changes in project costs after programming conceptual cost estimates are prepared and submitted? If so, please describe these mechanisms.

MDT Response:

3. What triggers an update of an estimate during the planning and programming process? Are estimates updated on a periodic basis, when major design changes occur, or through some other triggering mechanism?

MDT Response:

SURVEY #3

PRELIMINARY DESIGN ESTIMATES: ADVANCED PLANNING / PRELIMINARY DESIGN PHASE

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

A. Estimate Preparation

1. Describe policies, procedures, techniques, and/or standards used in preparing advanced planning/preliminary design estimates. If these policies, procedures, techniques, and/or standards are formally documented (written), please provide either a copy or a website link.

MDT Response:

2. How frequently are estimates prepared (or updated) during advanced planning/preliminary design process? What triggers the update of an estimate (i.e. a set periodic basis, when design changes occur, or through some other triggering mechanism)?

MDT Response:

3. How do you ensure that advanced planning/preliminary design estimates reflect all elements of project scope (e.g., related to design, construction administration, construction, right of way, environmental, etc.) as defined at the time advanced planning/preliminary design estimates are prepared?

MDT Response:

4. What types of historical data do you use as a basis for preparing advanced planning/preliminary design estimates? How is this data adjusted for time (schedule), location, and other project specific conditions?

MDT Response:

5. How are contingency amounts incorporated into the estimate? Are contingency amounts based on total estimated cost, identified project risks, or some other variables?

MDT Response:

6. Who approves the advanced planning/preliminary design estimates? Once approved, is the advanced planning/preliminary design estimates communicated to executive management and/or the public as a point estimate (one number) or as a range of values with an indication of reliability?

MDT Response:

B. Estimate Reviews

1. Is there a formal estimate review within MDT? If so, go to 1a. If no, got to 1b.

MDT Response:

1a. Is there a set of formalized and institutionalized procedures for conducting such reviews? What personnel outside of those responsible for preparing the estimate are involved in the review?

MDT Response:

1b. How does MDT verify an estimate?

MDT Response:

2. Does project value or project complexity trigger additional reviews? If so, what are these trigger values?

MDT Response:

C. Cost Estimating Management

1. Are there established mechanisms to control/track changes in project costs after advanced planning/preliminary design estimates are prepared and submitted? If so, please describe these mechanisms.

MDT Response:

2. Is there an established reporting system that provides the necessary data to each level of management to track project cost, schedule, scope, and their changes?

MDT Response:

3. Are cost changes between advanced planning estimates and preliminary design estimates reconciled? If so, how is reconciliation performed?

MDT Response:

SURVEY #4

ENGINEER'S ESTIMATES: FINAL DESIGN (PS&E) PHASE

Name:	
Title:	
Department/Division:	
Phone:	
E-mail:	
Fax:	

A. Estimate Preparation

1. Describe policies, procedures, techniques, and/or standards used in preparing the Engineer's estimate. If these policies, procedures, techniques, and/or standards are formally documented (written), please provide either a copy or a website link.

MDT Response:

2. How do you ensure that the Engineer's estimate reflects all elements of project scope (e.g., related to construction administration and construction) as defined at the time the Engineer's estimate is prepared?

MDT Response:

3. What types of historical data do you use as a basis for preparing the Engineer's estimate? How is this data adjusted for time (schedule), location, and other project specific conditions?

MDT Response:

4. How are contingency amounts incorporated into the estimate? Are contingency amounts based on total estimated cost, identified project risks, or some other variables?

MDT Response:

B. Estimate Reviews

1. Is there a formal estimate review within MDT? If yes, go to 1a. If no, go to 1b.

MDT Response:

1a. Is there a set of formalized and institutionalized procedures for conducting such reviews?

MDT Response:

1b. How does MDT verify an estimate?

MDT Response:

2. Does project value or project complexity trigger additional reviews? If so, what are these trigger values?

MDT Response:

C. Cost Estimating Management

1. Are cost differences between advanced planning/preliminary design estimate and the Engineer's estimate reconciled? If so, how is reconciliation performed?

MDT Response:

APPENDIX E. INTERVIEW INFORMATION

Issues Discussed by MDT Staff

In most cases, the best source for identifying issues is to seek input from the staff directly involved with the process. STE has categorized the issues identified by MDT staff into five areas; namely, Management, Risk, Process, Communication, and Data. In some cases, the issues are interrelated with other categories. The following sections are quotes from the correspondence with MDT staff.

