Best Practices in Project Management

FINAL REPORT 511

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16. Abstract

ADOT's ability to manage a cost-effective construction program delivery and be accountable to policy-makers and customers regarding the cost and timeliness of highway projects is at risk. The following is ADOT's current situation:
- There is little consistency in project management.
- ADOT is not actively managing and controlling budget and scope.
- The organization does not hold itself and managers accountable for scope, budget, and quality.
- ADOT's process, tools, and procedures do not enable the most effective use of human and other resources.
- There will be continued impacts to ADOT's organizational capacity and health.

Following are the desired outcomes from improving ADOT's project management process:
- ADOT will be able to manage construction program delivery against scope, schedule, budget, and quality objectives on a department-wide basis at the program and project levels.
- ADOT will hold itself accountable for delivering the program vs. scope, schedule, budget, & quality objectives.
- The strategic importance of project management will be emphasized by ADOT management
- ADOT will increase its project focus to establish a project management culture.
- The importance and role of project managers and the project management discipline will be elevated.
- A consistent process at the project level will be established. In this way, more discipline and predictability will be brought to the process. This will strengthen ADOT's ability to manage overall program delivery.
- Scopes will be set and budgets managed at the project level. The role and authority of project managers will be strengthened to accomplish these objectives. The decision-making will be proactive, recognizing that in project delivery scope, schedule, and budget decisions impact each other.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000L shall be shown in m^3.				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
ILLUMINATION				
fc	foot candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE AND PRESSURE OR STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	Square millimeters	0.0016	square inches	in^2
m^2	Square meters	10.764	square feet	ft^2
m^2	Square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	Square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	Cubic meters	35.315	cubic feet	ft^3
m^3	Cubic meters	1.308	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
TEMPERATURE (exact)				
°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE AND PRESSURE OR STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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GLOSSARY OF ACRONYMS

AASHTO	American Association of State Highway Transportation Officials
ADOT	Arizona Department of Transportation
APSR	Active Project Status Report
ARTEMIS	Automated Reporting, Tracking, and Evaluation Management Information System
BCDP	Budgeted Cost of Deliverables Produced
BCDS	Budgeted Cost of Deliverables Scheduled
BVI	Bid Variation Index
CDSE	Chief Deputy State Engineer
CEVP	Cost Estimate Validation Process
CIP	Capital Improvement Program
COG	Council of Governments
Core Team	ADOT's Senior Management Team composed of Director, Deputy Director, and Head of each Division.
CPEI	Consultant Performance Evaluation Index
CPMS	Capital Program Management System
DCR	Design Concept Report
DOT	Department of Transportation
D-REWI	Design-Related Extra Work Index
EA/EIS	Environmental Assessment/Environmental Impact Statement
ECS	Engineering Consulting Section
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
FTE	Full Time Equivalent
FY	Fiscal Year
GAO	United States General Accounting Office
HES	Highway Engineering Safety
IRP	Issue Resolution Process
ISO	International Organization for Standardization
IT	Information Technology
ITD	Intermodal Transportation Division

ITS	Intelligent Transportation Systems
L/DCR	Location/Design Concept Review
PA	Project Assessment
PCR	Project Change Request
PDE	Project Development Engineer
PDPM	Project Development Process Manual
PE	Professional Engineer
PEP	Project Evaluation Process
PM	Project Manager
PMP	Project Management Plan
PPMS	Program and Project Management System
PRB	Project Review Board
PS&E	Plans, Specifications and Estimates
PSQAP	Project Specific Quality Assurance Plans
PWP	Project Work Plan
PWS	Project Work Schedule
QEI	Quantity Estimates Index
RE	Resident Engineer
ROW	Right-of-Way
R/W	Right-of-Way
RR	Railroad
SLIM	Statewide Long-Term Improved Management
SPI	Schedule Performance Index
SPMS	Statewide Project Management Section
SPR	State Planning & Research
STDEV	Standard Deviation
STIP	State Transportation Improvement Plan
SURF	Schedule Update Request Form
TAC	Technical Advisory Committee
TEA-21	Transportation Equity Act for the 21st Century
TRACS	Transportation Accounting System
TSC	Transportation Service Center
WBS	Work Breakdown Schedule

BEST PRACTICES IN PROJECT MANAGEMENT: FINAL REPORT AND IMPLEMENTATION PLAN EXECUTIVE SUMMARY

BACKGROUND

This executive summary presents an overview of the research, analysis, findings, and recommendations from a major study of Arizona Department of Transportation (ADOT) project management practices and processes that was conducted by Dye Management Group, Inc.

APPROACH

The researchers evaluated ADOT's project management process against industry best practices. Dye Management Group, Inc.'s methodology:

- Involved ADOT employees, business partners, and customers in identifying the critical issues confronting ADOT.

- Analyzed ADOT's documented policies and procedures.

- Analyzed actual ADOT practices.

- Evaluated issues, policies and procedures, and actual practices against industry best practice.

PRINCIPAL FINDINGS – RISKS FROM BUSINESS AS USUAL

ADOT's ability to manage a cost-effective construction program delivery and be accountable to policy-makers and customers regarding the cost and timeliness of highway projects is at risk. The following is ADOT's current situation:

- There is little consistency in project management.

- ADOT is not actively managing and controlling budget and scope.

- The organization does not hold itself and managers accountable for scope, budget, and quality.

- ADOT's process, tools, and procedures do not enable the most effective use of human and other resources.

- There will be continued impacts to ADOT's organizational capacity and health.

PRINCIPAL FINDINGS – BENEFITS OF CHANGE

The benefits of an improved project management process include:

- Ability to establish, manage, and actively control project costs to ensure cost-effective delivery of the construction program.

- Capacity to realize delivery efficiencies.

- Ability to address quality control and associated cost issues.

- Increased transparency and accountability for ADOT.

- Better human resource management and increased staff productivity.

- Increased precision in managing program delivery and performing cash management across multiple years.

DESIRED OUTCOME FROM AN IMPROVED PROJECT MANAGEMENT PROCESS

Following are the desired outcomes from improving ADOT's project management process:

- ADOT will be able to manage construction program delivery against scope, schedule, budget, and quality objectives on a department-wide basis at the program and project levels.

- ADOT will hold itself accountable for delivering the program against scope, schedule, budget, and quality objectives.

- The strategic importance of project management will be emphasized by ADOT management

- ADOT will increase its project focus to establish a project management culture.

- The importance and role of project managers and the project management discipline will be elevated at ADOT.

- A consistent process at the project level will be established. In this way, more discipline and predictability will be brought to the process. This will strengthen ADOT's ability to manage overall program delivery.

- Scopes will be set and budgets managed at the project level. The role and authority of project managers will be strengthened to accomplish these objectives. The decision-making will be proactive, recognizing that in project delivery scope, schedule, and budget decisions impact each other.

RECOMMENDATIONS

The study findings provide the following recommendations for the new process and strongly support the idea that they should be implemented as a package. Together they provide the elements of a reformed project management process.

Recommendations for Strategic Direction for Project Management

The recommendations are intended to ensure that there is department-wide accountability for and ownership of accomplishing project management objectives. The recommendations provide the department-wide leadership with direction to strengthen ADOT's project management culture.

Recommendation 1. Develop ADOT's project management culture by providing clear, consistent, executive communication and leadership regarding the department-wide importance of project management objectives and their accomplishment.

Recommendation 2. Establish department-wide ownership and accountability by senior management for strategic objective accomplishment in scope, budget, schedule, and quality.

Recommendation 3. Establish measurable ADOT strategic objectives for scope, budget, schedule, and quality and measure their accomplishment.

Recommendations for Roles and Responsibilities of the Project Manager

These recommendations address the concerns that project management at ADOT is inconsistent. There is no widely shared understanding of the role of the project manager or the project team; project management practices vary widely and the extent to which projects are actively managed at all is variable. The intent of the recommendations detailed below is to increase the consistency and discipline with which best project management practices are applied at ADOT.

Recommendation 4. Establish department-wide the roles, responsibilities, and authority of project managers, project teams, technical managers, technical leaders, and team members. Strengthen the project manager's level of authority.

Recommendation 5. Strengthen the consistency of project management across ADOT by establishing consistent project management procedures.

Recommendation 6. Revise project management policies, guidelines, and manuals to reflect these consistent project management requirements.

Recommendation 7. Establish measurable performance objectives for project managers that are aligned with ADOT strategic objectives and project managers' roles, responsibilities, and authority.

Recommendations for Project Management Tools, Reporting Systems, and Management Information

These recommendations address the imperative for consistent department-level information on project delivery status and for bridging the significant gaps in project-level information that form barriers to improved project management. Moreover, many ADOT project managers and other process participants state that they derive limited value from their current data reporting activities. The intent of the recommendations is to move toward a situation in which the highest performing managers are those who use the tools because they are helping them plan, execute, monitor, and control their work.

Recommendation 8. Develop and maintain department-wide project status information regarding project scope, schedule, and budget.

Recommendation 9. Strengthen scope management by revising policies and procedures to establish greater accountability and reporting mechanisms.

Recommendation 10. Establish a standardized process for project schedule planning and management.

Recommendation 11. Establish and manage project budgets.

Recommendation 12. Use quantitative information to evaluate ADOT labor requirements and establish work standards by activity to support project scheduling and budgeting.

Recommendation 13. Perform multi-project resource loading to evaluate the "deliverability of the program" and support overall program management.

Recommendations for Organizational Development to Strengthen ADOT's Project Management Function

The recommendations address the study findings that strengthened project management requires elevating and supporting the development of project management as a discipline within ADOT.

Recommendation 14. Create a department-wide organizational focal point for all project management at ADOT.

Recommendation 15. Establish project management as a visible and attractive ADOT career path.

Recommendation 16. Continue to emphasize and amplify training and professional development for project managers. This recommendation builds on the existing level of commitment to training for project managers and team members.

IMPLEMENTATION

ADOT needs to implement the package of recommendations in their entirety. It is recognized that there are a number of improvements underway to address quality, improve management reporting systems, and enhance partnering and other aspects that impact project management; however, the Tactical Advisory Committee (TAC) at their meeting on February 28, 2003 endorsed these recommendations and initiated their request that ADOT management pursue their timely implementation. The TAC expressed agreement that partial change exacerbates the problems by not really getting to the root cause of the problems. For successful implementation, ADOT must implement the recommendations as a package, provide executive commitment, and allocate the necessary resources.

Initial Steps and Organization

The study recommends the following implementation steps:

1. Secure Executive Sponsorship for Implementation.

2. Appoint an Implementation Manager and Team.

3. Have the Team Develop and Implement the Reformed Process.

Resource Requirements

Successful implementation requires the dedication of resources to manage implementation and resources to address individual recommendation areas. Initial implementation steps will determine resource requirements. Although ADOT's budget is highly constrained at present, successful implementation will yield a high return on investment and quickly pay for itself. The allocation of resources will determine how quickly the recommendations can be implemented.

I.   INTRODUCTION AND BACKGROUND

INTRODUCTION

This document is the final report for the Arizona Department of Transportation's (ADOT) Best Practices in Project Management Study. This study was performed by Dye Management Group, Inc. under the direction of a Technical Advisory Committee (TAC). The recommendations developed through this study involved many ADOT employees and drew upon Dye Management Group, Inc.'s research findings and first hand experience assisting other states to improve project management.

BACKGROUND

This final report combines the individual interim reports prepared during the course of the study. These interim reports were planned and sequenced to:

- Ensure that the consultant team focused on the issues of greatest concern to ADOT.

- Provide grounding in the theory, tools, and techniques of project management through a survey of best practices among other state departments of transportation.

- Identify best practices in project management.

- Establish a baseline description of ADOT's current project management approaches, documentation, systems, and business practices.

- Develop an integrated set of recommendations endorsed by the Technical Advisory Committee.

- Provide guidance on the how ADOT can implement the study recommendations.

Study Interim Reports

Prior study interim reports that this research report is based on are listed below:

Interim Report 1: Best Project Management Practices: Critical Issues. To prepare this interim report the consultant team interviewed ADOT executives, managers, and staff in order to elicit their views as to the most pressing issues in project and program delivery at ADOT. This interim report provided extensive base line documentation regarding the perception and reality of project management at ADOT.

Interim Report 2: Best Project Management Practices Literature Review. In an effort to identify industry best practices in project and program delivery, the consultant team conducted a literature review which referenced journal articles, books, and Websites. A key finding was that public sector infrastructure providers are turning to project management—not only as a tool for discrete pieces of work—but also as an overarching, department-wide strategy more aptly described as "management by project." This literature review focused on the characteristics of "project-oriented" organizations, which include structures of accountability at levels throughout the department, a well defined approach to project management structure, generally some variation of "matrix management" and project management information technology that allows for effective project and program-level planning and control.

Interim Report 3: Best Project Management Practices: Best Practices Survey. The purpose of this survey was to identify "best practices in project management" as developed by other state departments of transportation (DOTs). Based on input from the ADOT Technical Advisory Committee as well as consultant team experience, seven DOTs were selected for review: Massachusetts, Minnesota, Michigan, New Jersey, New Mexico, Utah, and Washington. In addition, project management training materials, computer documentation, manuals, reports, bidding documents, and capital improvement programs from 22 other states were analyzed. Among the findings of this survey were that program managers rely on project management as a means of planning, monitoring, and controlling the allocation of resources at the department level. Another finding was that most states are in the process of moving toward stronger matrices and no state was found to be moving toward a weak matrix, which ADOT has adopted.

Interim Report 4: Best Project Management Practices: Assessment of ADOT Practices. This interim report examined ADOT's current project and program management approaches, documentation, and systems. The consultant team's research methodology included a review of ADOT specifications, progress and financial reports, audits, training materials, and other written documentation as well as multiple rounds of interviews with ADOT executives, managers, staff, and partners.

Interim Report 5: Best Practices in Project Management: Findings and Recommendations. This interim report provided an integrated set of recommendations that addressed the change to business process, project manager roles and responsibilities, department-wide management, human resource management, reporting systems and procedures necessary to strengthen project management.

Interim Report 6: Implementation Plan. This interim report identified the implementation steps required for ADOT to implement the recommendations identified in prior study interim reports.

FINAL REPORT ORGANIZATION

The final report is organized into the following chapters. To emphasize the importance of the findings, recommendations, and implementation plan, they are presented prior to the research, results, and analysis.

Chapter II. Findings, Recommendations, and Implementation. This chapter details the study's findings, the recommendations that address them, and provides an implementation plan.

Chapter III. Critical Issues Analysis. This chapter reports the results from the critical issue analysis that comprised a series of structured interviews and focus groups with ADOT employees, business partners, and customers.

Chapter IV. Current Practices. This chapter details ADOT's current project management policies, procedures, and practices.

Chapter V. Best Practices Research. This chapter presents the findings from a literature review, an evaluation of other state departments of transportations' documented practices, and a best practice survey.

Appendix A: Interviewees. This Appendix contains a list of ADOT staff and consultants involved with project management and delivery functions who were interviewed during this study.

Appendix B: Sampling of Performance Measures from the Minnesota Department of Transportation, the New Mexico Highway and Transportation Department, and the Washington State Department of Transportation that capture project level outcomes.

Appendix C: Survey Questionnaire, Summary of Responses from Benchmarking States, and Innovative Practices by States in Improving Project Management.

II. FINDINGS, RECOMMENDATIONS, AND IMPLEMENTATION

INTRODUCTION

This chapter details the study's finding with the recommendations that address them, and provides an implementation plan. Chapters III-V contain information and documentation that support the findings and recommendations contained in this chapter.

The chapter is organized into the following sections:

The first section is a background section, summarizing the purpose and context of the five study interim reports.

The second section presents the reasons supporting the study recommendations.

The third section discusses the desired outcome from a fully reformed process or the improved function of the project manager process at ADOT.

The fourth section discusses success factors, or those factors necessary at ADOT to achieve an improved project management function.

The fifth section contains the recommended organization necessary to achieve success.

The sixth section discusses and lists the recommendations to achieve project management improvement under three heads: 1) Strategic direction for project management; 2) Roles and responsibilities of the project manager; and 3) Project management tools, reporting system, and management information. Under each heading, there is a discussion of findings and implementation steps.

BACKGROUND

Preceding interim reports for this study were planned and sequenced to (1) ensure that the consultant team focused on the issues of greatest concern to ADOT; (2) provide grounding in the theory, tools, and techniques of project management through a survey of best practices among other state departments of transportation; (3) identify best practices in project management; (4) establish a baseline description of ADOT's current project management approaches, documentation, systems, and business practices; and (5) develop an integrated set of recommendations.

The implementation plan provides guidance on how ADOT can implement the study recommendations. These recommendations were developed through a study that involved many ADOT employees and drew upon Dye Management Group, Inc.'s research findings and their first-hand experience assisting other states to improve project management.

Prior study interim reports that this implementation plan addresses are listed below:

- The first interim report was entitled, "Best Project Management Practices: Critical Issues." The consultant team interviewed ADOT executives, managers, and staff in order to elicit their views as to the most pressing issues in project and program delivery at ADOT. This interim report provided extensive base line documentation regarding the perception and reality of project management at ADOT.

- The second interim report was "Best Project Management Practices Literature Review." In an effort to identify industry best practices in project and program delivery, the consultant team conducted a literature review that referenced journal articles, books, and websites. A key finding was that public sector infrastructure providers are turning to project management, not only as a tool for discrete pieces of work, but also as an overarching, department-wide strategy more aptly described as "management by project." This interim report focused on the characteristics of "project-oriented" organizations, which include structures of accountability at levels throughout the department, a well defined approach to project management structure, generally some variation of "matrix management," and project management information technology that allows for effective project- and program-level planning and control.

- The third interim report was entitled "Best Project Management Practices: Best Practices Survey," and its purpose was to identify "best practices in project management" as developed by other state departments of transportation (DOTs). Based on input from the ADOT TAC as well as consultant team experience, seven DOTs were selected for review: Massachusetts, Minnesota, Michigan, New Jersey, New Mexico, Utah, and Washington. In addition, project management training materials, computer documentation, manuals, reports, bidding documents, and capital improvement programs from 22 other states were analyzed. Among the findings of this survey were that program managers rely on project management as a means of planning, monitoring, and controlling the allocation of resources at the department level. Another finding was that most states are in the process of moving toward stronger matrices and no state was found to be moving toward the weak matrix favored by ADOT.

- The fourth interim report, "Best Project Management Practices: Assessment of ADOT Practices," examined ADOT's current project and program management approaches, documentation, and systems. The consultant team's research methodology included a review of ADOT specifications, progress and financial reports, audits, training materials, and other written documentation as well as multiple rounds of interviews with ADOT executives, managers, staff, and partners.

- The fifth interim report, "Best Practices in Project Management: Findings and Recommendations," provided an integrated set of recommendations that

addressed the change to business process, project manager roles and responsibilities, department-wide management, human resource management, reporting systems, and procedures necessary to strengthen project management.

WHY ADOT SHOULD TAKE ACTION

Overall findings in the Best Practices in Project Management Study indicate that there is wide support in the department for a change in the project management process. Some of the findings that relate to the project management function at ADOT are:

- **ADOT executives are perceived by managers and staff throughout the organization as being receptive to an increased focus on project management.**

   However, project management is perceived as having languished since the 1990s. Further, the efforts to improve project management, such as partnering and training, are perceived as useful and effective but not coordinated within a department-level approach.

- **An executive level emphasis on schedule accomplishment is perceived as the single overriding project-related performance measure.**

   This emphasis is widely viewed as having had adverse impacts on other aspects of project management, including scope, budget management, and quality.

- **ADOT's project management culture does not emphasize fiscal discipline.**

   This is reflected not only in the overriding schedule emphasis, but also in the fact that project managers do not plan, manage, or control overall project budgets.

Strengthening ADOT's project manager function is key to strengthening the project management culture within ADOT. A strong project management culture is a shared culture that values meeting and balancing scope, schedule, budget, and quality commitments on projects. Improved project management will allow management and staff to better manage ADOT's capital program throughout the project life cycle.

The benefits of improved capital program control include the following:

- **Ability to establish, manage and actively control project costs to ensure cost-effective delivery of the construction program.**

   Currently, ADOT does not manage project budgets effectively. Improved project management will position ADOT to deliver more projects through better management of scope and budget.

- **Capacity to do more projects more quickly.**

  Better resource planning and control at ADOT will enable management to remove bottlenecks, allocate resources more effectively, and establish realistic work standards to manage delivery.

- **Ability to address quality control and associated cost issues.**

  Improving project quality at the design phase can produce savings during construction. ADOT's design engineers and resident engineers alike attribute construction cost overruns to design errors and omissions that occur because of late rushes to meet the letting schedule. ADOT's construction engineering costs as a percentage of the entire construction cost appear to be high relative to other state departments of transportation.[1]

- **Increased transparency and accountability for ADOT.**

  ADOT is temporarily at a comfortable point having demonstrated to the Legislature that the agency can meet its delivery commitments. However, ADOT needs to provide accountability to policy-makers and its customers regarding the cost-effective delivery of the construction program. If ADOT is to establish the business objective that the construction program says what the Department is going to do and the Department does what it says, then project management must be strengthened. The recommendations provide the building blocks to establish accountability for how long it takes and how much it costs to deliver transportation projects.

- **Better human resource management and increased staff productivity.**

  ADOT faces several issues in human resource management: (1) ADOT does not apply work standards, or measure, or manage the labor resources for project delivery; therefore, it is difficult to determine a project's actual cost or manage labor productivity; (2) because the agency lacks the capacity to perform resource leveling, which would require the use of standard labor durations in scheduling, it cannot assess the appropriateness of the number, function, or geographic location of its employees; (3) ADOT's current, exclusive focus on schedule has often led to last minute "heroics" and long hours that staff say have led to organizational stress and depressed morale; (4) the agency, like most others around the country, is facing waves of retirements and a declining pool of

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[1] Recent research by the Washington State Department of Transportation undertook a construction cost benchmarking study that included responses from 25 states, including Arizona. While ADOT's preliminary engineering costs for a single lane mile of roadway were low relative to peers at 8% of total budget, construction engineering costs at 15% put ADOT in the higher end of the range. Although other factors, including scope creep and changed conditions, account for a portion of ADOT's construction engineering costs, the data do not contradict the views of ADOT's own engineers that weak project control leads to design quality problems, which are reflected in change orders and construction engineering costs.

civil engineering graduates. Implementing a stronger project manager function at ADOT would address each of these issues.

- **Increased precision in managing program delivery and performing cash management across multiple years.**

    ADOT will achieve greater cash management capacity as it gains a more up-to-date, more precise basis upon which to estimate revenues and expenditures, both current and projected.

DESIRED OUTCOME FROM A FULLY REFORMED PROCESS

The desired outcome is for ADOT to hold itself accountable for managing construction program delivery against scope, schedule, budget, and quality objectives department-wide at the program and project levels. ADOT management will emphasize the strategic importance of project management and the organization will enhance its project management culture.

The importance and role of project managers and the project management discipline will be elevated at ADOT. A consistent process at the project level will be established. In this way, more discipline and predictability will be brought to the process to strengthen ADOT's ability to manage overall program delivery. Scopes will be set and budgets managed at the project level.

The role and authority of project managers will be strengthened to accomplish these objectives. The decision-making will be proactive and recognize that in project delivery, decisions regarding scope, schedule, and budget impact each other.

SUCCESS FACTORS

The study recommendations require considerable change across the Intermodal Transportation Division affecting senior management, project managers, technical managers, and staff. This change will take place in the context of an organization that has experienced considerable labor force transition and that will continue to experience staffing constraints.

Successful implementation of the study recommendations needs to address the following success factors:

- **Executive sponsorship and department-wide commitment to timely implementation.**

    The recommendations address one of ADOT's principal business activities—the completion of the projects in the highway construction program. Successful implementation of the recommended changes to the project development process will yield the following benefits:

- Ability to establish, manage, and actively control project costs to ensure cost-effective delivery of the construction program.

- Capacity to deploy ADOT and consultant resources more effectively.

- Ability to address quality control and associated cost issues.

- Increased transparency and accountability for ADOT.

- Better human resource management and increased staff productivity.

- Increased precision in managing program delivery and performing cash management across multiple years.

Strengthening project management through the recommended improvements will enable ADOT to deliver the entire construction program, as well as individual projects, with greater predictability and at a lower cost. The recommendations affect the entire department and need top down support for timely implementation. Therefore, successful implementation requires executive sponsorship and prioritization of implementation. This will provide leadership and direction to the entire organization regarding the importance of addressing the study recommendations.

- **Need to establish implementation as a business improvement project with an implementation manager and team accountable to senior management.**

  Management at all levels within ADOT must spend a considerable portion of its time addressing the immediate needs of production and maintaining business continuity. There are many competing claims on time. In consequence, for implementation to proceed successfully, ADOT needs to establish a "project management business improvement project and team" accountable for implementing the recommendations.

  To reduce risk and address success factors, the team should establish a detailed work plan for implementation and be accountable to senior management for timely implementation.

- **Need to implement the recommendations as a package.**

  A key to success is addressing the recommendations as an interrelated package. Study findings indicate that addressing recommendations in a piecemeal fashion will not deal with the underlying issues.

- **Need for careful organizational change management and communications.**

  Change management and internal communications need to be well managed during implementation. The recommendations involve a number of business

processes and it is imperative that the employees at all levels buy into and participate in the development and introduction of the new process.

- **Need for detailed implementation planning and resource assessment.**

  Implementation will require staff resources and an implementation budget. A key success factor will involve establishing a detailed, resource loaded work plan for implementation. The implementation needs to provide an incremental pragmatic role, one that will provide new procedures and tools that ADOT managers and project managers can start to use quickly and one that will provide early benefits.

IMPLEMENTATION ORGANIZATION

The study recommendations provide the framework for establishing an improved process, procedures, tools, accountability mechanisms, and organizational structure for project management. Implementation needs to address the package of recommendations in its entirety.

It is recognized that there are a number of improvements underway to address quality, improve management reporting systems, and enhance partnering and other aspects that impact project management. Successful implementation requires implementing the recommendations as a package, top down commitment, and the allocation of resources.

The following organization is recommended for providing oversight and managing implementation:

- **Executive sponsor and oversight.**

  The Executive Sponsor will provide top down ownership and support for implementation. In this way, implementation will be affirmed as a priority for ADOT. The implementation manager will be accountable to the Executive Sponsor and the Core Team for timely implementation. (The Core Team is ADOT's senior management team and is composed of the Director, the Deputy Director, and the Heads of each division.) The Executive Sponsor will address resource needs and leadership action required to make implementation a success.

- **Project management business improvement project established.**

  Recommendations implementation is established as a business improvement project that is a strategic initiative of the Department. It has an identity in its own right. The project is established with a charter, work scope, and time line.

- **Implementation manager and team.**

  An implementation manager is appointed with responsibility for managing the project management business improvement project. A high level team provides policy direction and support to the implementation manager. The implementation manager is accountable to the Executive Sponsor and the Core Team for implementation progress. The implementation team should be cross-functional and will require staff support.

  A consideration for the Executive Sponsor and the Core Team is whether the Implementation Manager should be the individual who would have the management responsibility addressed through recommendation 14 "Create a department-wide organizational focal point for all project management at ADOT." If the Executive Sponsor and the Core Team concur with recommendation 14, then it would be desirable for the implementation manager to transition into that position. In this way, there would be organizational continuity and the individual would be overseeing the development of the organizational function and capability that he or she will manage.

- **Staff support.**

  Staff support is required to develop the detailed design for the new processes, business rules, and tools for strengthened project management. The implementation plan envisions that staff support will develop "straw man" or prototype new business rules, tools, and procedures that address individual recommendations. They will perform this work with input from ADOT validation teams. These teams will provide review and input to the development of the new business rules that address study recommendations. The staff support will then refine the business improvements until they are ready for Implementation Team review and approval for Core Team (i.e., ADOT senior management) adoption. This staff support is also necessary for addressing the organizational change management, communications, and work planning.

- **ADOT validation teams.**

  The implementation plan anticipates establishing validation teams that involve ADOT staff in addressing individual recommendations. The approach anticipated is that staff developing the new business rules will convene a work group to provide review and input at key points. The approach would use these ad hoc groups selectively to provide input and validation of staff work at key steps.

- **Resource requirements.**

  Successful implementation requires the dedication of resources to manage implementation and staff resources to address individual recommendation

areas. These staff resources would be supplemented by targeted input and validation from current process owners, participants, and managers on a targeted basis as discussed under validation teams.

Initial implementation steps will involve determining resource requirements. At a minimum, a dedicated implementation manager is required with in-house or contracted staff support. It is understood that ADOT's budget is highly constrained at present. However, there is no doubt that successful implementation will yield a high return on investment and quickly pay for itself. The allocation of resources will determine how quickly the recommendations can be implemented.

PHASE I – ESTABLISH IMPROVEMENT PROJECT AND PREPARE DETAILED WORK PLAN

The purpose of Phase I is to secure executive level support, conduct the initial change management and communications, and conduct detailed work planning.

The following are the major Phase I steps:

Step 1. Secure executive sponsorship for implementation.

This step is a prerequisite for success. In this step, the TAC secures executive sponsorship. The desired outcome is that executive management concurs with the business imperative for change and directs ADOT to implement them as a strategic priority.

Step 2. Establish implementation manager and team.

A high level team is established to provide policy direction and oversee implementation. The team leader or manager is accountable to the Core Team for implementation progress. The implementation team should be cross-functional and will require staff support. The Executive Sponsor appoints the implementation manager and team.

Step 3. Establish project charter.

To establish the project as a department-wide strategic initiative, a project charter will be developed by the Implementation Team for adoption by the Executive Sponsor and Core Team. The charter will summarize the project goals and the governance structure.

Step 4. Prepare detailed work plan.

The final step for Phase I is to develop a detailed work break-down structure, resource requirements, and time line to manage implementation. The work plan needs to ensure that implementation is coordinated and aligned with other change initiatives underway, such as the implementation of SPR 515 (*Program and*

Project Financial Management Needs Assessment (1)[2]) recommendations, new reporting systems, and quality improvement initiatives among others. The work plan should break the recommendations down into discrete subprojects, address any dependencies between them, and identify priorities and ADOT's capacity to implement subprojects concurrently.

The work plan needs to include a communications plan and an organizational change management plan. These will need to consider organizational change management, ADOT's capacity to adopt change, and other issues.

PHASE II – DESIGN AND IMPLEMENT IMPROVED PROCESS, TOOLS, ACCOUNTABILITY MECHANISMS, AND ORGANIZATIONAL STRUCTURE

Phase I will develop a detailed work breakdown governance structure and plan. The following discussion identifies at a high level an implementation approach for each of the study recommendations.

Recommendations for Strategic Direction for Project Management:

Recommendation 1. Develop ADOT's project management culture by providing clear, consistent, executive communication and leadership regarding the department-wide importance of project management objectives and their accomplishment.

This recommendation is intended to ensure that ADOT's project management culture and program have the required management support. Best practices survey results indicate that executive level support is the single most important factor in implementing management by project. It is critical in overcoming organizational resistance to new ways of doing business, and it is required for resource allocation.

Implementation steps:

- Endorse study recommendations.

- Establish the Project Management Business Improvement Project as a strategic ADOT priority.

- Communicate to department, customers, and partners through appropriate communications vehicles.

- Ensure that Core Team adopts business objectives and performance measures developed under recommendation 3.

- Provide implementation resources.

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[2] Numbers in parenthesis refer to texts listed in the References section.

Recommendation 2. Establish department-wide ownership and accountability by senior management for strategic objective accomplishment in scope, budget, schedule, and quality.

This recommendation reflects the bottom line fact that what ADOT produces and maintains are capital projects (along with certain services). For this reason, it is everybody's job at ADOT, from senior management down, to ensure that projects are managed and delivered efficiently. Accordingly, program and project delivery accomplishment should be front and center in the performance plans and appraisal criteria across senior management, and this emphasis should permeate throughout the levels and divisions of the agency.

Implementation steps:

- Identify roles and responsibilities of senior managers and line managers with respect to accomplishing ADOT's department-wide project management objectives.

- Review performance plans and performance review criteria of senior managers and line managers and revise as necessary to address project management responsibilities.

Recommendation 3. Establish measurable ADOT strategic objectives for scope, budget, schedule, and quality and measure their accomplishment.

The intent of this recommendation is to establish department-wide strategic objectives for the delivery of the program within planned scope, schedule, and budget. This would go beyond measuring the extent to which the promised capital program is delivered on schedule. It would also take into account the interim costs, quality impacts, and organizational effects. The purpose of setting strategic objectives in the areas of scope, schedule, budget, and quality is to provide accountability to better manage ADOT's limited financial and human resources.

The following sample performance measures for scope control and quality are being submitted for ADOT consideration. They could be applied at the project level and rolled up to the program level:

- Scope control can be measured by considering differences in cost estimates at various points in the project life cycle. For instance, State Transportation Improvement Plan (STIP) programmed amount versus the engineer's estimate can be used to capture scope creep in preconstruction. Meanwhile, a measure such as bid award amount versus cost at completion reflects scope change (as well as other factors) in construction.

  The categorization, quantification, and magnitude of extra work orders during construction is another means of measuring scope change during construction. Because other factors, including unforeseen conditions or

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changes in materials' prices, may influence project cost, these measurements must be considered in context.

- An interesting means of capturing project design quality is the analysis of bid variation relative to project magnitude. According to recent research sponsored by Massachusetts Highways, wide variation in construction bids is an indicator of poor design quality. The reason for this is that the competitive marketplace demands that bidders identify the least costly means of meeting project uncertainties.

  When pricing contingencies, bidders are usually most influenced by the clarity, thoroughness, and consistency of plans, specifications, and contract documents. Bidders respond to risk by building contingency into their estimates, and contingency is the most variable element of construction bids.

  This hypothesis was borne out in experimental research that found that projects with less variation in bids were unlikely to have construction extra work orders caused by design shortcomings. ("Design Quality Research: Definition, Benefits, Measurement, Model, Testing," The Engineering Center for Massachusetts Highway Department, December 1999.) As such, construction bid variance could be used as a performance measure for design quality.

Implementation steps:

- Establish candidate objectives and departmentwide performance measures that address scope, schedule, budget, and quality (for example, deliver X% of projects within the planned quarter, 2 years out).

- Develop business procedures for monitoring and reporting on business objective accomplishment.

- Core Team selects and adopts measures.

- Roles and responsibilities of the project manager

These recommendations address the concerns that project management at ADOT is extremely inconsistent. There is no widely shared understanding of the role of the project manager or the project team; project management practices vary widely and the extent to which projects are actively managed at all is variable.

Findings:

- **The authority of the project manager in ADOT's weak matrix structure is not well understood—at either executive or staff levels.**

  According to the *Project Development Process Manual* (2), the following players have vital roles on project teams:

  – Project Manager

  – Technical Manager

  – Technical Leader

  – The project team itself

  This weak matrix structure is widely seen as the right approach for ADOT, which evidences a strong overall team orientation. However, the roles and accountability of project managers, technical managers, and technical leaders are subject to varying interpretations.

  The higher his or her place in the organizational hierarchy, the more authority the project manager is assumed to exert. Interviews with ADOT executives confirmed that senior level managers tend to assume that project managers are empowered to control project scope, schedule, and quality. Meanwhile, project managers, who must often work with higher-ranking technical staff, tend to view themselves as relatively powerless coordinators or facilitators. Despite this generalization, there is widespread variation within the ranks of senior executives, program managers, and project managers as to their actual authority.

- **ADOT project managers do not follow consistent approaches to the practical aspects of project management such as schedule development, communications, documentation, or quality assurance.**

  Although project management procedures, checklists, and other instructions are specified in the *Project Development Process Manual* (2) and the *Project Manager's Handbook* (3), they are not fully or consistently implemented.

- **Project management documentation needs to be updated, consolidated, and made more user-friendly.**

  The *Project Development Process Manual* (2), which serves as the primary source for project management, is not maintained as a "living" document into which policy and process changes are integrated on an ongoing basis. The document has not been updated since 1995, and subsequent changes and clarifications (e.g., scoping guidelines) are in different locations.

The *Project Development Process Manual* (2), while thorough, contains far more information than project managers need to do their jobs, and its dense text is difficult to digest. The *Project Manager's Handbook* (3) is less a "how to" guide than a loosely organized assembly of sample documents and checklists.

- **Although the *Project Development Process Manual* (2) sets forth a cradle-to-grave approach to project management, there is in practice a disconnect between preconstruction and construction phases.**

    Feedback on the quality, completeness, constructability, and maintainability of design is not consistently relayed back to project managers and designers so that it can be incorporated into improved future designs.

Recommendations for the Roles and Responsibilities of the Project Manager

These recommendations address the concerns that project management at ADOT is inconsistent. There is no widely shared understanding of the role of the project manager or the project team; project management practices vary widely and the extent to which projects are actively managed at all is variable. The intent of the recommendations detailed below is to increase the consistency and discipline with which best project management practices are applied at ADOT.

> **Recommendation 4. Establish department-wide the roles, responsibilities, and authority of project managers, project teams, technical managers, technical leaders, and team members. Strengthen the project manager's level of authority.**
>
> According to the *Project Development Process Manual* (2), the project manager has no individual authority to make project decisions. Many ADOT project managers describe themselves as facilitators or coordinators. Although the consultant team heard from several technical managers that ADOT's weak matrix model is right for the agency's team-oriented culture, a number of project managers reported that they can do little more than monitor the work of others under this structure. In practice, significant decisions that would be made by project managers in organizations with stronger matrices are made through ADOT's formalized issue resolution process, or the Project Review Board. The best practices survey research conducted for this study found that, while several state DOTs had established their project management programs on relatively weak matrix models, there has been a steady migration toward stronger roles for the project manager. No state DOT interviewed for this study, or encountered in the literature review, is moving toward a weaker matrix.
>
> Implementation steps:
>
> - Define project manager roles and responsibilities.
>
> - Specify new authority, business rules, and process changes necessary for project managers to effectively perform roles.

- In conjunction with recommendations 15 and 16, reflect new roles in job classifications, job descriptions, ADOT manuals, and communicate department-wide.

Recommendation 5. Strengthen the consistency of project management across ADOT by establishing consistent project management procedures.

Regardless of the level of authority ADOT ultimately establishes for project managers, it is important that a core set of standardized requirements and procedures for project management be established. Consistent processes for establishing and managing project scope, project schedule, project budget, and project quality would be required for this effort.

Implementation steps:

- Document the project management procedures to be used by all project managers and other employees responsible for projects.

- Develop and incorporate new business rules and procedures for setting, updating, and providing the status of scope, schedule, and budget.

- Document the authority and responsibilities as defined in recommendation 4.

Recommendation 6. Revise project management documentation to reflect these consistent project management requirements.

The intent of this recommendation is to provide ADOT project managers and others with accurate, up-to-date information on project management practices and procedures. The recommendation will involve: 1) updating the *Project Development Process Manual* (2) and establishing it as an organic, "living" authority on ADOT's policy and processes; and 2) redeveloping the *Project Manager's Handbook* (3) to indicate the roles and responsibilities of project managers, technical managers, technical leaders, project teams, and other players (e.g., Project Review Board, National Forest Service, etc.) at each phase of the project and by major activity, and to refer the project manager to any other resources needed to do the job.

Implementation steps:

- Draft a new updated *Project Development Process Manual* (2) and *Project Manager's Handbook* (3) (consolidation is also a possibility).

- Establish it as an on-line resource.

- Incorporate into the manual business rules, procedures, roles, responsibilities and other business changes resulting from the package of recommendation.

Recommendation 7. Establish measurable performance objectives for project managers that are aligned with ADOT strategic objectives and project managers' roles, responsibilities, and authority.

This recommendation would integrate project-related performance measures for technical managers and technical leaders that reflect their roles, responsibilities, and authority.

Implementation steps:

- Develop candidate project management performance measures. Such measures would address project delivery against scope, schedule, budget, and quality criteria.

- Assess business procedures and technology change required to track and report measures.

- Refine the measures such that they can be readily monitored and reported.

- Define procedures for tracking and reporting performance.

PROJECT MANAGEMENT TOOLS, REPORTING SYSTEMS, AND MANAGEMENT INFORMATION

The study analysis found that ADOT does not have consistent department-level information on project delivery status and that there are significant gaps in project-level information that present barriers to improved project management. Moreover, ADOT project managers and other process participants do not derive value from their current data reporting activities. The intent of the recommendations contained in this section is to move toward a situation in which the highest performing managers are those who use the tools because they are helping them plan, execute, monitor, and control their work.

Overall Finding

- **Limited information exists regarding the scope, schedule, budget and overall delivery status of projects at project or program levels.**

  In keeping with ADOT's overriding emphasis on meeting the advertisement schedule, the primary reporting system is the Program and Project Management System (PPMS), through which the Active Project Status Report (APSR) is produced. While the APSR contains milestone data for each programmed project, it does not provide any indication of projects' budget performance, interim schedule performance, or earned value.

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<u>Scope Findings</u>

- **Project scopes are not actively managed.**

  Rather, project definition and purpose in many cases remain fluid beyond the scoping stage; the means of achieving the intended purpose can change multiple times throughout the project life cycle; and project boundaries often shift.

- **Time lags between original scoped documentation and the initiation of design activity is a problem.**

  Such lags result in significant cost and schedule increases due to factors including inflation, increased right-of-way costs, and project footprint.

- **Project managers report that they are pressured by local interests and districts to expand the scope of the project late in the design process and even into construction.**

  This is problematic not only because it can lead to cost overruns at project and program levels, but also because the general expectation that scope will change discourages technical leaders from providing project managers with timely support since they suspect later rework.

  There are several reasons behind districts' reported tendency to expand project scope late in the process. One is that they see it as a means of obtaining needed improvements that would otherwise be difficult to justify. Another is that District personnel do not become involved in project delivery until design is close to completion due to competing claims on their time or other factors.

<u>Schedule Findings</u>

- **Many project managers do not use schedules to track or manage their projects.**

  Rather, ADOT project schedules are used for department-level status tracking for the purpose of assessing progress toward meeting the scheduled advertisement date.

- **Existing project status reporting information limits management's ability to control schedule variance.**

  The APSR only indicates whether a project will meet the scheduled advertisement date. Existing reporting does not indicate progress toward intermediate steps and whether there are links to other projects.

- **ADOT has not established validated work standards for labor requirements or estimated activity duration from which to develop project schedules.**

  Project managers no longer use project templates to develop schedules. The lack of standardization in activity duration is an issue in the development of realistic schedules, in the agency's ability to resource load across the department, and in ensuring accountability for work productivity.

Budget Findings

- **ADOT has not established the expectation, accountability mechanisms, or cultural orientation for effective budget management.**

  In practice, project managers do not plan, execute, monitor, or control project budgets.

  Budgets for the key components of project labor, right-of-way, utilities relocation and construction are not established at conception and adjusted accordingly as the project progresses.

  Budget management issues arise at both program and project management levels. Preconstruction budgets are not set, expenditures against budget are not tracked, scope impacts on budgets are not addressed, and construction budgets are managed separately.

Quality Findings

- **ADOT has defined quality and articulated its quality objectives.**

  However, issues in project management practices are barriers to their achievement.

- **Current project management practices present barriers to achieving these quality objectives.**

  Best practice analysis indicates that quality conscious organizations are characterized by the way they build quality into the process. Work is done correctly the first time and there is little rework. The organization is characterized by quality assurance as opposed to quality control. Through our analysis, we suspect that some of ADOT's quality concerns arise from the fact that rework is often required late in a project to address scope change.

  It is widely perceived, among both preconstruction and construction managers, that ADOT's emphasis on meeting the advertisement schedule leads to errors and omissions in design. Resident engineers believe that projects are being bid with existing design problems unresolved with the

expectation of addressing them in construction, at which point it is more time-consuming and expensive to do so.

Recommendations for Project Management Tools, Reporting Systems, and Management Information

ADOT does not have consistent department-level information on project delivery status and there are significant gaps in project-level information that form barriers to improved project management. Moreover, many ADOT project managers and other process participants state that they derive limited value from their current data reporting activities. The intent of the recommendations contained in this section is to move toward a situation in which the highest performing managers are those who use the tools because they are helping them plan, execute, monitor, and control their work.

Recommendation 8. Develop and maintain department-wide project status information regarding project scope, schedule, and budget.

The intent of this recommendation is to enable multi-project and department-level views of project and program delivery status. Such capability could be used to identify project status at an exception level so that corrective action could be taken to get projects back on schedule or to adjust to a changing situation by accelerating other projects when some are delayed.

Implementation steps:

- Recommendations 3, 4, 6, 7, 9, 10, 11, 12, and 13 will create requirements for project management information to be used in implementing this recommendation.