Management

- MDT works closely with its customers. Negative public perception when cost estimate changes cause project delays, reduction in scope, or complete drop out.
- Over programming what we can afford. Then enter new political parties and watch what used to be a priority goes to the back burner - this causes inflation way beyond what was accounted for in the original nomination estimate. This affects the estimate/schedule.
- The department requires several different formats for cost estimates.
- Schedules are constantly changing due to funding issues.
- Cost need to be split out for different funding categories, counties, tribal boundaries, etc.
- Generally there is a time crunch when the Tentative Construction Schedule is being prepared for the upcoming year. If the project has not been programmed it takes a while to come up with a realistic estimate of costs.
- Significant changes in overall funding levels and project costs cause major schedule issues. It is difficult to determine when a particular project should be started/worked on. There are a number of projects in the pipeline that are beyond MDT's five-year planning horizon from a funding standpoint. This tends to cause a start/stop scenario rather than a fluid design process.
- Staffing workloads and new policies add additional project time. Sometimes a case of too-many-cooks-in-the-kitchen results in changing project scopes and last minute adjustments.
- MDT needs to be looked at how much money it is willing to spend to get accuracy. If it needs to know within 1% the estimated cost, that can be done but it will require a lot of resources.

Risk

- Unexpected utility move costs, impact project costs.
- Right-of-way costs are not properly captured early in the process.
- Risk is not always accounted for properly.
- The issue of 3% inflation has caused our estimates to be way low, thus we provide a poor estimate.
- Unforeseen market events that significantly affect the cost of major items.
- Issues that come up during Right-of-Way negotiations sometimes cause significant project cost increases and schedule delays, we use a contingency factor, but by the time plans have been designed and the RW negotiators are doing their work, the Contingency factor in the cost estimate has been reduced to 0% (and really shouldn't be, especially on projects that are anticipated to have RW challenges).

Process

- Projects costs are often underestimated.
- There is often project scope creep, too long time span between project nomination and project delivery.

- Sometimes project nominators do not consider all of the project factors and the costs are therefore, too low.
- As far as issues to providing information, Bob's excel was out of date for 2 yrs that has since been addressed.
- In my opinion, inflation should not be added to estimates at our (cost estimator) end. It should be built in to our program when we assign the project a particular letting date.
- A total project cost estimate includes estimates from several different Functional Units (Bridge, Road, Geotech, Hydraulics). There are inconsistencies on what is included in an estimate and how the estimates are done.
- Cost estimates are constantly changing.
- Too many tools in too many places. Predicting material cost escalations make some historical data un-reliable.
- There still appear to be drastic differences in how different people develop cost estimates. Before Trns-port Estimator (which we've only now been using for a year or so), developing unit prices was purely educated guesswork, and different designers could come up with drastically different estimates for the same project. Estimator has helped some in that regard, but many designers and even project managers either don't know how to use it or still refuse to use it. So apparently there is still not a whole lot of consistency. I do believe that cost estimation is an art, and probably always will be, but it appears that there still could be somewhat more consistency than there is now.
- The most difficult scheduling items we have are the purchase of right-of-way, and relocation of utilities. The process can take 1 year or 3 years depending on where the project is.

Communication

- We don't have an easy or reliable cost tracking system.
- Others in the pipeline - not knowing the exact letting date as compared to projected letting date.
- It is difficult to get a good estimate in a timely manner from another area.
- There is not a one stop shopping area for cost estimates.
- There is confusion on what the current project priorities are with the Department. Functional Areas sometimes work on projects that are lower priority in terms of funding compared to others.
- The biggest issue that I see with providing information is lack of knowledge of the project and what is being asked for. There is a large misunderstanding in the Department of what the information is needed for a project thus, the best information is not necessarily obtained by the right people. Preliminary cost estimates are an example of information that may not be as usable to some because the person preparing the information is not aware of what it will be used for. This leads to major misinformation being provided unintentionally.