- Implementation requires evaluating the technology options for generating this information and may require an information technology study that defines the technology solution for addressing these requirements. Through this study the information technology costs will be identified.

Recommendation 9. Strengthen scope management by revising policies and procedures to establish greater accountability and reporting mechanisms.

This recommendation is intended to ensure that there is ADOT concurrence on the project at a fixed point beyond which project scope will not be revisited. Once scope has been locked in, the job of the project team and project manager is to design a project that can be built within the scoped budget and schedule. The project budget could be updated and finalized when the scope is locked in. Establishing and maintaining this control will require the active support of ADOT's senior management.

Implementing this type of scope control addresses issues of the organization's ability to meet budget, schedule, and quality objectives because it increases project predictability and reduces the need for rework. It also rewards early completion of tasks. Under a situation in which scope can change until design is 95% complete, there is a distinct disincentive for many technical disciplines to perform work activities because they suspect that they will end up doing rework to address future scope change.

Implementation steps:

- Design improved business process for measuring, reporting, and tracking scope change during design.

- Use estimated cost of construction as one of the indicators of scope and establish key points in the design process at which this is calculated and reported.

- Establish improved process for managing and controlling scope change. This includes rules for approving scope change that support project managers.

- Incorporate new procedures into work performed to implement recommendations 14 and 16.

- Place emphasis on providing training and communications to institutionalize the new business rules and process.

Recommendation 10. Establish a standardized process for project schedule planning and management.

This recommendation provides a standardized process for setting project schedules and managing them. The intent is to increase the rigor with which project schedules are built and the process through which schedule changes are made. The recommendation is for project schedules to be built by project type based upon estimated activity durations and labor requirements. These activities need to parallel the activities referenced in the ADOT procedures manual. The process would include best practice principles such as:

- Schedules are set based upon work standards.

- Project managers and teams establish schedules that they commit to delivering.

- Projects are managed to a "ready date," not the letting schedule.

- Schedule management includes contingency and the proviso that work is done to "catch up" when a target is missed.

Implementation steps:

- Implementation requires developing 1) the tools or methodology that will support project managers and others managing projects to develop schedules based on known activity durations, resource requirements, and project type; and 2) business rules and management controls through which project managers set schedules, update schedules, and report schedule status.

- Determine extent to which existing scheduling support tools and procedures can be used as a starting point. Develop methodology based on leveraging these.

- Develop and validate durations and resource requirements from which to build schedules.

- Develop business rules for setting, updating, and managing schedule change.

Recommendation 11. Establish and manage project budgets.

This recommendation calls for transitioning to a situation in which a project budget is established that addresses all preconstruction and construction costs. This will require phased implementation. The recently completed SPR 515 (1) project detailed issues and solutions to establishing project level financial reporting capability. The intent of this recommendation is to establish a process for establishing a broad project level budget and monitoring project expenditure status against the budget. This action establishes a departmentwide process for defining project budget and monitoring it and reporting actual expenditures.

While the information available to support the process may lag behind the institution of the process, it is important to begin the cultural change and orientation toward budget management. The type of approach can establish a project budget by major cost category such as design, right-of-way, survey, environmental process, construction, and construction engineering. This could be established at scoping and revised at two or three milestones during the project.

Implementation steps:

- Coordinate this recommendation with implementation of SPR 515 (1).

- Establish key point in project life cycle at which project budget is updated to reflect actual expenditures, and forecast expenditures such as right-of-way or construction costs.

- Determine business rules regarding responsibilities, timing, and methodology for updating budget estimates.

Recommendation 12. Use quantitative information to evaluate ADOT labor requirements and establish work standards by activity to support project scheduling and budgeting.

ADOT requires a quantitative base from which to determine resource requirements at project, program, and department levels. Among its benefits, implementation of this recommendation would enable ADOT to determine in which functions and geographic areas resource constraints are holding up project delivery and/or impacting quality.

Implementation steps:

- Coordinate implementation with recommendations 10 and 11. In addition, close coordination with SPR 515 (1) implementation is required because the process will require charging technical resource, project manager, and consultant hours to project delivery activities.

- Implement this recommendation by using the project delivery network and the associated project delivery activities developed through recommendation 10 as the starting point. To each activity estimated standard labor requirements will be assigned.

- Validate labor requirements with ADOT staff.

- Develop procedures for recording actual labor applied to activities and determine a strategy for incorporating this information into the information systems used to support project management.

- Establish procedures for project managers for when to use the standard resource requirements and when to deviate from them.

- Define business rules for reporting and recording labor.

Recommendation 13. Perform multi-project resource loading to evaluate the "deliverability of the program" and support overall program management.

ADOT technical managers and senior managers responsible for program delivery currently lack the tools to compare the labor resources required to deliver the scheduled program with available resources. ADOT does have sufficient staff to deliver the program effectively and manage consultant resources. Some project managers are responsible for 20 or more projects. Balancing this amount of work is difficult and is compounded by a lack of experienced project managers. This recommendation is to enable managers to identify any bottlenecks based upon the anticipated labor demands of current project schedules. Such bottlenecks could be addressed by adjusting schedules or by deploying additional resources. This would also provide a way of identifying and quantifying project and program delivery risks.

Implementation of this recommendation would enable ADOT to make department-wide resource adjustments based on the amount of ADOT labor required by technical discipline and location to deliver the program. Implementation is dependent on recommendations 10 and 12.

Implementation steps:

- Determine the requirements for multi-project resource leveling and program level management as input into any information technology development or enhancement performed to support recommendations 10 and 12.

- Establish business rules and procedures for multi-project resource loading. This includes the application of consultant resources to address both bottle necks and deliver entire projects from start to finish.

Recommendations for Organizational Development to Strengthen ADOT's Project Management Function

Strengthened project management requires elevating and supporting the development of project management as a discipline within ADOT. This broad issue is considered in the following findings and recommendations.

Findings

- **The activities, systems, training and documentation needed to implement and support project management at ADOT are not consolidated.**

    There is no single "champion" for project management, nor is there a single place in which to find guidance, materials, coaching, or support. Revealed in the best practices survey is that state DOTs with strong project management programs provide a single focal point at the state level, even if project management authority is delegated to district levels.

    Among the purposes of such a central focal point is to create a visible presence and support for the project management function. In several states, project managers are "represented" by these centralized offices, which puts them on a stronger footing in their dealings with their organizations' technical leaders.

- **ADOT, like many of its peer states DOTs, is concerned about the recruiting and retention of skilled, experienced project managers.**

    The combination of ongoing retirement waves, declining civil engineering enrollments, and competitive pressure from the private sector poses a formidable challenge. It is important not only that ADOT find ways to fill its project management positions, but also that the agency "institutionalize" the project management knowledge that resides within engineers who are nearing retirement. *Ad hoc* project management may be functional (if not optimal) when practitioners have decades of agency experience. However,

when cohorts of newly minted project managers try to find their own way through the project management process without consistent guidelines, disorganization and waste are the likely results.

- **Management recognizes the need to ensure that ADOT's hiring, training, and classification practices support the development of a pipeline of project managers.**

  Management understands that a good engineer does not necessarily make a good project manager.

Recommendation 14. Create a department-wide organizational focal point for all project management at ADOT.

The intent of the recommendation is to provide organizational support and ownership for the project management discipline and process at ADOT. The recommendation involves establishing an organizational function with the following responsibilities:

- Maintaining and communicating ADOT's project management policies, practices, and procedures.

- Assuring that project management references are up to date.

- Monitoring of project management activities to ensure that the established practices are followed in the field. Where they are not working, this entity could refine them.

- Providing mentoring, advocacy, and support functions for project managers including managing training for project managers and technical personnel who work on projects.

- Reporting to senior management.

- Coordinating with other departments, such as human resources, to ensure that the activities of other departments are consistent with ADOT's project management objectives.

- Serving as ADOT's information clearinghouse for project management.

Implementation steps:

- Outline alternatives to current organizational structure to address the recommendation.

- Implementation manager and team refine and prepare detailed recommendation for Core team.

- Present recommendation for Core team.

Recommendation 15. Establish project management as a visible and attractive ADOT career path.

The intent of this recommendation is to address human resource management issues such as classification levels and performance appraisals for project managers.

Implementation steps:

- Review existing job classifications and grades for project manager positions to ensure that they provide an attractive career path relative to other options, including the technical management track.

- Review position descriptions, responsibilities, and performance development goals and performance appraisal criteria to ensure that these address and support project management responsibilities.

Recommendation 16. Continue to emphasize and amplify training and professional development for project managers. This recommendation builds on the existing level of commitment to training for project managers and team members.

Management has placed increased emphasis on project management training, which is reflected in its support of the "Effective Project Development Team Skills" and "Communications and the Successful Management of the Project Development Process" courses. These courses provide critical "high-level" skills in team building and communications.

Training and professional development would address following principles:

- Project Management should be a technical discipline, emphasizing the competencies and content set forth by the Project Management Institute in its publication, *A Guide to the Project Management Body of Knowledge* (4).

- Project Management Policies, Practices, and Procedures at ADOT should focus on concerns such as schedule development and control, use of ADOT software and other standardized tools, templates, and checklists, and "who does what."

Implementation steps:

- Provide communication, training, and documentation of new business rules, process, and other results from implementation of the recommendations.

- Establish ongoing training and support program.

Establish a "Project Management Academy" that addresses ADOT's project management process and allows ADOT managers to exchange experiences.

III. CRITICAL ISSUES ANALYSIS

INTRODUCTION

This section identifies the critical issues relating to project management practices for Arizona Department of Transportation's (ADOT) project delivery process. These critical issues were identified by ADOT managers and senior project managers with regard to overall best project management practices. The critical issues assessment provided detailed information for the study regarding the focus and direction of this research into the extent to which ADOT's practices conform to best project management and delivery practices.

APPROACH

The critical issues were identified through Dye Management Group, Inc.'s interviews with ADOT staff and consultants involved with project management and delivery functions, as well as an initial e-mail survey. (A listing of those interviewed during the preparation of this report can be found in Appendix A.) ADOT's project management issues are grouped into similar categories as those presented in the *Project Management Institute's Body of Knowledge* (4). These findings will be used to focus detailed analysis on ADOT's critical issues. The critical issues presented in this section were identified through the following research steps:

- An e-mail survey to identify critical issues was developed and administered the survey to a broad cross section of process participants, managers, and customers at ADOT. A sample frame was identified by the Technical Advisory Committee.

- An interview guide was prepared that was structured to document issues against the primary elements of project management practices as detailed in the *A Guide to the Project Management Body of Knowledge* (4).

- Interviews were conducted with process participants, including state-wide engineering management, senior project managers, and technical area managers.

- The survey and interview results were analyzed to identify and group critical issues against processes and procedures typified within the *Guide to the Project Management Body of Knowledge* (4).

In reviewing the identified critical issues, it is important to note that they are derived from interview results, which by their very nature include both facts and perceptions provided by interviewees. It is the purpose of subsequent research tasks to provide a factual analysis of these issues.

ADOT CONTEXT

Many of the participants in the issue identification interviews provided an organizational context within which ADOT's critical issues were framed. This organizational context is briefly detailed below because it provides context for the issues that were identified and the organizational constraints and opportunities for improving project management at ADOT.

- **ADOT's overriding imperative of meeting the letting schedule provided to the Governor of Arizona.**

  In order to address legislative concerns regarding project delivery, ADOT has been held accountable for meeting a specific project delivery schedule provided to the Governor. Meeting this schedule has been a primary performance objective for ADOT. In turn, ADOT's project management priorities have addressed this objective of managing the delivery of projects in order to meet the letting schedule on at least 95 percent of the programmed capital projects.

  ADOT leadership has focused the organization on meeting these schedule commitments. In addition, senior management recognizes that while ADOT has met these objectives it is important now to address other project management objectives such as quality, budget, and schedule management. Although there is sentiment that the organization has "turned the corner" and has established credibility regarding its ability to deliver projects, senior managers realize the importance of addressing all the elements of good project management and delivery.

  Interviewees who have been charged with delivering the projects or managing the technical functions necessary for project delivery believe that the delivery commitments have resulted in considerable "organizational stress" and have been at times counterproductive to good project management practices. There appears to be concern that management is not addressing the other issues of importance, such as quality and scope management.

- **ADOT has a team-driven weak matrix project management model with project management responsibilities in different functional and geographic units of the organization.**

  Dating back to the early 1990s, ADOT established, and has since refined, its approach to project management. The current organizational model is a weak matrix model in which project teams are responsible for developing projects and making decisions. While many interviewees raised issues regarding the authority of project teams, they mainly believe the overall model is a good fit for ADOT as a technical organization.

Responsibility for project management is distributed across functional and geographical units within the Department, including the Bridge Group, Construction, Right-of-Way Section, and Roadway Engineering Group, the Districts, the Statewide Project Management Group, and Valley Project Management, among others. While the weak matrix format provides opportunities to manage and deliver more projects with fewer staff, it also spreads out authority and responsibility for project delivery more broadly than under a strong matrix, functionally aligned organizational structure.

From the perspective of most interviewees, the project management model works. The improvement opportunities lie in strengthening the procedures, skills, and management accountability for delivery. The biggest barriers to success are considered to be in the area of training, skills development, and human resources management for project management positions and competencies.

- **ADOT has been the focus of or has sponsored several business improvement initiatives and performance audits to improve project delivery performance.**

  Over the last 10 years, ADOT has completed several business improvement initiatives. In addition, the State has completed a number of performance audits of ADOT functions. The business improvement initiatives include:

  − Project Management Process Improvement Study, 1993–1995.

  − Effective Project Development Team Skills and Communication training courses, 2000.

  − The Partnering Process.

  The performance audits include:

  − Performance Audit of the Urban Highway Program for Maricopa County, 1991 (5).

  − Performance Audit of ADOT Highway Planning and Engineering Function, 1997 (6).

  − Performance Audit of ADOT Construction Management Function, 1997 (7).

  − Performance Audit of the Maricopa County Regional Freeway System, 2000 (8).

SUMMARY OF CRITICAL ISSUES IDENTIFIED THROUGH INTERVIEWS

A series of individual and group interviews were conducted with ADOT staff and consultants, to identify critical issues and concerns with the project management and delivery process. Appendix A contains a list of the staff interviewed for this task. Dye Management Group, Inc. interviewed staff from the ADOT management, project management, and technical/functional levels. In addition, consultants who have worked with and trained department staff on partnering initiatives, project scheduling, and project management activities were interviewed.

The critical issues identified through the interview process are summarized in Tables 1 and 2 on the following pages. The tables group the issues into overall program management and Project Management Institute body of knowledge areas.

Table 1 addresses overall program management. This refers to the overall management by a state department of transportation of a program consisting of many individual projects, and includes such areas as the overall organizational approach and management of project delivery, department-wide business objectives, human resources management across multiple projects, performance management of employees, organizational culture, and the organizational support for project management. These issue area groupings are derived from Dye Management Group, Inc.'s perspective on the overall program management framework and the organizational issues that need to be addressed to ensure that successful project management occurs as part of the delivery of the overall transportation improvement program.

Table 2 addresses critical issues relating to project management knowledge areas. The project management knowledge areas listed are those identified in the Project Management Institute body of knowledge, and those which are most applicable to project management in a state department of transportation.

Table 1: Critical Issues Summary – Overall Program Delivery Management

Organizational Approach to Effective Project Management	Issues Identified through Interviews	
	ADOT Program Delivery Management	**ADOT Project Management**
ADOT Organizational Model and Process for Project Management	• Project management responsibility distributed across different parts of the organization. • Concern that the process and procedures used to manage projects are not consistent. • Belief that the overall weak matrix model is right for ADOT but that there are issues regarding the authority and role of the project manager and project teams. • Management believes that ADOT is improving the overall management of delivery; the delivery schedule has been met and it is now time to address scope, budget, and quality. • Lack of consistency regarding the role of the project manager versus the team, and the authority of the team within the overall delivery process.	• Project managers do not control all of the factors of their own success. They have a limited role in scope development and do not set delivery schedule for their projects. • Role of project managers is not defined or implemented consistently across the organization or by management. • Management process is not consistently implemented throughout organization. • Project managers are project delivery facilitators; technical review responsibilities spread throughout the organization. • Project phases are completed in a disjointed manner due to time lapses, personnel changes, and personnel management.

Organization-wide Performance Objectives and Accountability for Program Delivery	• Current performance measures and accountability address schedule delivery compare planned versus actual measures, by month and fiscal year, of:
	
	  − Number of construction projects advertised.
	
	  − Number of construction program dollars advertised.
	
	  − Number of construction projects awarded.
	
	  − Construction program dollars awarded.
	
	  − Percent of difference between actual days worked versus original contract days.
	
	  − Percent of difference of final construction costs versus original bid.
	
	  − Percent of difference between modified contract cost versus original bid amount.
	
	• No department-wide objectives, measurement, and accountability set for schedule, scope, budget, and quality.
		• Accountability is primarily for schedule.

Organizational Approach to Effective Project Management	Issues Identified through Interviews	
	ADOT Program Delivery Management	ADOT Project Management
Executive Leadership	• Some interviewees expressed concern that there has not been executive follow-through and leadership for strengthening program delivery management and project management. • Leadership has targeted schedule delivery.	
Extent of Project Management Culture	• Management recognizes the need to establish a stronger project management culture.	
Performance and human resources management: • Aligned with those required for a project management organization. • Program-wide resource management	• Management identifies the need to ensure that hiring, training, and classification structure supports the hiring and development of project managers. • Place emphasis on training. • Management concerned about organizational "stress" due to pressures to meet delivery schedule. • Need to improve knowledge management and manage work force transition to address consequences of retirements and FTE levels. • Lack of metrics regarding workload for project management and functional activities for project delivery. • ADOT's lack of work standards limits ability to manage human resources across multiple projects, especially the application of technical resources to teams. • Consultant services are used to address functional labor shortages as they arise.	• Retention of experienced project managers is a major departmental issue. • Filling vacant project manager positions. • Need to train new project managers in ADOT's policies and practices so that they can quickly become effective. • Staff shortages and heavy workloads are considered a barrier to success.
Management Information, Reports, and Tools	• The primary report used is the Active Project Status Report (APSR). • Appears to be limited overall management information regarding program delivery status against budget. • Schedules are not built using labor and duration standards.	• Few project managers use the project management system to manage their projects.

Table 2: Critical Issues Summary – Project Management

Project Management Institute Knowledge Areas	Issues Identified through Interviews	
	ADOT Program Delivery Management	**ADOT Project Management**
Project Schedule Management	• Governor directive to ADOT to improve project delivery. ADOT has established and met schedule commitments. • Schedules are being met, but management is concerned that this may have been at the cost of quality and budget. • Concern over the organization's stress due to schedule requirements.	• Project managers do not establish and commit to ready date. • Different processes are used for establishing schedules. • No established, validated work standards for activity duration from which schedules are built and managed. • Low utilization of established scheduling tools. • Project management staff do not fully utilize the scheduling tools. Available tools are used for developing status reports only, not for identifying project schedule issues. • Meeting project schedules has been paramount. • Schedules are compressed to meet bid date, at the expense of quality.
Project Scope Management	• Managers are concerned across all functions about the effectiveness of the scope management process. • Time lag between scoping and delivery impacts accuracy of scope estimates for a variety of reasons. • Cumulative impact of weak scope management makes the cost-feasibility of overall program delivery questionable. • Limited department-wide management and accountability for scope management. • Concern over program level impacts resulting from weak scope management.	• Project managers not involved in scope development. • Project managers are not accountable for delivering projects within the scope and associated cost estimates produced through the scoping process. • Management and control procedures for scope not clear or applied during project delivery. • Frequent changes in scope during design causes rework and delays functional tasks. • Concern that the team does not have the authority to manage scope and that ADOT Districts, as customers, influence scope significantly, well into the delivery process. • Control measures, such as the Project Review Board, tend to be after the fact. • Project managers not actively managing scope and not making trade-offs between schedule and budget.

Project Management Institute Knowledge Areas	Issues Identified through Interviews	
	ADOT Program Delivery Management	ADOT Project Management
Project Cost or Budget Management	• There is limited program level management of project costs. • Preconstruction costs- labor, right-of-way-utilities are not budgeted and managed as part of program delivery. • Construction cost management has not been the focus of attention. • Impacts of inflation and other financial factors affecting accuracy of cost identified in scoping are not considered. • Cultural orientation of the organization does not focus on project cost.	• Project managers are not managing budgets for preconstruction or construction. • Neither cultural orientation nor accountability expectations for project managers address budget management. • Project cost accounting data from which to mange project costs is not developed. • Project costs increase over original scope estimates due to changes in project parameters such as design, right-of-way, environmental rework, or due to poor estimates.

Project Quality Management	• There is consistency across ADOT regarding definition of quality.
	• Management is concerned about the impact on quality due to emphasis on meeting schedule.
	• Management has initiated measurement of quality:
	  − Number of change orders.
	  − Number of comments resolved/unresolved.
		• Project managers and technical managers believe that design quality has decreased. Projects are being bid with existing problems unresolved. Process has been to "fix it in construction." Errors include incorrect material quantities and material quality.
		• Review process is identifying problems that need to be addressed.

Project Human Resources Management	• Existing process does not provide project managers with human resources management authority for their teams. • Project managers are influencers. • No good metrics from which to manage and reallocate staff and labor force between functional areas.	• Knowledge, skills, and abilities of project managers need to be increased. • Not sufficiently trained or experienced with process. • Turnover of staff in the project management positions is high, inhibiting knowledge management and dissemination.

Project Management Institute Knowledge Areas	Issues Identified through Interviews	
	ADOT Program Delivery Management	**ADOT Project Management**
Project Communications Management	• Management has placed emphasis on training and process improvements to improve communications. • View is that communication has improved. • Communication with customers and partners regarding project status can be further improved.	• Communication skills important in hiring project managers. • Project managers believe the issue resolution and communication processes work. • Feedback regarding lessons learned and problems with construction is not given to designers and project managers. • Change order process does not include passing information back to the designers to inform them why changes were made. • Quarterly state-wide project management meetings are helpful for information sharing, but poorly attended by district staff due to high workloads.
Project Risk Management	• Risk management has not been emphasized or developed as a project management discipline. • On large projects, management becomes involved in risk management.	• Risk management and mitigation is not actively identified and reported on as part of project management. • Project managers are managing risk to some degree in all of their activities.
Project Procurement Management	• Management has strengthened accountability controls for design and technical consultants. • Change to deliverable-based contracts undertaken to improve procurement management.	• On some projects different design consultants are utilized for each phase of several projects. Project knowledge is not easily passed between one firm to the next, increasing the cycle time of project delivery. • Project managers do not always have the negotiation and contract management experience to most effectively manage consultants.

CRITICAL ISSUES IDENTIFIED THROUGH INTERVIEWS

This section provides a detailed description of the critical issues identified through the interviews with ADOT staff and business partners regarding project management. The issues are divided between overall program management and project management. In general, this distinction applies; however, in practice there is some overlap between the two in terms of the issues raised.

The distinction between the two areas is as follows:

- **Overall program delivery management**

    Overall program delivery management refers to the comprehensive management by ADOT of the entire list of individual projects. This includes such areas as the overall organizational approach and management of project delivery, department-wide business objectives, human resources management across multiple projects, performance management of employees, organizational culture, and the organizational support for project management.

    The distinction is important because ADOT management is responsible for the overall delivery of the transportation improvement program. Project managers are responsible for the individual projects.

- **Project management for individual projects**

    This grouping includes the issues that relate to the management of individual projects. The issues raised are grouped according to the Project Management Institute Body of Knowledge areas most applicable to project management at ADOT.

Overall Program Delivery Management

Issue area groupings are derived from Dye Management Group, Inc.'s perspective on the overall program management framework and organizational issues that need to be addressed to ensure successful project management to deliver the overall transportation improvement program.

The issues are grouped into the following categories:

- Organizational model and process for project management.

- Organization-wide performance objectives and accountability for program delivery.

- Executive leadership.

- Extent of project management culture.

- Performance and human resources management.

- Management information, reports, and tools.

<u>ADOT's Organizational Model and Process for Project Management</u>

There is broad agreement within ADOT that the Department's overall model and organization for project management is best suited for the organization. However, a theme across the interviewees is that there is limited consistency and standardization of ADOT's project management practices. Interviewees identified a number of organizational, process improvement, and management issues which need to be addressed in order to improve the effectiveness of ADOT's project management model.

The following issues were identified during the interviews:

- **The role and authority of project managers in ADOT's weak matrix management model need to be clarified.**

  ADOT's project management model incorporates a weak matrix approach. For some, this is considered a strength, as responsibilities are shared, and in a highly technical organization with different disciplines, this is considered appropriate. However, the role and accountability of project managers is subject to different interpretations. Some assert that the project manager is a member of the team who is responsible for scope and schedule, but who is not the overall leader. In this role the project manager is more of a coordinator.

  The project manager has no authority over the team and must influence or facilitate team decision-making. The overall philosophy expressed by many is that the approach is team-driven, with major decisions requiring team discussion. Many stakeholders consider this a strength, but this does lead to inconsistencies.

  Other interviewees believe that the project managers are accountable for schedule delivery, scope, and budget. This is the view of many of the managers who are responsible for ADOT's overall program management. A number of ADOT's management controls and procedures indicate the project manager must report status and management of projects against these objectives.

  Interviewee input indicates that in practice, depending on project managers and their teams, there is a continuum of the aforementioned situations.

- **ADOT staff do not have agreement on the desired role of project managers.**

  To elaborate on the prior issue, a dichotomy exists within the Department as to what is required of project managers. Some staff view project managers as facilitators, while others believe they should ultimately be responsible for the project's delivery.

Overall, interviewees believe that there is a lack of consistency across the organization regarding the role of project managers. This lack of consistency includes state-wide project management and ADOT Districts. Indications are that these inconsistencies fall within similar types of projects as well as across project categories, resulting in lengthened project schedules and higher costs.

This issue is most acute in regards to the project manager's role as a facilitator and team leader versus his technical ability to make decisions. From the perspective of some interviewees, the project manager is a member of the team and is not necessarily the leader with any authority over the team. Key project decisions are made through consensus.

- **Project managers have outdated or underdeveloped documentation on how to manage and deliver projects the ADOT way.**

  The *Project Manager's Handbook* (July 1996) (3) and the *Project Development Process Manual* (2, 1995) provide some of the information and guidance necessary on how to deliver projects the ADOT way. Project managers, both those who are veterans of the Department, as well as any new employees requiring an understanding of the project management process, need more detailed documentation that clearly describes the step-by-step processes required to manage projects.

  In these documents, some specific processes are not documented for the project mangers to follow. Project managers are seeking a policies and procedures manual that will provide written instruction in several situations:

  - What forms to use.

  - What checklists to monitor.

  - What policies and procedures are required for specific situations.

  - Who/what position you go to for resolving or answering specific issues or questions.

  The documents mentioned above clearly identify neither the roles/responsibility, policies, and procedures for each project team member, nor senior management's role in ensuring the documented procedures are followed state-wide. A consequence of this is that project managers located in the districts and at headquarters do not consistently follow the Department's policies and procedures for project management.

- **The scoping process is not considered to function effectively.**

  Interviewees consistently raised the issue of project scoping. Issues raised were from the perspective of overall program delivery management and

individual project management. For overall program management, the problem is that the scoping process can be performed a number of years before the projects are in the transportation improvement program. Therefore, even in cases where scoping is performed well, construction costs can change significantly due to inflation, changes in right-of-way acquisition costs, and many other factors. The cumulative impacts of this can cause ADOT to be effectively over-programmed (in other words, there would be an abundance of program projects and a shortage of funds needed for delivery). A further issue with the process is that for minor projects, scoping may not take place until the year in which the project is planned for delivery.

From the project management perspective, project managers are not involved in the scoping process but are expected to be accountable for scope management. This creates challenges which are compounded by project managers' concerns about the effectiveness of the current scoping process and ADOT's perceived weak scope management controls.

- **Responsibility is disjointed.**

  A number of issues regarding responsibility and accountability were raised during the interviews. Responsibility and oversight of individual projects are focused within one individual and are not consistently applied state-wide. For example, design/build coordination varies between districts. In addition, the project manager is responsible for the coordination of activities during development, but the Resident Engineer takes over these responsibilities during construction.

  Data on the constructability and maintainability of project designs is not readily fed back to the project manager and designers for them to learn and understand what designs worked, and what aspects of the design needed to be changed. Additional issues surrounding accountability and responsibility reside within the technical areas as well; this is most likely a result of the weak matrix arrangement. Since a project manager does not manage technically specialized staff, they do not have the authority to control the working time and results of individuals.

- **Coordination with outside agencies is difficult.**

  ADOT managers believe that the Department is successfully addressing how best to work with outside agencies in order to manage project delivery in a situation in which ADOT does not have control over all of the delivery steps. Change in state and federal laws influences ADOT's ability to deliver projects. In particular, it has been difficult to work with federal agencies due to staff turnover. On larger, long-term projects, some agencies do not provide the same staff to review and approve project documents over every stage of the project. Consequently, these agencies take inconsistent positions, and provide conflicting comments over the course of a project development lifecycle.

- **ADOT project managers do not follow consistent approaches and procedures in managing project delivery.**

  The processes for managing project delivery are documented within ADOT's *Project Development Process Manual* (2) and other documents, such as the *Project Managers Handbook*; however, staff have not fully implemented these procedures. New project managers are not extensively trained in the ADOT methodology and learn mostly from mentors and training, as well as from any previous experience and knowledge they have gained in their careers.

- **There are outstanding process issues such as ADOT's approach to life-cycle project management.**

  At present, the Resident Engineer is managing individual construction projects for ADOT. Issues were raised regarding the need to ensure that project management controls with respect to scope, schedule, and budget are effectively addressed in both construction and maintenance.

Organization-wide Performance Objectives and Accountability for Program Delivery

This issue area addresses the performance objectives that are established department-wide for program delivery and project management. These are critical because they define the department-wide objectives that project managers, technical managers, and team members are working together to accomplish. They state what is most important to the organization and bridge objectives for individual parts of the organization. They set the tone and help to establish the organizational culture.

The following issues were identified during the interviews:

- **Schedule accomplishment has been the single overriding performance objective set by management.**

  At the agency-wide level, ADOT has been managing schedule performance closely. The measured departmental objective has been the delivery of projects to meet the legislative requirements. This organization-wide objective was communicated across all functions and acted upon by all interviewees. The following performance measures are tracked and reported by the Department:

  − Number of construction projects advertised.

  − Amount of construction program dollars advertised.

  − Number of construction projects awarded.

  − Amount of construction program dollars awarded.

- Percent difference between actual days worked versus original contract days.

- Percent difference of final construction costs versus original bid.

- Percent difference between modified contract cost versus original bid amount.

These figures track ADOT's actual performance against planned figures, on a monthly and annual basis.

- **There appears to be no department-wide objectives, measurement, and accountability set for scope, budget, and quality.**

  At the program management and project levels, interviewees reported that they are not managing to, and are not held accountable for, defined department-wide project management performance objectives. This is now an issue of concern to ADOT leadership, who believe that the Department is moving forward in its efforts to improve delivery and management of capital projects. However, there is concern that too much attention has been paid to meeting the letting schedule at the expense of other project management objectives, such as quality and cost.

Executive Leadership

This issue area addresses the extent to which ADOT leadership is working across the functional areas to provide direction and organization-wide objectives for project delivery and project management. The following issues were identified during the interviews:

- **Interviewees expressed concern that strengthening project management has not received sufficient executive attention.**

  Interviewees consider that senior management has been overly focused on the schedule objectives. They believe that management needs to ensure that the organization is clear about project management objectives, and that cross-functional support and consistency requires senior management direction.

- **Senior management recognizes that more needs to be done to emphasize project management and what it means to ADOT.**

  Management identified the need to move beyond setting schedule accomplishment expectations to establishing quality and scope management objectives for program delivery.

- **Interviewees were concerned that management does not fully understand project management.**

Some interviewees believe that ADOT senior management does not fully understand the technical discipline of project management, or has not fully embraced or endorsed ADOT's project management process as a way of doing business. Some interviewees expressed their belief that ADOT administrators do not understand the details and aspects of project management at the Department. In addition, all managers have not fully embraced the principles of project management since the implementation of *Project Development Process Manual* (2) back in the early 1990s. Management has noticed over the last several years that processes are not being followed. The champions of the process improvement in the late 1980s and early 1990s retired before implementing the approved and documented processes. The employee turnover rate has created a challenge for ADOT to ensure that the project delivery processes are universally known and applied by all staff on a state-wide basis.

Extent of Project Management Culture

This issue area addresses the extent to which ADOT has the combination of executive leadership, performance management, accountability mechanisms, and human resources management policies and procedures that foster a project management culture. In a department with a project management culture scope, schedule, budget, and quality are managed at different levels in the organization with broad accountability for its accomplishment.

The following issue was identified during the interviews:

- **Management sees the need to establish a stronger project management culture.**

  Interviewees indicated that ADOT needs to do more to establish a stronger project management culture across the organization; this includes both technical managers as well as project managers. This research project is considered a mechanism for identifying actions that can be taken to develop such a culture.

Performance and Human Resources Management

This issue area addresses how project managers are hired and the overall management of human resources. It includes hiring project mangers with the knowledge, skills, and abilities to be successful project managers. It also includes how job performance is managed and evaluated and the extent to which this aligns with program and project management objectives.

For overall program delivery management, this area addresses the management of human resources across multiple projects. This multi-project resource loading is difficult to perform and is an important ongoing part of project delivery management. A further program level management issue is the overall management and career progression for project managers.

The following issues were identified during the interviews:

- **ADOT is concerned about the retention of experienced project managers and filling of project manager positions.**

  Project managers and technical managers consider the hiring and retention of project managers a major issue for ADOT. ADOT has lost a lot of experienced staff who had extensive project delivery knowledge; therefore, it is more critical to maintain the existing knowledge base while managing workforce transition. There is a shortage of middle management staff, as well as project managers with mid-level experience to effectively deliver the program.

- **Management identifies the need to ensure that ADOT's hiring, training, and position classification practices support the hiring and development of project managers.**

  Management recognizes that a good engineer does not necessarily make a good project manager. The key is to ensure that hiring addresses the communications, facilitation, and leadership skills required for managing projects. Given the number of vacant positions, project management needs to be a viable career path within ADOT.

- **ADOT staff and management recognize the need for continued emphasis on training and professional development.**

  Management has placed increased emphasis on project management training, as reflected by its support of the Effective Project Development Team Skills & Communications and the Successful Management of the Project Development Process courses. Although interviewees believe that this remains a priority, an issue raised is that the training requires another level of detail and support tools that can be used to provide training on how projects are delivered at ADOT.

- **Management is concerned about organizational stress.**

  Project managers and technical staff have experienced a large surge in workload levels to meet the increased delivery requirements under the Transportation Equity Act for the 21st Century (TEA-21) and state-funded programs. This coupled with the requirement to meet legislative commitments has created organizational stress. There is concern that this workload level can not be sustained and that the organization's health requires the transition to less crisis-driven management.

- **There is a need to improve knowledge management and better manage workforce transition to address consequences of retirements.**

There have been large changes in the experience level of ADOT's labor force, most notably in the experience of employees. To manage these changes ADOT needs to improve the documentation and standardization of practices and ensure that the labor force is managed with these constraints in mind.

- **ADOT does not have a set of workload metrics for project management and functional activities for project delivery.**

  A recurring issue raised is that ADOT does not have sufficient staff to deliver the program effectively and to manage consultant resources. From the program management perspective, the information from which to evaluate this issue and identify resource bottlenecks and manage human resources across technical areas does not exist. Interviews also indicate the lack of systematic information on workloads as well as workload standards.

  Some senior project managers are responsible for 20 or more projects. Balancing this amount of work is already difficult and is made more difficult by a lack of experienced project managers to assist or manage the work. The ADOT project delivery model does not address workload standards or outline the guidelines for appropriate/manageable levels of work for project managers. The lack of a standard or guideline makes it difficult to identify how people are needed by the Department to deliver the program.

- **The lack of workload standards limits ADOT's ability to manage human resources across multiple projects.**

  Interviewees indicate that there is little management of human resources across multiple projects. This means that it is difficult to balance workloads throughout the year and that individual projects could be delayed because they require technical work for which resources are not available because they are being used on other projects. Limited information also makes it difficult for management to make strategic assessments about relative workloads across technical disciplines, and to plan hiring and training strategies accordingly.

- **Consultant services are used to address ADOT labor shortages as they arise.**

  Consultants supplement ADOT resources in functional areas.

Management Information, Reports, and Tools

This issue area relates to the information and reports that management uses to manage program delivery. It also provides an indication of accountability to management for delivery. Reporting, especially exception reporting, is the usual mechanism for assessing status and relaying what is important to management.

The following issues were identified during the interviews:

- **The primary report used is the Active Project Status Report (APSR).**

  Project status reporting is performed through the APSR. This report can contain data that is up to three months out of date. Project managers report on individual project schedules by other means.

- **Limited management information exists regarding the scope, budget, and overall delivery status of projects.**

  There appears to be limited overall information on budget status, or the cost to deliver the program. Interviewees indicated that this information is not being used to manage overall program delivery.

- **Few project managers use the project management system to manage their projects.**

  The project management system is in general not being used to build and staff load schedules or to manage projects. To the extent that it is being used, it appears to mainly be serving as a reporting tool. Interviewee feedback varied in the value that this tool provides.

- **Project schedules and budgets are not built using labor and duration standards, and this limits the utility of management information.**

  There appears to be little consistency in how schedules are developed, managed, and reported.

PROJECT MANAGEMENT FOR INDIVIDUAL PROJECTS

This grouping includes the issues that relate to the management of individual projects. The issues raised are grouped according to Project Management Institute Body of Knowledge areas that are most applicable to project management in a state department of transportation. These include:

- Project schedule management.
- Project scope management.
- Project cost management.
- Project quality management.
- Project resource management.
- Project communications management.
- Project risk management.
- Project procurement management.

Project Schedule Management

In recent years, ADOT has placed the highest priority on meeting project schedules.

At project inception, the team develops a schedule, which, in many cases, is driven by the requirement to meet the already established let date. In practice, this results in backfilling the schedule from the let date (the date a project is advertised for construction). Once set, the schedule is then reviewed by all team members to ensure it can be met. Each project manager is assigned an assistant scheduler, who manages day-to-day updating of individual project schedule files. Project team members provide information to the assistants on a monthly basis through the Department's e-mail system. A team review of the schedule is conducted on a monthly basis. Authority to change the schedule is flexible, depending on the non-criticality/criticality of the change or results. Only the Project Review Board is authorized to change the let date on the project schedule.

Over the last several years, schedule management has been performed using the Primavera project scheduling software program, a project management tool used in several complex project management environments. Project managers also use Schedule Update Request Forms ("SURF reports"), and the PEP (Project Evaluation Process), a qualitative assessment of schedule by team members. Interviews indicate that while the project management software is being used to provide status reporting to management, project managers are not using all its capabilities.

The following issues were identified during the interviews:

- **Different processes are used for establishing schedules.**

  Inconsistencies exist in regards to when schedules are established, how they are set, and the project duration. A comprehensive schedule for each project is always developed; however, a standardized procedure and methodology is not used. In practice, project managers and teams build their schedules from a comparison of a recent and comparable project drawing on their own experience. There are no guidelines or historical data regarding the duration of activities that are used to build these schedules. In addition, resource availability or preconstruction budgets are not established as a basis for developing the schedules and loading resources into the schedules.

- **For subprograms, and on other occasions, schedules have not been established until the design is under way.**

  Interviewees indicated that there have been many cases when projects have been past the planning stages and into design without an approved schedule for managing the projects. This is often the case with subprogram projects that require a limited amount of preconstruction work. Interviewees also reported that this situation occurs on larger projects as well.

- **ADOT has not established validated work standards of labor requirements or estimated activity duration from which project schedules are developed.**

Project managers no longer use project templates to develop schedules. In the past, ADOT developed 18 schedule template models for developing new project schedules. However, interviewees reported that the models were never validated or populated with "actual duration or work load data." Consequently, staff questioned the value of the Primavera models and their use has generally been discontinued. Today, these templates are most likely out of date, requiring modification to reflect ADOT's current business practices. General input from project managers indicates that some of the models were never very accurate, and did not follow ADOT's management and delivery practices. In some cases, project managers have developed their own tools for tracking and reporting the status of projects.

- **Project schedules established in the scheduling system are not used to track or manage projects.**

  The scheduling office provides support to project managers in producing a project schedule. ADOT staff track project schedule performance through approximately 20 milestones. Monthly reporting of project status is done through the Active Project Status Report. The report documents the projects currently under development and the planned and expected bid letting dates. The overall scheduling goal is to meet the bid date at least 95 percent of the time. However, it appears that schedule management is being used as a status tracking and reporting tool, as opposed to a mechanism to manage projects.

  Because schedules are not used to track projects, there is considerable uncertainty about meeting performance milestones other than the let date. Consequently, interviewees characterized the situation as one in which project management teams are scrambling to complete design, right-of-way, and other activities in order to meet the assigned project bid dates. This style of project delivery has inevitably resulted in creating an environment where problems with quality will likely occur.

- **ADOT project managers do not use the tools on a consistent basis throughout the state.**

  Interviews indicated that some project managers are using the schedules. Others, however, only use them to report progress, and do not use the tools to project future events or to identify where development and delivery schedule problems may occur. For example, project schedules do not adequately identify the resources required to complete the delivery and, consequently, interviewees indicated that the schedules are not used to manage and adjust staffing.

- **Project managers would benefit from more training with scheduling tools.**

    Project managers indicated they are not trained universally in the Department's schedule management processes. Some managers are just beginning to compare actual versus planned occurrences of activities, while others have just recently come into the project management arena from other transportation areas and are unfamiliar with project scheduling.

- **Project status reporting information limits management's ability to exercise control of schedule variance.**

    The APSR reports only indicates if a project will meet the scheduled bid letting date, or if there will be some slip. The reports do not show where intermediate critical steps are, and whether there are links to similar projects. There is a significant lag time of between 30 and 60 days for the data.

Project Scope Management

Interviewees were very consistent in raising issues regarding the process through which scope is established, scope management practices, and procedures followed for controlling scope. This is a difficult area to address. In detailing the issues raised, we make the following general assumptions regarding scope. A project's scope reflects its original purpose or intent. To manage this scope, a description of the recommended improvements and a high-level project cost estimate is generated. The role of project management is to deliver the project that best meets this intent, at the original cost estimate. Construction costs can be used as an indicator of scope. Cost estimates can change as a result of one or more combinations of the following factors: inaccurate scoping; unforeseen circumstances; effects of delay that causes inflation or additional right-of-way acquisition costs; and changes to the original project intent.

ADOT's current practice is that project managers are responsible for managing the scope of projects. Final decisions on scope are made through the Project Review Board (PRB). If any changes in scope are required, the team members conduct a thorough review before taking to PRB. If there are changes, the project manager develops a Project Change Request (PCR) and takes to the PRB. The PRB evaluates changes based on several questions, and reviews the impacts on schedule and budget:

- Who requested the change?

- What changes are requested?

- Why is the change requested?

- When will the changes be made?

- How is the change affecting the objective of the original project scope?

In addition, ADOT staff analyze whether changes to a project's scope influences the costs, schedule, or budget of other projects in the program.

The following issues were identified during the interviews:

- **Managers are concerned about the effectiveness of the scope management process across all functions.**

  Interviewees indicated that ADOT is not successfully establishing or managing project scopes. There are differing opinions on what the primary drivers causing this problem are. Some view the initial scoping process as flawed because project managers are not actively involved in scoping. Others consider a major barrier to be that ADOT's principal project customers, especially the ADOT Districts, are often not involved in scoping and therefore request changes at a later date. All interviewees agree that the consequence of weak scope management is that the actual cost to deliver the program, as originally programmed, increases substantially, resulting in the need to rebalance the program. This delays some projects and reduces available funds for new projects.

- **The time lag between completion of project scoping documents and the project design phase impacts the accuracy of scope estimates for a variety of reasons.**

  Lag time occurs on many projects between completion of project scoping documents and the beginning of the design and preconstruction phase. In some cases, this lag has been anywhere from many months to several years. During the interim period, a project's footprint area, such as land ownership or identification of environmentally sensitive areas, typically changes. Consequently, costs to complete the project as originally scoped increase due to the identified changes. In addition, if inflation is not factored into the original project cost estimates, and a significant delay occurs in the schedule, inflation will also increase project costs. The problem is exacerbated for program management because scope estimates are in current year dollars and do not account for inflation.