Data

- Impacts of changes in market conditions (inflation) on materials, labor, fuel, land are captured adequately.
- Inflationary factors are constant (3%); haven't been updated recently; and don't necessarily account for regional market impacts.
- We don't have enough information available to perform cost based estimating when it would be the most appropriate method to use.
- Biggest struggle is trying to find consistency for unit bid prices. Often times, I will see a 75-100% difference in a single item on the same project. By this, I mean the bid tabs might show X dollars

for plant mix bidder A, and Y dollars from bidder B. This makes it very difficult to choose an accurate unit bid price for plant mix.

- Unit costs used are often not current.
- It is difficult to estimate time and costs prior to the Contractor bidding the work. Montana has a small group of Contractors doing the majority of the work. Costs have a direct relationship to the Contractors work load. Contract Time is typically based on "like" projects in the district.
- A comprehensive database on cost that is current need to be available.
- We use a 6 month history for bid items. If the quantity is small or large, it tends to skew the costs. i.e., small (very high costs). Many items may not be used in the 6 month period so costs may be difficult to obtain.
- The cost data out of Trns*port Estimator seem too digested to really get really good confidence in item costs. For many material products, the bid populations are relatively small. The diverse ordered quantities, regional differences, and different costing practices by firms create problems of heteroscedacity that Estimator doesn't pick up.
- Planning efforts to track trends using – mainly using national PPI and regional economic sources – may help spot trends more confidently. We have developed that data program, but have not yet refined it into an inter-bureau reporting program.
- Lack of recent bid history on seldom used big ticket items.
- Geographic differences are difficult to quantify when there are very few projects let in some geographic areas.
- Gravel is scarce in some areas of the District. Quantifying the increased cost of hauling gravel to the project can be difficult. The available bid history does not always provide a good representation of the additional cost.
- Changes in cost of construction materials and equipment. As the price of fuel, concrete, and steel go up, so does the cost of our projects. It is difficult to monitor the world wide need for such raw materials and estimate what that will do the cost of those materials over a 7 year period. The price of property has risen considerably over the past 10 years, and I don't think the projects that were started ten years ago were estimated to grow in price as much as they have.

Recommendations by MDT Staff

STE also asked if MDT staff had recommendations for improving the cost and schedule estimation process. STE has categorized the recommendations identified by MDT staff into five areas; namely, Management, Risk, Process, Communication, and Data. In some cases, the recommendations are interrelated with other categories. The following sections are quotes from the correspondence with MDT staff.

Management

- Finish the process to fill permanent Cost Estimator positions within Preconstruction.
- Allow a project stay on schedule by preventing it from becoming derailed & delayed by other priorities.
- Don't over program - causes cost increases and project splits.
- First and foremost is to get rid of inflation at the estimate stage, and put it in the stage of fiscal programming.
- Full time estimator/estimators using cost based estimating.
- Cost estimates at nomination need to be more realistic.
- Mainly I just need to do a better job. It is difficult to find the time to devote to the cost estimate process.

Risk

- Improving our risk analysis and management process.
- Mobilization costs, traffic control, and construction engineering costs are difficult to predict - historical costs by type of project and location may be useful. A large majority of the project costs are in these items (typically 12-25% IDC, 10-15% MOB, 8-10% Traffic Control, 8-18% Construction Engineering) and there are fewer tools available for justifying and tracking costs in these areas.

Process

- Improving our nomination estimates.
- Keep Bob's Excel sheets up to date; they're still the best we have in my opinion.
- The data needs to be thoroughly analyzed to make sure if is valid for not only the item but the specific project & location.
- The department should consider software that would handle the cost estimate for each project from nomination, planning, design, contract letting and construction. The software should be flexible to allow cost to be split into the different formats and individual cost as required by the Department. Anyone estimating should be able to enter the estimate as per bridge area or road length and as individual bid items as they are determined. Estimators should be able to pull up past projects that are similar to review historical cost per road length, bridge area or by individual bid items. Schedule ready dates should be revised based on funding levels on a quarterly basis to keep MDT priorities current.
- A one-stop-shop program that automatically calculates all the prices by region, scope, length, width, amenities, etc., using all of the existing tools and lists them side-by-side for comparison. Also a tracking ability to determine where the cost increases occur (materials, scope change, unknowns, etc.) so we can better predict.
- Consistency in handling costs for utilities, right of way, construction engineering, preliminary engineering and construction. Different departments want the information in different formats for reporting, some include IDC (Indirect Cost), others require traffic control or construction engineering to be separated out.