- **Project managers believe that they cannot be held accountable for scope management.**

  Interviewees believe that project managers have neither the tools nor the authority to be accountable for scope management. Project managers sometimes feel pressure from local interests to change scope late in the process, or even during the design and construction phases. Project managers also indicated that they have limited authority to manage scope, and that they are not empowered with the appropriate tools to effectively manage scope. Furthermore, they are compelled to address scope issues and potential changes raised by ADOT

Districts (and local entities) late in the design when most detailed work is completed and changes have significant impact on the design.

- **Management and control procedures for scope management during preconstruction are weak.**

  The process for reporting and managing scope does not track original construction estimates against new construction estimates by project milestone. Nor does it establish a specific point in the process at which scope is "locked" and it is extremely difficult to effect a change. In practice, scope changes are effectively managed after the fact through the PRB process.

  In contrast, there is a well-defined authority for changing scope during construction and there are well-defined financial control levels of scope change authority once a project has entered the construction phase. These include:

  − Changes costing less than $50,000: approval authority resides with resident engineers.

  − Changes costing between $50,000 and $250,000: approval authority resides with district engineers.

  − Changes costing between $250,000 and $500,000: approval authority resides with the Deputy State Engineer.

  − Changes costing over $500,000: approval authority resides with the State Engineer.

- **Project delivery is impacted by the expectation that scope changes will occur.**

  Weak scope management controls have resulted in a general expectation that scope will change during the delivery process, thereby compounding the project management challenges. In addition to impacting the project's budget, it affects schedule because it creates a reluctance for technical managers to begin utility and right-of-way activities earlier in the process because of their experience with having to rework an area after alignments have changed.

Project Budget Management

Scope management directly impacts budget management. Under budget management, the project management objective is to manage the delivery of the agreed upon scope within the planned budget. This includes managing the labor applied for preconstruction engineering, construction engineering, technical functions, right-of-way acquisition, utility relocation, and construction.

At present, it appears that ADOT project cost accounting practices and project management practices do not adequately establish a means for project managers to manage project budgets. Instead, the focus is on the overall project budget as established in the transportation improvement program. Budget management is ultimately the responsibility of the PRB. Project managers are given both project budget levels and project scope, and they are expected to minimize scope changes that affect overall project budget. The PRB manages any changes; any cost increases are identified by the project phase. Changes in budget are approved based on the criticality of the activities; this requires three levels of approval, including the PRB.

The following issues were identified during the interviews:

- **Project managers do not manage overall budgets for preconstruction and construction.**

  In practice, project managers do not manage project budgets. Budgets for the key components of project labor, right-of-way, and construction are not established at project inception and then tracked and adjusted accordingly. Interviewees indicated that project managers do not manage budgets in this way, nor is there a management expectation set for this.

  Furthermore, the responsibility for project budget management does not reside with an individual. Resident engineers are responsible for the construction engineering budget, while district engineers monitor the construction budget and manage the contingency funds. If there are any design changes, project managers have to bring them to the PRB, along with changes to budgets, for approval/rejection. Project managers do not have the authority to make significant changes to projects without approval from the PRB. However, Project managers provide status reports on project schedule and costs at group manager meetings.

- **ADOT has not established the expectation, accountability mechanisms, or cultural orientation for effective project budget management.**

  Issues surrounding project budget management arise at both the program and project management levels. Preconstruction budgets are not set and expenditures against budget are not tracked with other considerations. Furthermore, the impacts on scope budget changes are not addressed. Project decision-making is not always driven by managing budget constraints. For example, if a scope change in District X increases a project cost by $2 million, there is no counterbalancing decision made to reduce the scope on project Y or not to do project Y for two years.

- **Project budgets are mainly driven by scoping documents.**

  In some cases, the scoping document does not contain enough detail in the scope document to accurately estimate project budget. In other cases,

projects are not fully funded, creating a gap between need and available funding and causing unnecessary delays and cost increases. Inflation factors are also not included because ADOT does not always know when a project will be programmed.

- **Project cost accounting activities require strengthening to support project budget management.**

    From some perspectives, there is a need to strengthen the financial management of projects. It was reported that there is an inconsistency to whether time is charged to individual projects across all preconstruction functions and projects. For some sub-programs, there is no preliminary engineering charge account. Instead, charges are incurred against the "Program." There are inconsistencies between when consultants charge to individual projects and when ADOT forces charge to individual projects.

Project Quality Management

Overall, ownership and responsibility of project quality lies within all technical areas such as design, traffic engineering, and right-of-way. The technical leader for a project is responsible for ensuring the quality of each specialized area. Project managers are responsible for ensuring project team members follow the overall quality management process.

The current opinion is that ADOT is producing a lower quality of work (putting together an 80 percent solution in order to meet the bid schedule). As a result, those responsible for project construction expend resources to fix the problems left over from the design phase.

The following issues were identified during the interviews:

- **There is inconsistency across ADOT regarding what quality means.**

    In general, interviewees agree that a quality project is one that meets the customer's expectations for the project. There are varied perspective on how to track quality. Some define quality as adhering to ADOT standards and specifications in project designs. Others measure quality by the number of change orders that are required once project construction is initiated. Another measure is assessing how difficult it was to construct a project (this measure is very subjective compared to the number of change orders). An objective measure is the amount of rework that was required after the final design was approved; this measure could be represented in either dollars or time required to complete the project past the scheduled construction period.

- **Project managers and technical managers believe that design quality has decreased.**

  From the perspective of whether a project is biddable or buildable, many consider that ADOT needs to better address quality considerations in the process. From the project management perspective, the concern is that quality has been sacrificed in order to meet project schedules. There is a general perception that project quality is suffering on the projects that are being pushed out to meet the schedule. Errors in project designs such as incorrect quantities, incorrect geo-technical surveys, and changes to project alignments, have affected project costs, change orders, and constructability.

  In addition, quality management problems exist in right-of-way activities. There have been cases of ADOT requiring second takings, in which more than one right-of-way action on the same property has proven expensive.

- **The project review process is identifying problems that should have been dealt with earlier in the design stage.**

  The review process is identifying errors and other problems that need to be addressed prior to advertising, creating project rework. Interviewees suggest that quality is not being adequately built into the work.

- **Management is concerned about quality issues and has begun to track quality indicators.**

  Management has initiated a process for measuring and tracking of change orders approved during construction.

Project Human Resources Management

Project managers do not have human resources management authority for their teams. Instead, they influence team members and work with them to resolve issues.

There is a wide range of knowledge, skills, and experience among ADOT project managers. Turnover in the Department and in project management staff positions has created vacuums; new staff with little or no experience in project management is filling positions vacated by staff with many years of experience in both project management and corporate culture.

The following issues were identified during the interviews:

- **Project managers have limited control of team make-up.**

  Project managers do not have authority over staff selection to their teams; selections are made by technical area managers. Overall, management of team members by the project manager is less direct.

- **Project managers find it difficult to plan for resource utilization.**

  Limited workload information and work standards make it difficult for ADOT to plan resource utilization effectively at either the project or program level. This prevents the Department from knowing if sufficient resources are available in-house to complete the scheduled work and when contracted support is needed.

- **The knowledge, skills, and abilities of project managers regarding how ADOT delivers projects needs to be increased through training.**

  Overall, ADOT is not providing training that specifically identifies project management as a technical discipline and its application at ADOT. However, ADOT is placing an emphasis on training; new training is provided in order to teach the ADOT project management processes to engineers. In order to achieve this, ADOT needs to develop project management as a distinct technical discipline, both in general and as it relates to the ADOT project delivery model.

  Project managers are expected to take training and other development courses each year. However, many interviewees stated that there is no formalized training for project management other than a one-day course.

  Most staff learn through on-the-job experience from their supervisors or through informal mentor relationships. For example, there is little or no training relating to contract negotiations. Project managers stated they are unaware of any defined processes and have only learned negotiations through on-the-job experience.

- **ADOT is experiencing high turnover and staff shortages.**

  A number of factors such as early retirement and lower pay compared to the private sector has created employee turnover that is affecting project management positions. The push to achieve schedule at the cost of other factors has created overworked staff. This may be contributing to the high turnover.

Project Communications Management

Project communications management includes the processes required to ensure timely and appropriate generation, collection, dissemination, storage, and disposition of project information. It links people, ideas, and information required for a project's success.

The following issues were identified during the interviews:

- **Management has placed emphasis on improving communication.**

Interviewees believe that communications have improved and that the current process enables good communications. The partnering process has been successful in improving communications.

- **Project managers experience difficulty with their overall access to the data and information required for project communications.**

  Some project managers cannot keep track of all the information they need to effectively manage and deliver projects. For example, managers do not always know the right-of-way costs incurred or what permitting activities are required for a project. Procedures for managing project data need to be strengthened. For example, on some projects, different design consultants are used in each phase. Project data does not seamlessly transfer from one firm to another, so the continuum is broken, causing project delays while the new firms gain understanding of the projects.

- **There are a number of specific areas in which communications can be improved:**

  - Passing change order information back to designers.

  - Relaying maintainability issues to construction and preconstruction phases.

  - Coordinating finance and project management information.

  Interviewees identified specific communications issues. Overall there is a strong sentiment that issue resolution procedures and overall project communications are effective.

Project Risk Management

Project risk management is the process of identifying, analyzing, and responding to project risk. It includes the proactive steps necessary to maximize the probability of positive events, minimizing the probability and consequences of negative events.

- **Project managers do not engage in any formal risk management analysis and control.**

  The primary issue for ADOT is that project risk management is not performed as an explicit activity by project managers. Undoubtedly, ADOT's successful project managers are doing project risk management, but not as a conscious and discrete element of their project management role. A number of interviewees want the project managers to be more active and to schedule risk across all delivery activities.

Project Procurement Management

Project procurement management for ADOT project managers is the process through which non-ADOT personnel are hired and managed to perform activities necessary to deliver projects. From ADOT's perspective, they need to manage their buying of services effectively in order to meet project objectives.

The following issues in project procurement management were identified in the interviews:

- **Management has strengthened accountability controls for design and technical consultants.**

    ADOT has implemented a quarterly review for design consultants and contractors in order to improve communications, identify and document expectations, and ensure quality control of projects. ADOT has made procedural changes to better manage private/partner contracts, including deliverable-based contracts.

- **New project managers need to develop skills and abilities in procurement management.**

    Overall, project managers still learn most about procurement management (contractor selection, negotiations, etc.) through on-the-job experience. Consultant managers oversee billings and check the progress of work completed by design firms. Consultant performance is based on meeting cost and schedule estimates and measuring quality of deliverable against checklists, the number of comments, and the number of deliverables that were completed on time. ADOT is developing a database of reports to monitor and review the design consultant performance.

- **Deliverable-based contracts require careful procurement management and work best when the consultant is responsible for all activities.**

    ADOT uses lump sum or deliverable-based contracts for design consultants. This requires a rigorous development of scope and statement of work documents in order to severely limit the potential for change orders during the design phase. This does not work well when consultants are responsible for discrete activities with the project delivery process. In the current situation, ADOT may not be able to meet its schedule commitments, which can result in increased costs and change orders.

CONCLUSIONS

The findings from the critical issues in assessment, as expressed by ADOT staff and management, fall into four broad headings, each of which is summarized below. This assessment provided the basis for the research tasks undertaken in this study.

Executive Leadership and Organizational Development

ADOT interviewees reported significant achievements with regard to the organization's project delivery schedule—an outcome attributable in part to the Governor's directive. This achievement reflects ADOT's ability to focus resources in order to achieve a desired objective. Interviewees expressed interest in extending this success to other key objectives of effective project management—including project scope, budget, and quality. While interviewees and TAC members reported and evidenced solid ADOT morale and a commonly held interest in refining the organization's approach to project management, they also indicated the need for concentrated follow-up and ongoing executive leadership in this area.

Roles and Responsibilities of the Project Manager

In its effort to advance the organization's project management orientation, ADOT has made considerable strides over the past six years in setting forth new or revised roles, responsibilities, and relationships for project managers, functional managers, and staff. Interviewees and TAC members suggested that continued progress in specifying and standardizing these roles and responsibilities across projects, functions, divisions, and departments will be helpful in achieving desired project management outcomes consistently and enterprise-wide.

Scope, Schedule, Budget, and Quality Management

As noted above, tools are already in place at ADOT to ensure that projects are delivered in timely fashion. Interviewees and TAC members generally agreed that building on this base by developing state-of-the-practice metrics and tools with which to control project scope, budget, and quality would be of great value to project managers. Such tools would also be useful when rolled up for use at the program delivery level. Several interviewees observed that the primary existing tool for project control, the Active Project Status Report, could be augmented or replaced by a tool containing sufficient information to allow project managers to monitor and control project delivery status against budget.

Human Resources Management in a Project-Oriented Organization

Human resources policies and procedures must be aligned with the objectives of project management to effect a structure within which the skills and leadership qualities required for effective project management are a focus of recruiting, professional development (including career ladders), and performance appraisal. ADOT, like many other project-oriented transportation agencies, is faced with several critical issues around the area of human resources management: (1) the demand for qualified project managers that exceeds the supply; (2) the challenges of managing workforce transitions in terms of FTEs and retirements; and (3) the need to develop workload metrics and reporting systems to allow project and program managers to allocate scarce labor resources across projects, tasks, programs, and functions.

IV. CURRENT PRACTICES

INTRODUCTION

This chapter provides a baseline description and analysis of ADOT's current project management approaches, documentation, systems, and business practices. This chapter provides more detail on the issues identified and evaluated in Chapter III, Critical Issues Analysis. The current practices assessment involved the following approach:

- A review and evaluation of written ADOT policies, procedures, progress and financial reports, audits, training materials, and internal documentation concerning the project delivery process.

- Several rounds of interviews with ADOT executives, managers, process participants, customers, and partners. Throughout, we have sought to identify areas of strength, as well as opportunities for growth. The list of interviewees is provided in Appendix A.

The information in this chapter was originally presented in the fourth interim report. Earlier interim reports were planned and sequenced to:

- To ensure that the consultant team focused on the issues of greatest concern to ADOT.

- To provide grounding in the theory, tools, and techniques of project management.

- To identify industry best practices in project management.

Organization

This chapter is divided into four parts as follows:

- The first part provides historic context regarding the evolution of project management at ADOT.

- The second part comprises an analysis of existing roles, responsibilities, relationships, and authority among the key members of ADOT project teams.

- The third part discusses mechanisms that support project teams—emphasizing information technology and reporting as well as the team-building practices of project management training and partnering.

- The fourth part explains how successful project management programs are tied together such that business processes, data management, accountability structures, and performance measures are consistently integrated across functions and phases.

ADOT's Project Management Chronology

This best practices study is among ADOT's latest efforts to improve project and program delivery. ADOT, along with several other state departments of transportation, started to focus on project management in the 1980s (amid nationwide trends toward privatization and the "reinvention of government"). Touching upon some of ADOT's history since the late 1980s is helpful in understanding the agency's current project management efforts and status.

1989: Consultant Management Services

ADOT took a decisive step in 1989 by establishing its first project management unit, Consultant Management Services, which was charged with managing the development of "state-wide" projects for which consultants did the design work. The concept was to apply the principles of project management to consultant-led work to achieve more consistency and efficiency. The approach was not initially applied to in-house design projects, which were developed in a traditional, functionally sequenced, and separated process.

When consultant-led projects and ADOT-led projects needed the same resources at the same time (which is not uncommon) the existence of separate processes competing for the same resources became problematic. This was part of the reason that ADOT moved in 1991 to develop a broader project management approach that would also apply to design projects performed in-house. This timing coincided with the 1991 election of Governor Symington, whose administration also viewed ADOT's project management efforts as a means of promoting the Governor's tax and service cutting initiative, Project SLIM (Statewide Long-term Improved Management).

1991: Partnering Workshop

ADOT convened a Partnering Workshop in 1991 to generate ideas on improving its project delivery and business processes. The workshop was attended by ADOT managers and staff, contractors, suppliers, and consultants. The workshop's chief outcome was a Strategic Partnering Action Plan, in which project management figured prominently. Accordingly, a Project Management Process Team was created in February 1993. Its mandate was to develop a project management philosophy, approach, and guidelines for the agency.

1993: Project Management Process Team

The Project Management Process Team worked intensively between February and October 1993, when it issued its Project Management Process Final Report. Following are some of the Team's key findings:

- Projects were taking too long to get to the bid process.

- The project development process is ineffective.

- The responsibility for review is unclear.

- Schedules are not realistic.

- There is a lack of project ownership.

- Authority is poorly defined.

- Scope creep exists.

1995: *Project Development Process Manual* Update

The findings and recommendations from the Project Management Process Report were used to structure a new approach to project and program delivery, which was codified in the *Project Development Process Manual* (2)*,* a document of over 200 pages. The stated purpose of the new *Project Development Process Manual*, which still serves as a reference, is to "Describe the Project Development Process and to provide a guide for the management of project scoping activities, project design and production of construction documents, administration of construction contracts, and initial project operation and maintenance in accordance with ADOT policy" (*Project Development Process Manual*, Chapter 1, Section 1.5) (2).

The philosophy and processes set forth in the *Project Development Process Manual* (2) are important because they have set the course of project management at ADOT. They reflect the agency's comfort with a team-based approach to production and problem solving, which remains among the agency's strongest shared values. Following are some of the founding principles contained in the *Project Development Process Manual*:

- The process must consider the entire project life cycle—from concept through maintenance.

- The project manager is the focal point for accountability and responsibility.

- Project management is a team effort.

In covering the project development process, the *Project Development Process Manual* (2) is broad and deep. It takes as the starting point for a project the needs identification process in planning and follows the project through to maintenance. It specifies the roles, responsibilities, and authority of several dozen internal and external participants, including metropolitan planning organizations, the National Forest Service, and each ADOT entity that has direct or even indirect project responsibility. Organized by project phase, stage, activity, and task, it provides detailed guidance on corresponding

documents, deliverables, and review requirements. A matrix splitting out the respective roles of project manager, technical manager, and technical leader, by phase and major activity, is contained in a long appendix.

The *Project Development Process Manual* (2) also contains a section entitled "Communication," which covers partnering, issue resolution, project work plans, reporting requirements, and project change procedures.

Strengths of the Project Development Process Manual

- It provides a thorough, internally consistent framework for project management.

- It reflects the agency's team-based approach.

Weaknesses of the Project Development Process Manual

- It provides much more information than project managers need to do their jobs.

- With only a few graphics and text-dense pages, it is not reader-friendly.

- Although it is referred to as an authoritative source, subsequent policy and process changes have not been integrated into the manual.

1996: *Project Manager's Handbook*

Eighteen months later (July 1996), ADOT published the *Project Manager's Handbook* (3) as a companion to the *Project Development Process Manual* (2). Unfortunately, the *Project Manager's Handbook* (3) fell short of delivering on the foundation laid in the *Project Development Process Manual*. The *Project Manager's Handbook* appears to be a loosely organized assortment of checklists, e-mails, sample letters, agendas, letters, and memos.

The Late 1990s: Additional Guidance for Project Managers

Since the late 1990s, a number of additional guidelines, processes, and refinements to ADOT's project management process have been made. However, the agency does not have a process for integrating new processes, changes, or refinements into a single, official, "living" source. As a result, multiple, overlapping documents on similar topics exist. For example, three documents set forth guidelines on ADOT's various scoping methods: the *Project Development Process Manual* (1995) (2), Policy 88-2 (n.d.), and a memorandum entitled "Project Assessment/Scoping Letter/DCR (Design Concept Report) Guide" (January 28, 2002). Table 3 contains excerpts from each.

**Table 3: Example of Multiple, Overlapping Sources that are not cross-referenced that refer to the same aspects of the Project Development Process:
Project Scoping Alternatives—Scoping Letter, Project Assessment, or Location/Design Concept Report**

Project Development Process Manual	**Policy 88-2 Addressing Project Assessments**	**Project Assessment/Scoping Letter/ DCR Guide**
Whether a Scoping Letter, a Project Assessment (PA) or a Location/Design Concept Review (L/DCR) should be done. **Scoping Letter** • Scoping Letter Project Team. • Scoping Letter Project Objectives. • Scoping Letter Background Information. • Scoping Letter Field Review. • Initial Scoping Letter. • Initial Scoping Letter Review. • Final Scoping Letter. **PA** • PA Project Team. • PA Project Objectives. • PA Background Information. • PA Field Review. • Initial PA. • Final PA. **L/DCR** • DCR Project Team. • DCR Background Information. • DCR Field Review. • Initial DCR. • DCR Environmental Analysis. • Location/Design Public Hearing. • Final Location/DCR.	Whether a PA or a DCR should be done. **PA** • Responsibility. • Scope and Priority. • Project Assessment Format. • Process Outline. • Project Leader Involvement. • Field Review. • Design Exception Approval Procedures. • Schedule Model Modification Process. • Consensus. • Budget Overruns, Scope, and Schedule Changes. **L/DCR** • Scope and Priority. • When Location is an Issue. • DCR or L/DCR Format. • Approval Procedure. • Consensus.	In-House Preparation: • Obtain Data. • Determine AASHTO Controlling Design Criteria. • Field Review. • Initial Project Assessment. • Submit Recommended Project Change. • Write Design Exception. • Prepare Summary Comments. • Final Project Assessment/Scoping Letter. • Project Correspondence File. **Consultant Preparation** Detailed Format and Development Procedures: • Project Assessment Reports. • Location/Design Concept Reports.
	Policy 88-2 Addressing Project Assessments. n.d.	Arizona Department of Transportation Office Memo. Draft January 28, 2002. To: Roadway Predesign Personnel. From: Herman H. Mozart, Manager, Predesign Program Management Section. Project Assessment/Scoping Letter/DCR Guide.

It is important to keep in mind other ongoing efforts to improve ADOT project delivery, whether or not they fall under the official "Project Management" bailiwick. Two important support initiatives have much improved the team dynamics in projects at ADOT. The first is ADOT's Partnering Program, a nationally recognized leader in what is sometimes referred to as "precontracting," and Internmodal Transportation Division's (ITD) sponsorship of a well-received course entitled *Successful Management of the Project Development Process*.

PROJECT MANAGER AND PROJECT TEAM ROLES, RESPONSIBILITIES, AND AUTHORITY

This section compares and contrasts ADOT's project management model as it is specified in the *Project Development Process Manual* (2) with interviewees' perceptions of how and whether these specifications are applied in practice.