- Move toward a more standardized cost estimation approach that integrates as many inputs as possible. So, with good communication and a standardized approach, I believe that we can streamline the process even further.

Communication

- Review projects with unusual high percentage of PE, IC, CE, document reasons, check need for process changes and let staff know outcomes.
- Create a tracking system that uses data already input in our Oracle database.
- Keep design staff up to date with training.
- Continued input from the District.
- Training on Estimator - Staff need to be trained in how to use it so that everyone uses it and uses it the same way.
- Communication and training would help the process. By individuals understanding how things work, who uses the information, what the project is all about, they will hopefully do a better job of providing information that is relevant and accurate. It's the "big picture/puzzle" theory that if you know how you fit in, you will do a better job.

Data

- The current estimate system has a built in inflation factor that needs to be adjusted based upon the actual experience we are having. For the past several years we have used 2-3% as the inflation factor, when in reality we were seeing 30-40% actual cost increases. This will badly impact your estimates.
- Develop regional inflation rates and keep them up to date.
- I would also suggest that we have something available to us that gives us the current price of items. For example, have a source of information for what asphalt cement providers are charging at any given time. In my opinion, the best estimate we can provide would incorporate the unit bid prices for items that a contract would pay today.
- Develop external trend tracking sources, using non-MDT data, to help anticipate national and regional trends.
- Understand that 3% inflation is not realistic.

APPENDIX F. INFLATION ESTIMATING SURVEY BY WSDOT

Responses to WSDOT Cost/Inflation Estimating Survey – February 2007

Questions sent out to AASHTO/RAC List Serve	1. What do you use for inflation estimating?	2. Do you use a commercial forecast or in-house/agency assumed rates?	3. If using a commercial forecast, what service or product are you using?	4. Are there other approaches you are investigating or feel have merit for transportation capital projects?
Survey Responses				
Alaska Jeff Ottesen Alaska Department of Transportation jeff_ottesen@dot.state.ak.us	We have started to use the FHWA guidance as to inflating to the year of construction on major projects. This is currently 4% per year, which is certainly not consistent with recent inflation we have seen, or that experienced across the US. In the development of a new electronic STIP tool, we hope to have an automatic tie to the "Scope, Schedule and Estimate" sheet prepared for each project, so that as updated SSE sheets are prepared for any given project, the numbers in the STIP are linked. We are currently asking project engineers to update the SSE sheets for projects at the time of each STIP, and each major amendment for the STIP. But these sheets are normally based on an immediate year of construction, rather than a delayed year which is often the case as the balancing between costs and funding resources is accomplished. This is a paper intensive process and the quality of and thought that goes into each SSE varies considerably. In short, we are pretty low on the technology curve on this issue.	No	NA	Other than what I discuss in the answer to #1, no.
Arkansas Ed Hoppe Division Engineer Programs and Contracts Arkansas State Highway and Transportation Department 501-569-2262 Hoppe.Ed@arkansashighways.com	The Department maintains a Construction Cost Index for highway projects based on the FHWA CCI (1987 base = 100, by quarter past 6 years plus annual back to 1971). In estimating inflation we use the AR CCI in developing the rate. At present we have been using 6% per year inflation to estimate the increase in the cost of construction.	Same as 1.	While we do not specifically use a commercial forecast, we have access to AGC's The Data Digest and trade publications, such as , ENR, Roads & Bridges, Better Roads,	The information above relates to estimating for planning/programming purposes such as development of the STIP. PS&E estimate increases are handled on a project basis by the Department's

			etc., that report extensively on the trends and factors relating to highway construction inflation.	design divisions.
Illinois Jerry D. Cameron Illinois Department of Transportation Jerry.Cameron@illinois.gov	We use a price index from our bidding data	We use a system built in house that calculates an index similar to the federal price index	NA	Risk in Estimating utilizing a task force made up of IDOT and Industry
Iowa Sandra Q. Larson, P.E. Research and Technology Bureau Director Highway Division Iowa Department of Transportation 515-239-1205 sandra.larson@dot.iowa.gov	We use a 4.5% annual program cost increase factor, which is an estimate of both inflation and "project scope creep".	In-house/ agency	NA	No
Kansas Dick McReynolds Engineer of Research Kansas DOT dick@ksdot.org	On construction projects, the "Engineer's Estimate" uses the historical prices for each individual bid item for the region that the project happens to be. They use the TrnsPort software through AASHTO to compile and generate the estimate. The estimators get the "suggested" price for each bid item and they have the discretion of adjusting it. Recent historical prices are used to reflect the current inflation. The basis for the forward look the state uses is Moody's which is used to provide economic data and forecasts including inflation.	Both-see 1.	See 1.	NA
Massachusetts One Hwang Massachusetts Department of Transportation One.Hwang@state.ma.us	I derive my inflation rates from BLS's PPI indices because it's free, but I am hoping that MassHighway will purchase a copy of R.S. Means to explore the possibility of using values more specific to the transportation industry and to our region.			
Mississippi Paul Loper Mississippi Department of Transportation ploper@mdot.state.ms.us	A 3% rate is used for short term project planning. This rate was derived from the methods shown in question #2.	The rate approximates the historical increase in the construction index computed each year by the MDOT Construction Division. The	Do not use commercial forecast.	A trend line of the Construction Index mentioned will be updated each year. The projection method will utilize a

		computation method for the index is similar to the one used by the FHWA to obtain the price trends for federal aid construction.		second degree polynomial equation.
Missouri Travis Koestner, PE TSE - Contract Services Missouri Department of Transportation 573-526-2923	MoDOT uses 4% in its Statewide Transportation Improvement Program (STIP)	MoDOT's Resource Management and Transportation Planning Groups recommend a rate to use based on historical averages from FHWA and PPI rates.	NA	NA
Montana Lesly Tribelhorn, PE Highways Bureau Montana Department of Transportation 406-444-6242 ltribelhorn@mt.gov	We use a straight inflation rate of 3% per year, compounded annually. We inflate the total estimated construction cost after adding in contingencies. (Note: Lesly's perspective is from the engineering end of the process which uses the rate provided by the Planning Office to estimate construction costs)	We use an in-house assumed rate (from Global Insight Inc.) However, we have initiated the process to have an economist within our planning division determine appropriate inflation rates based on a market analysis.	See below	We have initiated the process to have an economist within our planning division determine appropriate inflation rates based on a market analysis.
Montana (continued) Paul Johnson, PE Project Analysis Bureau Montana Department of Transportation 406-444-7259 paujohnson@mt.gov	The Montana Department of Transportation (MDT) utilizes the services of Global Insight Inc. to determine inflationary factors for highway construction costs. The Highway Construction Cost Index provided by Global Insight provides MDT with historical values as well as future forecasts. (Note: Paul's perspective is from the planning end of the process which uses the rate provided by Global Insight, and incorporates current local data)	As mentioned previously, MDT utilizes Global Insight Inc. as a source for inflationary information. Global Insight is considered an official source of economic information for the State of Montana.	The Highway Construction Cost Index provided by Global Insight Inc.	MDT would like to develop a procedure for determining inflationary factors at the state level. (Presently, our best available data source is the national/regional information provided by Global Insight.) Additionally, MDT would like to evaluate the factors that cause our state rate to vary from the national average. However, it would require a substantial reallocation of resources within the department to make this happen. So while we are steering our efforts in this direction, it will take time to see meaningful results.

North Dakota James Rath Design Division North Dakota Department of Transportation 701-328-1722 jrath@nd.gov	4%	In-house assumed rates	NA	None
Oregon John Riedl, PE Senior Cost Engineer Oregon Department of Transportation 503-986-3886 John.J.RIEDL@odot.state.or.us	Inflation estimating is performed in house through the ODOT office of economics with Dave Kavanaugh together with information provided by the office of spec's, estimating and office of prelet (SOEPL).	The office of economics uses a number of services - including commercial services as well as in house forecasting expertise. Several commercial services are available - I so not have a list but can give you contact names for that information if desired.	Cost forecasting for smaller STIP projects is quite different than costs for mega projects as defined by FHWA. ODOT does follow the CEVP and CRA program protocols to a degree - depending on the order and magnitude of the work and risk. The recent OTIA III program was just evaluated for risk via a multi level risk analysis based upon work type, level of scoping based upon project bundles, market sector analysis of bid trends over the last 3 years and work sector workforce saturation.	The recently developed market sector analysis tool was copied and given to Jay Drye in WsDOT at this years TCCE meeting at AASHTO - he should have a copy available for you.
Saskatchewan, Canada Allan Widger Executive Director, Engineering Standards Branch Saskatchewan Highways and Transportation 306-787-4858 awidger@highways.gov.sk.ca	I received your questions through the AASHTO Committees so decided to respond. I was surprised to receive this question from Washington State since Saskatchewan just had a consultant review our Construction Bid Price Trends and estimating for our Department and most of the information they quoted was from your web site which I had given to them as a good reference. They included it as being one of the best sources of information.	Everybody is having the same problem with increasing construction costs and what to use as inflation rates. Historically there has been a slow continuous increase and predictions of things like bid price trends have been possible. With the cost increases of 50% or more in the last two years we are asking the same questions you are and have been unable to determine what to expect.	Saskatchewan has been trying to use the same approach that you do of breaking down the major construction components into the inputs and predicting the inputs such as labour/fuel/materials/equipment cost/profit separately since there does seem to be information available on	The Saskatchewan report has temporarily been pulled from our web site http://www.highways.gov.sk.ca/docs/reports_manuals/reports/report_transition.asp but should be posted again in the very near future.