ADOT's Weak Matrix Model

ADOT's project management model is best described as a weak matrix. The word "weak" here is not pejorative. Rather, it designates a form of project organization in which many of the characteristics of a functional organization are retained. In the DOT context, this means that technical managers are roughly equal in status and authority to the project manager, who serves primarily as a coordinator. In contrast, under strong matrix models, the project manager is dedicated to this function, has considerable authority, and is often supported by administrative staff. Interviewees generally concur that ADOT's weak matrix model works well in this team-oriented organization.

Under ADOT's weak matrix model, project management responsibilities reside in the various functional units of the organization. Project *teams* as opposed to project managers are ultimately responsible for developing projects and making decisions. Technical responsibility (including quality) is distributed across functional and geographical units. According to this model, the project manager shares responsibility with the technical manager and the technical leader assigned to his or her team. Their respective roles according to the *Project Development Process Manual* (2) are depicted in Table 4.

Table 4: ADOT Project Management Roles: Project Team, Technical Manager, Project Manager, and Technical Leader

Project Team	Technical Manager	Project Manager	Technical Leader
• While individual team members have responsibil-ities for unique aspects of the project, the Project Team as a whole is responsible for the total project. • Staff filling team roles are supervised by group managers and the Chief Deputy State Engineer.	• Responsible for scheduling and assigning work within each organizational unit to individual projects. • Commits resources necessary to each project. Monitors project work status and demand for labor within the unit. • Responsible for establishing and maintaining quality standards, policies, and practices within the overall technical unit	• Ensures that all project development steps are followed. • Leads, assists, delegates, and coordinates efforts. • Ensures public involvement. • Monitors, scope, schedule, and budget. • With Project Team consensus, is empowered to make decisions within set limits.	• Assigned by the technical manager of each discipline involved in the project. • Responsible for that discipline's work on the project, including content and quality. • Makes project task assignments and monitors his part of the schedule. • Monitors and reports on assigned project activities to the project manager and to the functional manager. • Responsible for taking action to correct negative variances from planned progress on his or her part of the project.

The *Project Development Process Manual* (2) takes the approach to balance the conflicting goals of independent project *teams* and central coordination by empowering, within limits, the project manager to make changes in a project scope, schedule, and budget as long *as there is a consensus among the project team*. The limits of the empowerment are set to give the Project Team flexibility without serious impacts to the overall program (4, p.3.7). Empowerment permits the team, with the project manager acting as its representative, to implement project changes which do not affect the overall project objectives, such as changing the advertisement date or the construction budget. Without consensus, a set project Issue Resolution Process must be followed. Put simply, ADOT project managers are "empowered" only to the extent that the team approves. Table 5 indicates changes in project scope, schedule, and budget that the project manager may authorize.

Table 5: How Project Managers are Empowered at ADOT
(Subject to Team Concurrence)

Project Scope	Adjust the scope as required to meet the project objectives
Project Construction Budgets.	May make cumulative changes up to the greater of $100,000 or 10% of the original programmed construction cost.
Project Scoping Phase Schedules.	May make changes of up to 90 days in the scheduled completion date of a PA or a scoping letter and up to 180 days for a Design Concept Report, but not beyond the cutoff date for programming consideration.
Project Design Schedule.	May make changes in the original programmed advertisement date up to: • 90 days, but not past the end of the fiscal year (FY) for projects programmed to be advertised in the current FY. • 180 days, but not beyond the end of the FY for projects programmed to be advertised in the next two FYs. • Any change, but not beyond the end of the FY for projects programmed to be advertised in fourth and fifth years of the Five-Year Program.

ADOT's Issue Resolution Process

ADOT has a formalized Issue Resolution Process to deal with the conflicts that may arise as thousands of employees and contractors seek to deliver hundreds of complex projects for which resources (time, labor, money) are scarce. Issue resolution is an area in which there appears to be consistency between the *Project Development Process Manual* (2) and practice. ADOT's experience is that the types of conflicts that may emerge within project teams fall into three categories: technical, policy, or project-related. A technical example would be a conflict between traffic and highway engineers regarding layout of a highway intersection. A policy example would be a local government asking ADOT to provide special roadway lighting fixtures. A project related example would be a District asking Design to add a passing lane to a pavement preservation project.) The flowchart illustrating ADOT's established issue resolution process is depicted below (Figure 1).
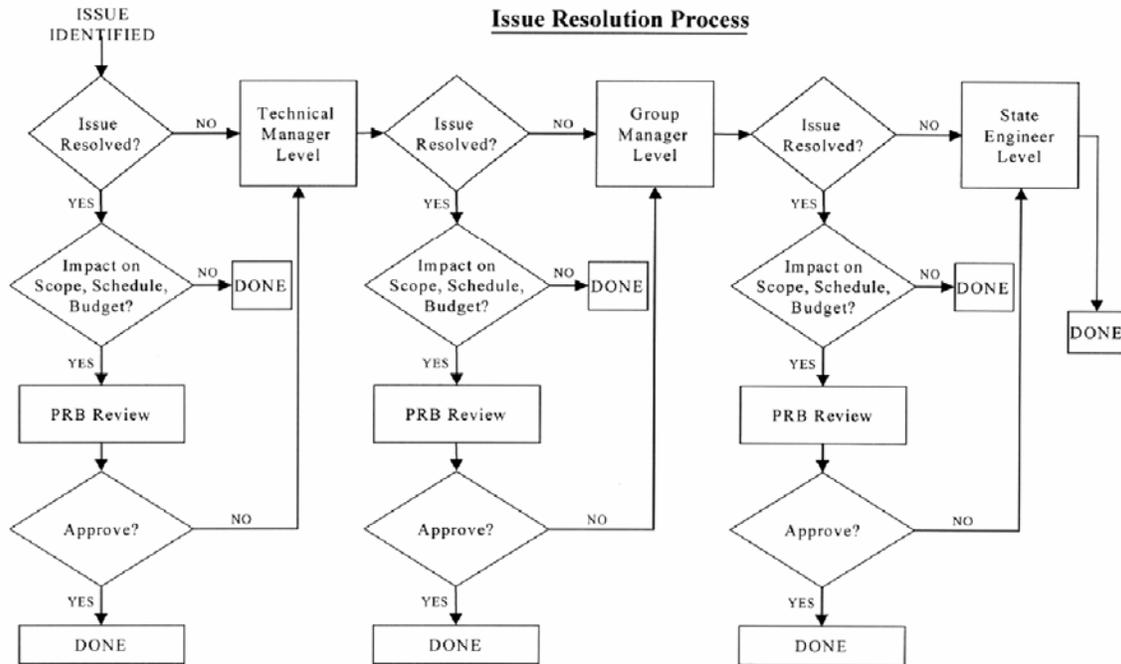
Figure 1: ADOT's Project Issue Resolution Process

The Project Manager's Role is Not Well Understood

In its interviews with ADOT project managers, the consultant team found widespread uncertainty as to the role and authority of the ADOT project manager. There are differences between groups (e.g., ADOT executives and ADOT program managers and project managers) as well as differences within these groups regarding the appropriate role of the project manager. Project managers who had worked in the private sector or in state DOTs with strong matrix approaches felt particularly unsure as to their roles. Following are issues raised in interviews with ADOT project managers:

<u>The role and authority of project managers in ADOT's weak matrix model needs to be clarified.</u>

The role and accountability of the project manager is subject to different interpretations. Some interviewees assert that the project manager is a member of the team who is responsible for scope and schedule, but who is not the overall leader. Meanwhile, others believe that the project manager is accountable for schedule delivery, scope, and budget. This is the view of many of the managers who are responsible for ADOT's overall program management.

In practice, depending on project managers and their teams, there is a wide spectrum of arrangements among team members with regard to their roles and responsibilities.

ADOT executives are under the impression that project managers are authorized to exercise scope, schedule, budget, and quality control. Meanwhile, project managers have mixed impressions

The extent to which a given project manager actually monitors and controls aspects of a given project may vary depending on the individual's experience, the particular team assembled, the type of project, and a number of other factors.

The research findings are that, with the exception of Valley Project Management, in general ADOT project managers are not managing or exercising scope, budget, and quality controls.

PROJECT MANAGEMENT TOOLS, INFORMATION AND REPORTING SYSTEMS, AND TEAM BUILDING

Interviews with ADOT staff and managers, as well as the consultant team's review of data sources, systems, and reports revealed issues with regard to ADOT's project management tools, information, and reporting systems. The approach in this section is to describe existing tools and processes, and then to present related issues concerning their actual application.

Project Schedule Management

ADOT's primary management reporting tool is its Active Project Status Report (APSR), which is used primarily to track project status relative to planned contract advertisement dates. The APSR is built up from the individual project schedules produced in-house and by consultant project managers who submit their schedules for integration. Project managers are provided individual reports for their own projects as well.

The Active Project Status Report

The APSR contains schedule milestone data for each programmed project. All active projects are sorted by Bid Ready date, and projects that failed to advertise are flagged. In addition, the APSR indicates when projects have been added, deleted, or rescheduled. Graphic representations of the number and percentage of projects making their bid dates are also presented.

Schedule Development

Original project schedules are developed by project managers, whether the design work is done in-house or by consultants. ADOT's Program and Project Management System (PPMS) provides a starting point for schedule building in that it has established a system of standard activities, milestones, and checklists that is to be incorporated into every programmed ADOT project. Activities and milestones are organized by design stage (of which there are five, each corresponding to a percentage of design completion). PPMS collects the consultant schedules and incorporates them into the ADOT Master Schedule.

<u>Design and Construction Scheduling are Separate</u>

Despite the cradle-to-grave approach envisioned in the *Project Development Process Manual* (2), the PPMS schedule function covers only the design phase. A separate system is used for construction administration. PPMS tracks schedule progress on a monthly cycle, which involves prompting project managers to indicate any changes via a Schedule Update Request Form (SURF). PPMS updates all of the schedules using the SURF form returned by project managers and combines the results into the APSR

<u>Scheduling Issues as Expressed by ADOT Interviewees</u>

Our interviews provided the following findings with regard to ADOT's schedule management tools and information systems:

There is little standardization in the establishment of work schedules

There are no established, validated work standards for activity duration from which schedules can be built and managed. Activity duration and sequencing are set based on the individual project manager's experience and intuition, as opposed to established, empirically-based agency standards.

The lack of empirically-based work standards by activity is an issue for at least two reasons: (1) without them it is more difficult for ADOT to project "what-if" scenarios involving funding and other resources within their capital program; (2) given ADOT's employee turnover issue and difficulty replacing retiring engineers, the informal intuitive approach may not provide needed guidance to new project managers.

Use of established scheduling tools is low

Rather than actively using established scheduling tools to manage their projects, project managers tend to manage their projects without them, and in many cases only use them to meet PPMS update requirements.

Some interviewees work around PPMS' scheduling controls by building in extra float or by performing certain tasks before all internal and external approvals have been obtained, gambling on the hope that they will be approved, and that the Project Manager will make his or her advertising date. In short, the system's potential as a resource-loading tool across projects, departments, or enterprise is not being used.

Project Budget Management

Although budget management is generally a critical project management responsibility, individual ADOT project managers rarely see or work with project budgets directly. Rather, ADOT's project managers rely on "soft skills," including organization, coordination, negotiation, and persuasion to get team members to pull together to meet the scheduled advertisement date. Therefore, the emphasis is overwhelmingly on schedule

without regard to cost. Project-level budget management at ADOT is not an expectation. Even if it were, existing accounting systems would not support it.

ADOT documentation regarding budget control is vague

While the *Project Development Process Manual* (2) refers to a resource planning sheet, the relationship between such planning sheets and an actual budget is not specified. Throughout ADOT's project management documentation, project managers and technical managers are referred to as "managing resources," with very little or no mention of hard budgets.

In practice, project managers do not manage project budgets

Budgets for the key components of project labor, right-of-way, and construction are not established at project inception and then tracked and adjusted accordingly. Interviewees indicated that project managers do not manage budgets in this way, nor is there a management expectation for this.

The Project Review Board has a key role in budget control

In a number of areas, projects are clustered into programs and subprograms, where aggregate budgets are effectively managed by the Project Review Board, which must approve any change that would affect an individual project's advertisement date, scope, or resource requirements. Interviewees noted that the resulting lack of budget management at the project level has adverse program-level implications.

ADOT's project management culture does not emphasize fiscal discipline

There is feeling among interviewees that ADOT lacks a cultural focus on project cost and budgeting in the larger sense, which limits its ability to perceive and then act on the benefits of tighter financial management. (This is not the case with the Valley Transportation Project, which functions according to a different project management model and has specific financial management requirements.)

Project Scope Management

Interviewees were very consistent in raising issues regarding the effectiveness of the scope management process across all functions. Managers expressed concern about the process through which scope is established, scope management practices, and procedures for controlling scope. There are differing opinions as to the primary drivers of scope issues at ADOT, chief among them the following:

Project managers are not responsible for managing scope development

Several interviewees expressed frustration that although they are not involved in the scoping process, they are held accountable for scope creep. However, the *Project Development Process Manual* (2) indicates a very early and substantial role for the project manager, as illustrated in Table 6. According to this document, a project manager is assigned as soon as "Conceptual Design Strategic Plan" has been developed by the project's technical manager. Apparently, there are significant differences between the *Project Development Process Manual* specifications for this phase and actual practice. At the very least, there is a widespread perception of a disconnect between official and actual practices.

Project managers inherit outdated, unrealistic scopes

The scoping process may be completed several years before a project is programmed into the construction program, by which point inflation, right-of-way, utility relocation, and construction costs have risen well beyond initial estimates.

Interviewees noted that a recent positive development is that the same design consultant is performing the scoping and then the subsequent design work for some projects.

Project managers report pressure from local interests and districts to increase project scope, often late in the design phase

Project managers report feeling pressure from local interests and from district managers to change scope late in the design and even construction phases. The later the scope changes, the more significant, expensive, and time-consuming the impacts tend to be.

Project managers are limited in their ability to control scope

Project managers also indicate that they have limited authority to manage scope, and that they are not empowered with the appropriate tools. Weak scope controls have resulted in a general expectation that scope will change during the delivery process, thereby complicating the delivery process (e.g., it is more difficult to elicit the cooperation of technical leaders when they believe that the scope will change, necessitating redesign work at some future point).

In practice, scope changes are managed after the fact by the Project Review Board

If changes in scope are required, project team members conduct a review before taking the issue to the PRB. The PRB evaluates the changes based on several questions, and reviews the schedule and budget impacts:

- Who requested the change?

- What changes are requested?

Table 6: The Project Manager's Role in Scoping by Step and Activity
(Project Manager Tasks are indicated in bold face. Source: *Project Development Process Manual*)

Step	Activity	Project Manager	Technical Manager	Technical Leader	Other
1	Needs identification.				**Districts** – Assemble lists of potential major and minor projects from COGs and District Operation and Maintenance.
					ADOT Systems Management – Assemble list of potential projects in HES, Traffic, Bridge, Pavement, Park Roads and Roadside Improvement categories.
2	Objectives meeting on Potential Major Projects.	Statewide Project Management Section senior staff confer with District Engineers and project initiators.	Pre-Design confers with District Engineers and project initiators.		**District Engineers** – Participate in Objectives meeting.
					Project Initiators – Participate in Objectives meeting.
					TPD – Receive objectives report from SPMS.
3	Candidate Projects.				**Highways Division, TPD Management** – Select major projects for scoping.
					TPD – Selects proposed non-major projects for scoping; sets programming evaluation date for all projects being scoped.
4	Resource Requirements and Activity Durations for Scoping Candidate Project.		Pre-Design Mangers and SPMS senior staff.		**PPMS** – Coordinates evaluation and prepares preliminary schedule.

Step	Activity	Project Manager	Technical Manager	Technical Leader	Other
5	Conceptual Design Strategic Plan (including use of On-Call and Project consultants).		Pre-Design Managers and SPMS senior staff.		**PPMS**– Coordinates strategic planning and prepares schedule.
6	**Assignment of Project Manager.**		SPMS recommends project manager		**CDSE** – Appoints project manager (PM).
7	**Project TRACS Number.**	Verifies number assigned.			**Pre-Design Management** – Assigns TRACS number to candidate projects.
8	**Project Objectives Meeting and Outside Agency Identification (Non-Major Projects).**	Attends Objectives Meeting.		Technical unit preparing scoping document organizes and conducts objectives meeting.	**District** – Attends meeting. **Initiating Agency** – Attends meeting.
9	**Assembly of Project Team.**	Requests Technical Manager to assign.	Assign technical leaders to team.		
10	**Project Scoping Phase Project Work Plan (PWP).**	Coordinates PWS preparation.	Reviews Technical Leader estimates.	Prepares scope. Estimates activity duration and resources.	**PPMS**– Processes schedule.
11	**Consultant Selection and Contracts (if used).**			Preliminary technical unit provides scope and schedule to ECS and assists in selection and negotiation.	**ECS** – Administers consultant selection process.
12	**Design Team Kickoff Meeting.**	Organizes and conducts meeting.		Participate.	

Step	Activity	Project Manager	Technical Manager	Technical Leader	Other
13	**Background Data, Accident Analysis, and Controlling Design Criteria Analysis.**	Coordinates preparation of analysis.	Monitors preliminary design exceptions.	Prepare analyses and preliminary design exceptions.	
14	**Field Review.**	Attends and assures Team participation.		Primary technical unit organizes and conducts field review.	**District, Traffic, Environmental Planning, Right-of-Way, Structures, Materials** – Participate. **FHWA** – Participate. **Outside Agencies** – Participate.
15	**All-Agency Scoping Meeting.**	Organizes and conducts meeting.		Participate in Partnering.	**ADOT Partnering Office** – Provides facilitator on major projects. **Outside Agencies** – Participate.
16	**Initial Project Assessment/Design Concept Report/ Environmental Documentation.**	Monitors project objectives; monitors progress.	Monitor technical preparation of studies and reports.	Prepare studies and reports.	
17	**Initial PA/DCR/En Docs Review and Consensus Meeting.**	Monitors review and coordinates comment resolution or scope consensus meeting.	All involved review initial scoping comments and comment.	Primary technical units circulate documents for review; respond to comments.	**Involved Outside Agencies** – Review PA and comment.
18	**Determine whether PA has defined project.**	Recommends DCR to CDSE if project not defined.	Roadway Group Manager concurs in determination.	Project Team determines.	
19	**Public Hearing.**	Attends and monitors public hearing process.		Environmental Planning organizes and conducts, Team attends.	

Step	Activity	Project Manager	Technical Manager	Technical Leader	Other
20	**Design Exception Request**	Monitors.	Roadway Group Manager approves design exception.	Requests design exception approval from Roadway Group Manager.	**FHWA** – Approves design exception request on Federal-Aid projects not under Certification Acceptance Procedures.
21	**Final PA/DCR/En Docs**	Monitors project objectives; monitors progress.	Monitor technical preparation of studies and reports.	Prepare final studies and reports.	
22	**Final PA/DCR/En Docs Approval**	Approves PA/DCR/ Environmental documents.	Roadway Group Manager/ Environmental Planning Manager approve.		**District and Initiating Agency** – Approve PA/DCR/Environmental docs, schedule milestones and construction budgets.
23	**Outside Agency Approvals and Commitments**	Transmits documents; monitors approval process; obtains Project Agreement.			**FHWA** – Approves documents on Federal-Aid projects not under Certification Procedures. **Other Agencies** – Concur in project, commit to funding or participation.
24	**Programming Data to TPD**	Submits PA, schedule and budgets to TPD for evaluation.			**TPD and Project Rating Team** – Evaluate projects. **TPD and PPC** – Review ratings, select new projects and recommend tentative program.
25	**Five-Year Program**	Monitors progress.			**Transportation Board** – Review, hold hearings and adopt projects into Five Year Program.
26	**Preliminary Design Phase Project Work Plan**	Coordinates preparation of PWP.	Reviews Technical Leader estimates.	Prepares scope, estimates activity duration and resource requirements.	**PPMS** – Processes schedule and resource requirements.

Step	Activity	Project Manager	Technical Manager	Technical Leader	Other
27	**Project Design Phase Schedule**	Verifies programmed schedule.			**PPMS** – Prepares program schedule, adjusts project schedules to balance resources.
28	**Schedule and Resource Allocations; ADOT and Consultant Assignments**				**CDSE/PRB** – Confirms program schedules and resource allocations.
29	**Final Design Phase PWP**	Coordinates final Design PWP.		Prepares final Design PWP.	**P2S2** – Processes final PWP schedule.

- Why is the change requested?

- When will the changes be made?

- How is the change affecting the objective of the original project scope?

Project Quality Management

ADOT Knows What Quality Means

Unlike state DOTs that are still struggling to define quality, ADOT has articulated a quality vision that is consistently reflected in its Partnering Program, in its Value Analysis function, and in the context of project management. At the project level, the issue is one of developing business processes and performance measures that will help achieve ADOT's quality vision.

At the project level, responsibility for project quality lies within each technical discipline, and the technical leader for a project is responsible for ensuring the quality of each specialized area. Project managers, meanwhile, are responsible for integrating the quality plans of each technical leader and ensuring that the overall project quality plan is adhered to.

Existing Performance Measures Emphasize Schedule at the Expense of Quality

Both project managers and technical managers at ADOT believe that the agency's push to get projects out by scheduled advertisement dates has hurt design quality. Resident engineers believe that projects are being bid with existing problems unresolved and the unspoken expectation of fixing them in construction.

Tension occurs between project managers and resident engineers when design errors or emissions are discovered "after the package has been thrown over the fence," as one resident engineer put it. Errors have included incorrect materials, quantities, and material quality. ADOT is working through its Value Engineering Section to better understand the nature and cause of costly change orders by tracking and analyzing them. Eventually, consultant and contractor payments for extra work will be tied to this new control process.

Team Building

The "soft skills" involved in project management include organizing, motivating, and developing the competencies and contributions of individuals and groups. Such skills, categorized here as team building, are critical in project management, particularly in a weak matrix model such as ADOT's. The agency addresses team building through its Partnering Program and through special project management training.

Partnering

ADOT has led the industry in other areas relating to project management, chief among them Partnering. Essentially, under Partnering, the groups and individuals who will be working together on a project commit to a common mission, issue resolution process, and protocols that govern practices and communications within the group and with entities outside of it. ADOT's Partnering Program is one of only 11 listed on the Associated General Contractors Website, and it is the only DOT represented (other public agencies represented include the Department of Defense and the Army Corps of Engineers).