			each of the input factors for our small market.	
Texas Jack Foster, P.E. Director, Systems Planning Transportation Planning and Programming Division Texas Department of Transportation 512-486-5024 jfoster@dot.state.tx.us	Currently TxDOT uses four percent as our inflation rate.	TxDOT uses rates derived in-house.	Not applicable.	TxDOT is not currently investigating other approaches.
Virginia John W. Lawson Director of Financial Planning Virginia Department of Transportation 804-786-2454 John.Lawson@VDOT.Virginia.gov	We inflate construction projects to the year of advertisement. If a project is to begin in FY 2010, it would be inflated from the current years estimate by a factor representing the forecasted cumulative growth for fiscal years 2007, 2008, 2009 and 2010. We include an inflation factor for the current year since our project estimating tool is based on historical costs from the prior year. The inflation rates are applied by the agency's cost estimating tool.	We obtain our inflation forecast through the Virginia Department of Taxation. They have worked with Moodys.com to develop a construction forecast for this purpose.	The custom forecast from Moodys.com explained above is a blended forecast based on PPI for transportation construction and materials.	We have looked at using ENR or just the PPI for land transportation, but they have not tracked well for us.
West Virginia Robert Watson ,P.E Budget Division West Virginia Division of Highways 304-558-9623 rcwatson@dot.state.wv.u	Federal-Aid Construction Price Index (national values) 10-year rolling average.	In-house	N/A	We are not evaluating any at this time.
Wisconsin Steven Krebs Wisconsin Department of Transportation steven.krebs@dot.state.wi.u	The Wisconsin Construction Cost Index	In House Agency assumed rate and/or CPI.	Sometimes CPI	We are currently investigating this very question. At this time we don't have information to add.
Washington Aaron Butters Systems Analysis and Program Development Manager Washington State Department of Transportation 360-705-7153 ButterA@wsdot.wa.gov Eric Meale Economics Manager	WSDOT currently uses a private service to supply this information. The construction forecast assumptions have been taken from an index prepared and maintained by Global Insight. Global Insight is an economics and forecasting consulting firm.	Global Insight provides inflation estimates for 10 years and the last year's inflation rate is used to project to 50 years.	Global Insight Highway Construction Cost Index	In its 2007-09 biennial budget request, WSDOT updated estimates on a project-by project basis to reflect current costs (June 2006). Some project cost updates merely reflect the increased cost escalation of the project from the date of the last estimate, while others also reflect

Washington State Department of Transportation 360-705-7942 MealeE@wsdot.wa.gov				the continued engineering refinement of design details. From there, WSDOT has applied an inflation factor for each of the project phases of Project Engineering, Right of Way, and Construction to year of expenditure, as follows: • Project Engineering cost projections include a general measure of inflation (the Implicit Price Deflator for personal consumption). • Right of Way cost growth through 2007 reflect assumptions based on a forecast of the market value of real and personal taxable property prepared by the state's Economic and Revenue Forecast Council, and for 2008 and beyond, the forecast is derived from a forecast of assessed property value (Puget Sound baseline) prepared by Conway Pederson Economics. • The construction forecast assumptions have been taken from an index prepared and maintained by Global Insight.

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