ADOT's Partnering Group reports impressive bottom-line improvements in project delivery, attributing the decline in construction arbitration costs to this form of "precontracting." Construction arbitration and litigation analysis cost the agency $39.8 million in FY 1991 with 60 claims; that number had declined to $28.5 million in 1992 with 20 claims. For the years since 1996, construction arbitration and analysis has cost ADOT a total of just $154,812 on a total of three claims.

Among the Partnering Group's current goals is to increase the practice of Partnering during preconstruction phases. In fact, the Partnering Group has set an FY 2003 objective of ensuring that "at least 60% of ADOT Development Teams, 10% Operations, and 30% of Others, utilize the Partnering Evaluation Program." [3](ADOT Goal 2, Objective 3b (3)).

Training

Another area in which ADOT is making progress in developing its project management function is training. ADOT began a few years ago to offer a course entitled *Successful Management of the Project Development Process*. This ITD course's stated goal is to "assist individuals in developing the skills necessary to initiate, implement, and evaluate small and large-scale projects."[4]

Expected training outcomes are set forth in the introduction to the participant's manual. By the end of the course, participants are expected to be able to do the following:

- Describe the project development process at ADOT, including the four major phases (scoping, preconstruction and design, construction, and maintenance).

- Identify the factors critical to project success, primarily scope, schedule, budget, and quality.

- Describe the scoping phase of project development and learn to identify a project's critical success factors.

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[3] ADOT Goal 2, Objective 3b(3) (n.p.). Accessed November 11,2002.
<http://www.dot.state.az.us/about/ppms/index.htm>
[4] ITD Division, ADOT, Carla Carter, UOP, Presenter, "Successful Management of the Project Development Process," Participant's Manual, p. 4.

- Describe the pre-construction and design phase of project management and the major activities associated with this phase.

- Use several planning tools including the Work Breakdown Structure, involvement matrix, task planning worksheet, workload planning worksheet, kick-off meeting checklist, and schedule tool.

- Describe ways to estimate completion time and insert allowances for contingencies, thereby reducing uncertainly in a project.

- Describe the techniques for monitoring the progress of a project, including the Issue Resolution Process, ADOT's Activities Status Report, SURF, and Technical and Project Management Reports.

- Discuss the role of the Project Review Board and the steps teams need to take when resolving issues.

- Determine the closing steps of this phase in order to effectively hand off to the construction business unit.

- Describe the large list of competencies of the successful project management team.

- Identify the Project Development Process' strengths/opportunities for improvement.

The course is organized around the scoping and preconstruction phases of the project life cycle. Three of the nine modules are devoted to planning in Preconstruction and Design. They focus on work breakdown structure, resource management, and kickoff meetings, respectively. The course has received favorable evaluations.

EXECUTIVE-LEVEL LEADERSHIP FOR PROJECT MANAGEMENT

According to the peer state DOTs surveyed for this study, executive leadership is the single most important factor in the successful development of the project management function. Not only do senior executives set the agency's direction and priorities, they also allocate resources at the highest level.

Perceptions of Executive Level Understanding and Support for Project Management at ADOT

Consultant team interviews with executive managers, senior staff, and other internal and external stakeholders revealed concern that the initiative toward "management by project" that began in the early 1990s, and started to bear fruit in the mid-1990s, has not maintained its momentum in all areas, although strides in project management training and Partnering are notable. In short, whereas delivering the capital program according to the letting schedule has become an overriding priority, other

meaningful project management outcomes, such as budget performance or quality, have not been among senior executives' key themes.

Interviewees expressed concern that strengthening project management has not received sufficient executive attention

Interviewees consider that senior management has been overly focused on the schedule objectives. They believe that management needs to ensure that the organization is clear about project management objectives, and that cross-functional support and consistency require senior management direction.

Interviewees were concerned that management does not fully understand project management

Some interviewees believe that ADOT senior management does not fully understand project management as a discipline or has not fully embraced or endorsed ADOT's project management process as a way of doing business.

ADOT executives are perceived as being receptive to improving project and program management

While interviewees perceive a lack of active support of the project management function at this time, they also express confidence that executive managers recognize its potential for improving agency service delivery overall. Indeed, they view this Best Practices Study as a step in revisiting and strengthening ADOT's project management function.

Project Management-Related Performance Criteria

In "reality checking" the perception that ADOT senior managers are not as proactive as they could be in embracing management by project as a key part of their management strategies, it is interesting to compare ADOT with its peers in terms of the type, variety, and project-relatedness of the performance criteria to which they hold themselves publicly accountable. A sampling of performance measures from the Minnesota Department of Transportation, the New Mexico Highway and Transportation Department, and the Washington State Department of Transportation can be found in Appendix B.

Business objectives/performance criteria

ADOT regularly reports on 12 performance measures, four of which are geared to the Intermodal Transportation Division (ITD). The others pertain to the Motor Vehicle Division and transportation services. Of the four ITD performance measures, only one is directly tied to project or program level outcomes: "Ensure that 90-100% of the total construction dollars planned to be awarded in the FY 2003 is awarded by the Board." (ADOT also tracks and reports the percent difference between actual days worked versus original contract days, percent difference of final construction costs versus original bid, and the percent difference

between modified contract cost versus original bid amount.) Other states use up to a dozen diverse performance measures that tie directly to project outcomes.

<u>To date, ADOT's project management-related performance criteria are narrow</u>

ADOT's performance measures, compared to those of peer state DOTs including Washington's, New Mexico's, and Minnesota's, for example, are narrow. That ADOT management has chosen to focus on a single aspect of project management indicates at least three possibilities, which are not mutually exclusive:

- ADOT is remarkably focused at achieving its goals.

- ADOT has yet to take on the other elements of project management and their relationships to overall management efficiency.

- ADOT desires to present a more balanced account, but the underlying information management and reporting capacity are not yet in place.

Accountability

From what the consultant team was able to discern, ADOT's job classification system does not include any job classes that are project manager specific. ADOT project managers for the most part wear two hats—juggling their technical work with overall project management.

In contrast, state DOTs that have embraced management by project as an enterprise-wide approach to program and service delivery, including Utah, Michigan, and New Jersey, have defined career paths for project managers. These career paths include specific job classifications for project managers. These job classifications have their own pay scales, educational and experience requirements, and appraisal forms. Project management accountability is carried through to the individual level by developing performance plans and criteria that reflect the outcomes of projects for which individuals are responsible.

V. BEST PRACTICES RESEARCH

INTRODUCTION

Management by project is an approach that is fast gaining currency among state departments of transportation (DOTs)—particularly since the mid-1990s. California, Indiana, Iowa, Oregon, Kansas, Michigan, Minnesota, Utah, New Jersey, Georgia, and Massachusetts, to name but a few, are finding ways to provide major infrastructure facilities and services with greater efficiency and control by tailoring established principles of project management to their own organizational structures and business needs.

Project management is a discipline according to which the scope, schedule, cost, and quality of any project, regardless of size, complexity, or industry, can be managed through the systematic organization of project activities, resources, analysis, and controls. In so doing, DOTs can integrate design, construction, finance, and environmental tasks across functions and work units.

APPROACH

The best practices research involved a three-pronged approach. First, the research team conducted a literature review of project management best practices. Next, the team conducted a review of internal DOT documents. Then it conducted a best practices survey. Each is discussed below:

- **Literature review.** As a first step in identifying best practices in project management, the research team conducted a literature review encompassing the Internet, books, professional journals, and other published sources on project management theories and applications.

- **Review of internal DOT documents.** The research team reviewed a wide range of documents including training and procedures manuals, requests for proposals, bidding documents, contracts, capital program reports, software documentation, and other working documents pertaining to other DOTs' project management practices. Documents from 19 DOTs were reviewed.

- **Best practices survey.** The research team conducted a survey of state DOTs, one special purpose local government entity, and two private sector firms. State DOTs thought to represent best practices were selected to take part. These selections were made on the basis of suggestions from the ADOT Technical Advisory Committee as well as Dye Management Group, Inc.'s knowledge of the practice among state DOTs and other transportation agencies. Representatives of the selected DOTs were contacted by ADOT Deputy State Engineer Sam Maroufkhani by e-mail formally requesting the individual's participation and providing a copy of the survey instrument (Appendix C). The research team followed up by arranging and conducting

one-hour phone interviews. Representatives of the following organizations were interviewed:

– Massachusetts Highways

– Minnesota Department of Transportation

– Michigan Department of Transportation

– New Jersey Department of Transportation

– New Mexico State Highway and Transportation Department

– Utah Department of Transportation

– Washington State Department of Transportation

In addition, the research team interviewed representatives of Bechtel and Fluor Daniel.

The survey of state DOTs aimed at finding out how they are addressing project management and discerning best practices. State DOTs thought to represent benchmarking values in best practices were selected to take part. These selections were made on the basis of suggestions from the ADOT Technical Advisory Committee as well as Dye Management Group, Inc.'s knowledge of the practice among state DOTs and other transportation agencies. The research team worked with program management staff and other administrators within each DOT to determine the most appropriate person to represent the organization's project management practices. Once that person had been identified, ADOT Deputy State Engineer Sam Maroufkhani issued an e-mail formally requesting the individual's participation and providing a copy of the survey instrument. The research team followed up by arranging and conducting one-hour phone interviews, which were carried out by a two-person team, with one person leading the interview and the other person taking notes. More detailed discussions of these benchmarking state practices can be found in Appendix C.

Bechtel and Fluor Daniel were two private firms the research team contacted because of their long histories of transportation infrastructure.

Findings

The findings of this best practices survey are organized around three categories: (1) key characteristics of project-oriented entities; (2) critical support systems; and (3) best practices in project management.

LITERATURE REVIEW

Introduction

This section documents the results of a literature review conducted as part of the Arizona Department of Transportation's effort to identify industry best practices. The project management practices of organizations including state departments of transportation, federal agencies, local governments, and private sector firms as documented in a wide range of material available on the Internet, in books, and in professional journals are considered. The References section at the end of the report provide the bibliography.

Project management is a discipline with well established principles that have been applied for decades by the private sector in industries that range from construction, contracting, and pharmaceuticals to consumer durables. Increasingly, though, public sector infrastructure providers are turning to project management—not only as a tool for discrete pieces of work—but also as an overarching, enterprise-wide strategy more aptly described as "management by project." More than any other entity or level of government, the federal government sets transportation funding levels and policy, and the federal government has become increasingly conscious of failed or faulty major infrastructure projects. This awareness is behind several recent efforts to improve public sector accountability, including requiring financial plans for transportation "mega-projects." The United States General Accounting Office's (GAO) past work has identified a variety of federal capital projects where acquisitions have yielded poor results—costing more than anticipated, falling behind schedule, and failing to fully meet mission needs and goals. Whether it is pursued as management by project or strengthening of an agency's project management culture and practices, public sector executives are looking to project management as a line of sight to show how unit and individual performance can contribute to overall organizational goals and help them understand the connection between daily activities and the organization's success (4). Ultimately, project management is coming to be seen as the most effective means of deploying scarce public resources to provide critical facilities and services—amid fierce public scrutiny (9).

What is a Project?

Broadly speaking, "projects" can be distinguished from operations in that that they are temporary in nature; that is, they have discernible starting and ending points; and they are aimed at creating a unique product or service (4). Project management entails the skills, knowledge, and tools needed to plan, execute, monitor, control, and—ultimately—successfully deliver such individual projects. The project manager's challenge is to balance competing demands for scope, time, budget resources, and quality in an environment over which s/he has less than total control.

<u>Organization</u>

The first part of this literature review considers the characteristics of project-oriented organizations, whereas the second part considers best practices in project management with reference to the planning and execution as well as the control of scope, schedule, budget, and quality.

Characteristics of a Project-Oriented Organization

The following conditions are drawn from the literature review.

<u>Executive Leadership</u>

Executive leadership is a prerequisite in establishing and maintaining a project management culture insofar as effecting change generally requires linkage with the agency's strategic plan, new forms of performance measurement and appraisal, new reporting or functional relationships, and tough resource allocation decisions (10).

Senior executives' growing interest in managing by project is related to the pressures that they are facing to be accountable for delivering the overall programs of projects and services. Forced by legislatures and political competition, governors and their appointees now find transportation at the top of state-wide agendas, along with education and healthcare. This is reflected in the relatively recent adoption of outcome-based performance and compensation systems among senior public sector executives. Delivery has come to mean ongoing appraisals of measurable outcomes including levels of service and cost-value certifications (11).

<u>Accountability</u>

Effective management by project means that the organization's project management policies, procedures, and performance measurements flow directly from the organization's strategic plan (12). Moreover, projects and their expected outcomes are linked with unit and individual employee goals and objectives. Overarching goals for the project, business unit, and organization are translated to individual groups and managers and the results are fed back up the line (4).

Project management, while focused on the individual project, is a critical building block in state-wide capital programming (12). The ability to plan and control cost and project delivery at the individual level has "roll-up" benefits at the capital program level, which entails the following functions:

- Seeking the most efficient means of utilizing available budget allocation funding and workforce resources provided by the Legislature and others.

- Prioritizing projects in a timely fashion.

- Integrating, coordinating, communicating, and simultaneously controlling multiple projects.

- Monitoring and reporting of progress and results to executives and customers (13).

Organizational Structure

An organization's project management culture is reflected in how well it organizes its project and functional management. Organizational structures span a spectrum from functional to projectized, with a variety of matrix structures in between (4). The weakest project management emphasis is found in functional organizations, which do not treat project management as an integrative process that brings together the various disciplines required by complex engineering projects (e.g., highways, structures, right-of-way, and utilities relocation). Rather, functional organizations' staff members are grouped by specialty and report through a functional chain of command. The classic functional organization is a hierarchy where each employer has one clear supervisor. Although functional organizations still have projects, the scope of a given function's project is limited to the boundaries of the function. Where an organization is managed by function, each function performs its work independently. In this model, one functional group "hands over" its work to the next functional department, usually in a linear, predetermined sequence with little or no concurrent work.

Management by project is found in "projectized" organizations, which define the other end of the spectrum. Team members drawn from diverse functions are often collocated so they can work together in projectized organizations. Most of the organization's resources go to project work, and project managers have a great deal of independence and authority. Projectized organizations often have organizational units called departments, but these groups either report directly to the project manager, or provide support services to the various projects (4).

Few organizations are fully functional or fully projectized. Most fall somewhere in between, and variations on the "matrix" theme capture the many shades of gray. In weak matrices, which contain many of the characteristics of a functional organization, the project manager role is more of a coordinator or expediter than manager. In similar fashion, strong matrices have many characteristics in common with the projectized organization—full time project managers with considerable authority and full time project administrative staff (14). Arizona DOT has described itself as having a weak matrix structure for project management, a characterization borne out by the consultant team in its interviews with ADOT management and staff. The functional approach is contrasted with the projectized approach in Table 7.

Table 7: Functional Project Management vs. Projectized Management

Functional Approach (Traditional)	Weak Matrix — Strong Matrix	Projectized Approach (Emerging)
• A hierarchy where each employee has one clear superior. • Staff members are grouped by specialty (e.g., pavement, structures, environmental, ROW). • While functional organizations have projects, the perceived scope of the project is limited to the boundaries of the function; that is, different departments do their work independently of one another. • Function responsible for the task. • Hand-off of project between functions. • Procedures are familiar and established. • Work teams well established. • One or few disciplines.	• Matrix organizations are a blend of functional and projectized characteristics. • Weak matrices maintain many of the characteristics of a functional organization, and strong matrices have many characteristics of a projectized organization. • Personnel are tapped for their expertise as needed throughout the project. • Project managers communicate project needs to functional managers, who assign appropriate personnel. • Team members may also work with other project managers to whom they have been assigned for other projects.	• Team members are often collocated. • Most of the organization's resources go to project work. • Project managers have a lot of independence and authority. • May have departments, but these groups either report directly to the project manager or provide support services to the project managers. • Single project manager for project. • Full life-cycle management. • One-time, unique, challenging. • Each process is new. • New people, new teams. • Multi-disciplinary.

The most authoritative source on project management, the Project Management Institute, does not advocate one form of organizational structure over another (4). Rather, it observes that organizational form is influenced by the maturity of the organization with respect to its project management systems, culture, and style. This observation reflects back to the earlier assertion that management by project requires the active endorsement of senior leadership insofar as this is the level at which systems, culture, and style are set.

Organization, Roles, and Responsibilities in a Project-Oriented Entity

Clearly, any kind of a matrix organization which has multiple functions must spell out each team member's role, authority, and responsibility (15). In some public agencies, such relationships are spelled out in a manual and remain standardized by project type or phase (4). In other organizations, custom-made "work plans" are developed case by case. Nonetheless, even in strong matrix organizations, it is important that the project manager emphasize his or her role in facilitating and coordinating the work of various groups, as well as identifying for management any critical conflicts or issues (16).

In addition to managing deliverables, the project manager (PM) serves a broader purpose within the organization by:

- Considering the project at hand in relation to the organization's overall needs and expectations.

- Building alignment among stakeholders around the project vision.

- Developing a strategy to deliver on that vision (14).

The role of the project manager depends on the organization's starting and ending point for a "project." Some projects may be cradle to grave, in which the same project manager is assigned at pre-design, and works from design to construction. It is much more common among departments of transportation for a project manager to be given a project at the predesign or design stage and then carry it through advertisement (at which point it usually becomes a separate construction project). The more "projectized" the organization, the more comprehensive is the project manager's involvement in the project (e.g., predesign through construction) (17). Whereas the project manager retains primary responsibility for coordination, the functional manager, who serves as technical expert, is relied upon for product quality.

In addition to the project manager and the functional manager, project teams generally involve staff as well. The respective roles of these players by project phase are summarized in Table 8 (10).

Project Management Practices in a Project-Oriented Entity

The conclusions from the literature review regarding scope, schedule, budget, and quality management are discussed in turn.

<u>Scope Management</u>

Succinctly stated, the project scope sets forth all of the work required to complete a given set of objectives, and only the work required (4). The scope defines the boundaries of what the project does and does not include. The rest of the project manager's tools—work breakdown structure, schedule, and budget—all derive from scope. The benefits of a carefully developed scope include the following:

- A higher probability of ultimate project success—however measured.

- Optimization of cost and schedule.

- Reduced risk during execution.

- An end project that meets customer expectations.

- Improved team alignment (14).

Table 8: Respective Roles of Project Manager, Functional Manager, and Project Team on a Project-Oriented Entity

	Project Manager	Functional Manager	Project Team
Project Initiation	• Identifies needs and expectations of project sponsors.	• Determines how and by whom technical work will be done.	
Project Planning	• Leads project team in developing a management plan that defines scope, schedule, cost, resource needs, risk, and communication needs. • Ensures that the PMP includes all work required, and only the work required, to produce the project.	• Assigns task members when requested by PM or task manager. • Assigns equitable workload to individual employees.	• Provides input into development of PMP.
Project Execution		• Directs project team members in product delivery within agreed time frame. • Develops qualified staff. • Empowers staff to do jobs with minimum supervision. • Provides technical and procedural direction. • Approves staff and other project expenditures.	• Delivers products within the time frame of the PMP. • Executes changes as directed. • Works together as a team. • Monitors work package production and progress.
Project Control	• Monitors project progress, taking corrective action. • Communicates sensitive issues and project progress to district management, the sponsors, and project team. • Inputs into the performance evaluation of project team members and recommends changes to the project team membership when needed. • Serves as single point of contact on matters involving overall scope, cost, or schedule. • Resolves problems affecting scope, cost, or schedule. • Controls change to the project scope, cost, or schedule throughout the project life cycle.	• Ensures that staff has right skills. • Ensures products comply with all standards, regulations, and policies. • Ensures that products have required features. • Focuses on intermediate products: reports, environmental documents, plans, specs, estimates, appraisal reports, title deeds, permits, bid docs, and as built plans. • Monitors and provides feedback to staff.	• Communicates sensitive issues and project progress to task managers. • Controls at the activity level.

	Project Manager	Functional Manager	Project Team
	• Manages the interface between task managers, ensuring that they know who will receive and use their products. • Coordinates overall team efforts, including chairing project team meetings. • Controls the project budget (support and capital).		
Project Closure	• Accepts responsibility for timely project completion. • Ensures that final work product meets needs of customers. • Discusses final product with sponsors to gauge their level of satisfaction. • Makes a final report on the project, with recommendations for improvement. • Provides feedback to team on lessons learned.	• Closes.	• Provides feedback to functional managers on how work can be done more efficiently.

The need for strong scope development is reflected in the consensus among engineers and contractors that "any decision made at the beginning stage of a project life cycle has far greater influence than those made at later stages" (17). This axiom is illustrated in Figure 2.
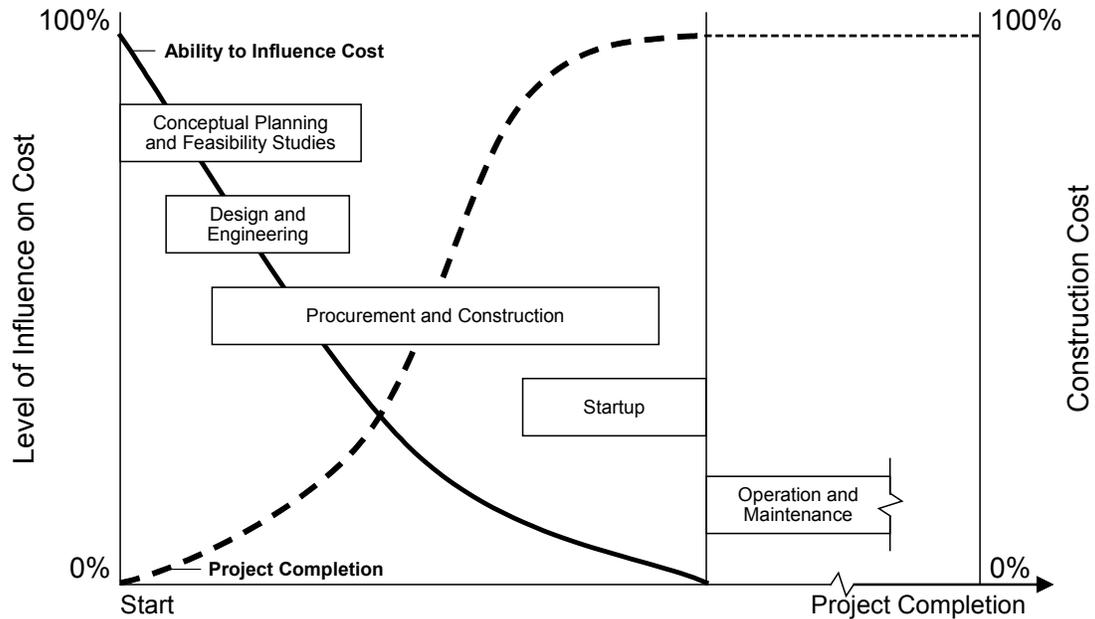
Figure 2: Opportunities to Influence Construction Cost are much Higher at Scoping and Predesign than in later Project Phases

Scoping and scope development standards vary among state departments of transportation. The New Jersey Department of Transportation, for instance, defines project scope as "the necessary activities to bring the project from Concept Development to a level of engineering detail necessary to support the environmental documents (approximately 15-25% of design)" (18). At the Oregon Department of Transportation (19), the following elements must be covered in every scope report:

- Clear problem statement.

- Clear scope including all project elements.

- Estimate of preliminary engineering, construction engineers, and Right-of-Way (ROW) costs.

- Design exceptions anticipated.

- Agreements required.

- ROW requirements.

- Environmental Scope.

- Utilities and permits.

- Unique Elements.

A project may be scoped without the input of the project manager ultimately responsible for its execution. It is not uncommon for project development staff to develop a scope at pre-design to hand over to a project manager at design, and for the "scope" to be translated into a contract at construction, with or without the design manager's participation. However, recent successes using the design/build delivery model, along with experiences from agencies with strong matrix structures, have demonstrated the value that can be achieved by having one project manager serve from "cradle to grave." The benefits of including the project manager at pre-design include commitment and buy-in; whereas the continuity through construction allows for the integration of lessons learned in construction to be carried through to the next design project (20).

The scope planning process followed by the Oregon Department of Transportation is illustrated in Figure 3.
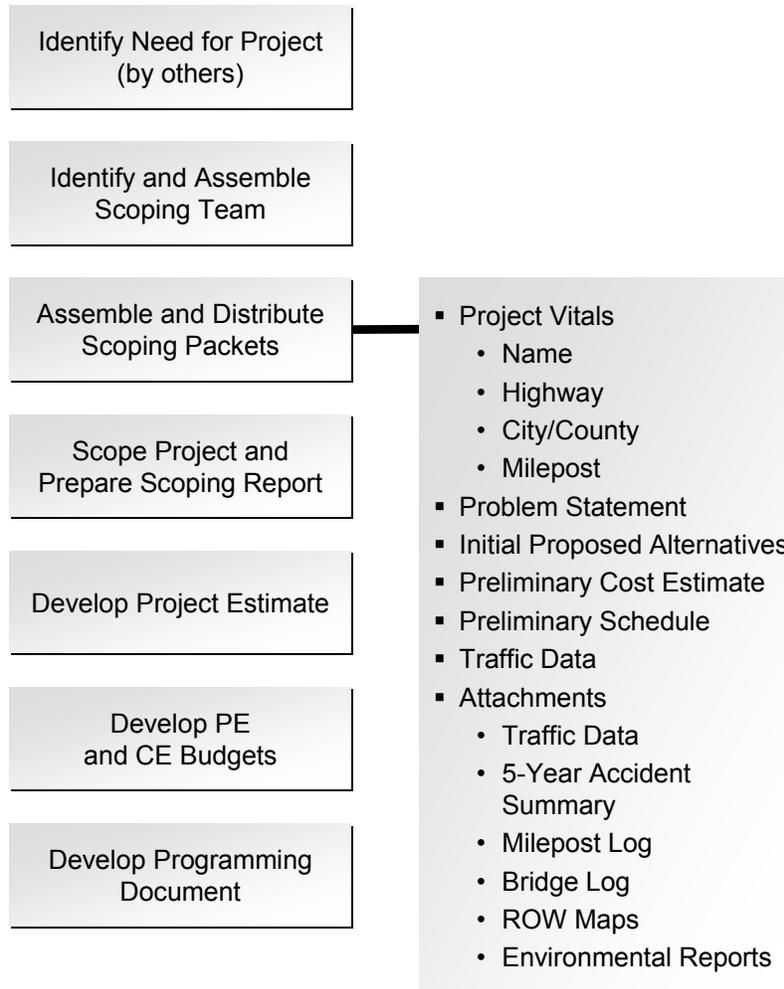
Figure 3: Example of Detail Required for Scope Management

Scope management entails three primary tasks:

- Scope verification.

- Scope change control.

- Scope change management.

<u>Scope verification</u>

Scope verification makes sure project deliverables and other work products fall within the scope parameters. Scope verification should be done on an ongoing basis to ensure that that all work necessary on a given project is being carried out. To verify scope, the project manager may scrutinize project designs, reports, and other project documentation as they are produced, as well as conduct field inspections, audits, or other measurements (4).

In matrix or fully projectized organizations, project managers are responsible for scope verification, whether they perform it firsthand or delegate it to a functional team member or an independent consultant. In the construction phase, scope verification may be performed by field inspectors, owners' engineers, or project managers or functional managers directly. Ongoing scope verification is also important as a tool in monitoring and controlling project schedule and budget.

Scope change control

Pressure for scope change may arise from multiple sources, including changes in the external environment, value added, or correction of missing project or process elements (errors and omissions) (4). When elements, capacity, or design features beyond those identified in the original scope are added, negative schedule and budget impacts are virtually unavoidable. As such, best practices in project management include procedures for scope change prevention or control.

Project scope changes (number and magnitude) can be averted through:

- Carefully attending to initial scope development—including preparation and review of project purpose and objectives, right of way and utility relocation requirements, and work breakdown structure.

- Verifying scope on a frequent and ongoing basis.

- Making sure that all team members and customers "buy into" the scope from the outset. This can be achieved through techniques such as chartering, wherein the team is guided through the process of defining and agreeing upon the project scope, the team's role, responsibilities, and authority and means of resolving conflict.

- Ensuring that the organization has a means of anticipating sources and impacts of scope change through the collection and dissemination of "lessons learned" from previous projects.

Scope controls include the paperwork, tracking systems, and approval levels necessary to authorize scope changes and additional resources. Best practices in scope control center on consistency. Where scope change controls are applied and documented consistently, organizations can develop powerful tools with which to predict subsequent budget and schedule impacts of given scope changes. Project managers can then identify alternative courses of action and tradeoffs (4). This capability allows senior executives to make better informed decisions about when and how to permit scope change.

Agencies may use different forms of scope control based on the reason for the added scope (e.g., higher or different standards for scope additions that are the result of errors or omissions) and its magnitude. Examples of scope change control include the requirement that scope change at a given threshold be justified before a review board, or district authority in order for additional payment or work authorization to be released.

Schedule Management

In order to establish a useful schedule, the project manager must have a clear understanding of the minimum work necessary to meet the core needs to which the project is addressed. In schedule development, the project manager must work closely with functional managers whose staff will complete the technical work required. The better the quality and completeness of the underlying scope, the better the project manager will be able to develop an efficient, realistic schedule. It is vital that the project manager understand the range and priority of performance measures on which the project will be judged (e.g., reducing traffic impacts, achieving safety improvements, etc.). Other factors that need to be considered in developing a schedule include human resource factors and logistical factors.

Human resources factors

These include:

- **Staff capabilities.** The project manager, in conjunction with the functional managers, looks at the capabilities of the various team members assigned to the project in order to determine what it would reasonably take them to do the work, and how much management time is necessary to oversee their work (14).

- **Experience on similar past projects.** The project manager and functional managers should look at past projects to determine the time necessary to complete similar tasks. They pay particular attention to schedule and budget overruns to account for these risks in the current project.

- **Other projects.** Because projects are worked on simultaneously, the project manager and the functional manager need to look at all projects on which team members are working (21).

Logistical factors

- Need to produce project within the state-wide transportation improvement program (STIP) year.

- Need to produce project early enough to meet construction season.

In addition to providing appropriate schedule contingencies by task, best practices in schedule management include building in time for reviews, project documentation, quality management, and project closeout.

Schedule control

Schedule control is concerned with:

- Influencing the factors that create schedule changes to ensure that changes are agreed upon.

- Determining that the schedule has changed.

- Managing the actual changes as they occur.

Tools for identifying and correcting issues in schedule control are summarized in Table 9.

Table 9: Tools for Identifying and Correcting Schedule Problems

Tools for Identifying Schedule Problems	Tools for Correcting Schedule Problems
Schedule Change Control System defines the procedures by which project schedule may be changed. Includes the paperwork, tracking systems, and approvals necessary for authorizing changes. **Project management software** tracks planned dates versus actual dates and forecasts the effects of real or potential schedule changes. **Performance Measurement techniques**, such as performance review meetings, help to asses the magnitude of any variations that occur. **Variance Analysis** compares target dates with the actual/forecast start and finish dates to provide useful information for the detection of deviations and the implementation of corrective solutions. Float variance is also an essential planning component to evaluate project time performance. Best practices in this area include distinguishing between critical and sub-critical activities. For instance, a major delay on a noncritical activity may have little effect o the project overall, while a shorter delay on a critical activity may require immediate action. **Trend Analysis** involves examining project results over time to determine whether project management performance is improving or deteriorating. **Earned Value Analysis** integrates scope, cost, and schedule measures to help the project management team assess project performance (more on this in the "Budget" section.	**Schedule Updates** are any modifications to the schedule information that is used to manage the project. Schedule updates may or may not require adjustments to other aspects of the plan. **Corrective Action** is anything done to bring expected future scheduling performance in line with the project plan. Corrective action in the area of schedule management often involves expediting special actions taken to ensure completion of an activity on time or with the least possible delay. Corrective action often requires root cause analysis to identify the cause of the variation. The schedule recovery can be planned and executed for activities delineated later in the schedule. **Integration of Lessons Learned into Future Projects** studies the causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from schedule control. These are documented so that they become part of the historical database for other projects. One means of eliciting and documenting lessons learned is to conduct post-project reviews.

Source: Project Management Body of Knowledge

Budget Management

Budget management is discussed in terms of Budget Planning and Budget Control.

Planning

Best practices in budget planning are rooted in the development of a properly decomposed Work Breakdown Schedule (WBS). Many organizations start the process of developing a WBS with an automated template, which can save project manager's time (depending on the amount of customization needed) and reduce the risk of omitting work elements (4). Flowing from the scope of work, the WBS is the point of project development at which the scope is broken into manageable activities (17). In a sense, the WBS is a more fully fleshed out scope of work. In breaking down the work elements implied by a project scope, the first step is a "high level" WBS, which typically defines groupings of products or services to be delivered. Specific products and services are then broken out as the hierarchy is decomposed. Critical work elements, or those entailing substantial risk, may be broken down to a lower level in order to manage them more closely. From the WBS flow other steps in the budget planning process, including assessment of resources required (by type and quantity), and cost estimates. Ultimately, the budget baseline is established, which involves allocating the overall cost estimates to individual activities or work packages. Throughout the budget planning process, in addition to automated templates or systems, project managers may rely on historical information from within the agency or from a peer, and from individuals who have worked on similar projects.

Control

Project budget control entails four primary functions:

- Prevention of incorrect or unauthorized charges to the budget.

- Prevention of unauthorized changes in the project baseline.

- Ensuring that all appropriate changes are accurately recorded in the cost baseline.

- Providing corrective action to bring expected costs within acceptable limits.

A powerful tool in monitoring the project budget, as well as the schedule and scope, is Earned Value Analysis, which relates the percentage of work actually completed at a point in time to both budget and schedule baselines (22). Earned Value focuses on two elements: the authorized work that has been completed and the original budget authorized to perform the completed work (22). Earned Value Analysis is most effective when it is tracked frequently and consistently, which requires accurate, timely data on all project charges as well as the percentage of work completed by task and subtask (23). While some state departments of transportation track internal labor charges, many do not, which makes it difficult to determine the true cost of delivering projects.

Best practices in project management require scrutiny of both negative and positive variances from the budget baseline. A positive cost variance may mean that unauthorized charges are being incurred, that the cost estimate was too low for the WBS, that work is taking longer than it should, or that scope creep is going unchecked. A negative cost variance, on the other hand, may indicate that needed work is not being carried out or that charges are not being recorded accurately. Depending on the results of the Earned Value Analysis, the project manager may be required to revise the budget baseline—including a new Estimate at Completion, which may require additional approval processes and authorizations.

Quality

While quality is a somewhat elusive concept, public agencies and the consultants they employ have begun to plan and execute quality programs that define desired quality outcomes and set forth quality processes for achieving those outcomes. An organization's concept of quality will be rooted—as are the entire key bases upon which it makes decisions and prioritizes products and services—in the organization's mission and strategic plan (24).

A way of simplifying the notion of quality is to define it as a given product's ability to stratify the purpose for which it was established. Indeed, this is the American Society of Civil Engineering's point of view, which states that quality is "the totality of features, attributes and characteristics of a facility, project, process, component, service or workmanship that bear on its ability to satisfy a given need."

Among state departments of transportation there are a wide range of quality definitions, programs, and perceptions of responsibility (25). In some organizations, the design consultant is expected to propose project-specific quality plans that set forth communications, documentation, review, and approval processes. Some standardization in private engineering firms' approaches to quality has emerged as a result of competitive pressure to achieve ISO 9000 certification (24), which some public agencies have also pursued (26).

Even where consultant teams set forth and execute their own quality plans, it is public sector organizations that are ultimately responsible for the quality of the product or services supplied to the end customer. Here it is important to note the centrality of the functional manager in the matrix organization (14). The functional manager determines how and by whom technical work will be done or overseen, provides technical and procedural direction, and ensures that all products within his or her function meet all required standards, regulations, and policies—including those related to quality. The focus of quality performance review varies widely among state departments of transportation. They include methods such as formal design reviews, audits, and inspection (25) (21).

BEST PRACTICES RESEARCH

The results of a survey of state departments of transportation, which focused on innovative project management strategies deployed by state DOTs with reputations for effective project management, are presented in this section. DOTs nationwide have approached and applied the principles of project management in very different ways, with differing results and lessons learned. The following is a survey of best practices in project management, emphasizing the state DOT experience.

The research team heard repeated references to two key characteristics of successful management by project: (1) executive leadership; and (2) the existence of a "project management culture."[5]

Executive Leadership

Transportation commissioners, governors, and legislators nationwide are demanding sturdier, more transparent, empirically-based means of holding state DOTs accountable. According to Jim Weingartz, of the Minnesota Department of Transportation, "Executive leadership is the most important factor. Our top bosses have funded project management training and initiatives and that is what makes the difference, along with their emphasis on putting measurements into place. It's to their benefit, since they will ultimately be accountable for project and program results at the enterprise level."[6]

Management by project requires enterprise-level resource allocation—piecemeal implementation is not feasible.

The essence of project management is the integration of goals, efforts, and data across disciplines and departments. Insofar as the delivery of a new interchange, for example, typically requires the coordination of structural engineers, pavement designers, hydrologists, geologists, archaeologists, environmental planners, consultants, contractors, and construction managers, piecemeal project management would be awkward and probably unworkable. The enterprise-wide resources required to establish or refine data and project management tools require executive-level sponsorship. Moreover, insofar as a shift to management by project entails new or different relationships among work groups and individuals, executive leadership is critical in encouraging forward thinking and overcoming resistance.

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[5] Dye Management Group, Inc. considers these characteristics to be necessary but insufficient conditions for the development of effective management by project. Other necessary conditions include levels of accountability that cascade through the organization; ongoing training and development; and timely, accurate, functionally integrated data collection and reporting tools. In any case, executive leadership and project management culture merit special attention.

[6] Scheduled telephone interview conducted by Dye Management Group, Inc.

The cumulative results of project management are better program and enterprise-level planning and control.

While the foundation of management by project is at the individual project (or even project manager) level, the cumulative results of project management, whether measured in terms of cost, time, or delivery, are easily rolled up to subprogram and program levels. Overarching goals for the project, business unit, and organization can be translated to individual groups and managers and these results fed back up the line. By the same token, management by project allows resource allocations to be unrolled to programs, subprograms, and projects according to strategic plan goals and objectives. Ultimately, management by project can be traced to the individual project manager's level, as in Michigan, where project managers' performance appraisal criteria are based on measurable outcomes of the projects for which they are responsible.

Project Management Culture

While senior executives in state DOTs can make project management an integral part of their agencies' strategic plans, and support it through resource allocations and communications, evolution of a project management "culture" tends to be more gradual. State DOTs that have been effective in fostering cultures of project management have observed and have had to overcome several sets of tensions or conflicts.

Project Manager vs. Functional Manager.

The balance of accountability and authority between functional managers and project managers is the single biggest issue in management by project in state departments of transportation. Under "traditional" means of project delivery, functional managers in DOTs (analogous to ADOT's technical managers) were the single authorities on these aspects of project development for which they were directly responsible. In contrast, under management by project, they are members of a team, whose individual interests must be tempered by overall project needs. Moreover, their efforts are monitored and, to various degrees, constrained by a project manager. As such, management by project entails some losses in autonomy and control for functional managers, not all of whom are convinced of its benefits.

Adaptation of "Bottom Line" Considerations.

Emphasis on cost containment and efficiency across a given project's functional areas is another important difference between traditional DOT practices and the trend toward management by project. Incidentally, this cost efficiency emphasis is also reflected in new means of contracting, including design-build and lump sum agreements.

Generational Issues.

Survey respondents reported that some engineers have resisted learning and applying new project management skills and techniques (e.g., critical path scheduling, new software,

etc.). Currency in these skills appears to be less of an issue for newly minted engineers whose college programs and early training require extensive computer use.

Degree of Centralization.

Another factor that figures into the development of a project management culture is the DOT's degree of centralization. Increasingly, states like Michigan and Utah are working to decentralize project management. In Michigan, projects will be managed within each of the state's 26 Transportation Service Centers. In some states, it is not uncommon for attempts by headquarters to foster organizational change to be seen as an intrusion on regional resources, turf, and autonomy. Decentralization of the project management function is seen as a means of better aligning local resources, priorities, and accountability. While executive leadership at the state-wide level communicates the value of management by project and provides the resources to put it into practice, regions or other subdivisions should have latitude in prioritizing and executing their projects if a project management culture is to be properly established.

Overcoming the obstacles to establishing a project management culture is a gradual process.

Several DOTs interviewed for this effort (including Michigan's, Minnesota's, and Utah's) reported that the establishment of a project management culture has not been without struggle, and that if their experiences are any indication, a certain amount of time (and retirements) may have to come to pass before the new culture can take hold.

Indicators of a Project-Management Culture.

According to survey respondents, indicators of a growing project management culture include the following:

- Project management data are supplied and updated consistently.

- Project management tools are widely used for their intended purposes.

- Project management is perceived as one of the organization's most attractive career paths—one to which the agency's "best and brightest" aspire (Fred Doehring, Utah Department of Transportation).

Supporting Systems

How state DOTs manage their human resources and information technology are key determinants of the extent to which they are able to establish and develop effective project management practices. For this reason, it is important to understand the role of these supporting systems in DOTs' project management efforts.

Human Resource Management

Aligning human resource functions with enterprise-level project management objectives is important in several respects. First, it is important that the job classifications for project management positions are attractive and competitive in terms of pay, grade, and development opportunities – both within the DOT and outside of it. Second, it is important that performance appraisal criteria be tied to the organization's strategic goals. In fact, tying project outcomes to performance assessment is the ultimate means of linking individual accountability up through the organization. Described herein are some of the human resource management issues with which state DOTs are grappling in terms of project management:

The growing emphasis on management by project is driven in part by DOTs' need to address losses of experienced employees to retirement.

The drive to organize around project management is partly due to transportation agencies across the country facing waves of retirement. Unless the decades of project management expertise residing in the minds of retiring engineers can be institutionalized—through reorganization, education, and technology investment—DOTs will be hard pressed to deliver their programs. Stable or falling civil engineering enrollments, combined with private sector competition for talent, exacerbate the crunch. Survey results indicate that project managers for state DOTs are not actively recruited from private industry or other agencies; rather, they are developed and promoted from within. "We are facing an aging workforce. Having lost so many FTEs to retirement in the past ten years, we are now trying to make up. It almost seems like nobody under 30 works here. That's a problem." Tom DiPaolo, Assistant State Engineer, Massachusetts Highways[7]. The consolidation of decades of project management expertise before a critical mass of experienced engineers retires is a first step in the institutionalization of their knowledge. The second step is the standardization of that expertise into policies and procedures that can be applied to projects Department-wide. The third step is the dissemination of that expertise to new project managers through training. In this fashion, the rationalization of project management can compensate for retirement losses.

Project management requires a broad skill set, including budget control and team leadership.

There is a shared sense that DOTs need to reflect the importance of project managers by training, paying, and developing them well. In DOTs that strive for strong project management, the perception is that the organization's "best and brightest" aspire to positions as project managers, and are seen as professionals with a broader and more business-oriented skill set. Project managers are the ones who are interested in the complexities of project delivery—they understand not only the engineering, but also finance. They figure out how to lead diverse teams toward a common goal—even if they don't have much direct authority. It is notable that private sector firms (to whom DOTs

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[7] Scheduled telephone interview conducted by Dye Management Group, Inc.

sometimes lose project managers) offer separate development programs for project managers and technical experts, although both are considered critical to the bottom line.

State DOTs strongly prefer project managers with engineering and/or construction experience.

Although project managers need a broader skill set than engineers who work within functional areas on discrete, separable aspects of complex projects, the consensus among the DOTs surveyed is twofold: (1) technical expertise in either design or construction is strongly preferred if not required; and (2) project managers need to make their way up through the ranks by working on DOT projects. While some DOTs, including Utah's, employ non-engineers as project managers, their career prospects are limited insofar as professional engineering registration remains a hallmark among upwardly mobile engineers in both public and private sectors.

Few DOTs have tailored job classifications or performance appraisal criteria to the project manager function.

To date, state DOTs appear to have focused their efforts on establishing project management practices, processes and information systems—without specific consideration of whether and how project managers should be separately classified and developed. In fact, a logical next step for most states in the evolution of their project management practices would be to review position descriptions, responsibilities, and performance expectations for project managers, functional managers, and staff to ensure that position descriptions, performance plans, and appraisal criteria reflect their roles in a project-oriented enterprise.

"Creating a project manager career track and continuing project management education will support and enhance the position of the project manager within the organization, and will hopefully help get and retain the best project managers. To facilitate these efforts, a strong visible project office with support from upper management must be developed and maintained." (Gerry Rohrbach, director of the Minnesota Department of Transportation's Office of Technical Support at a meeting of the Midwest DOT Project Management Consortium, Lincoln, NE, October 4-5, 2000).

Examples of DOTs That Have Tailored Job Classifications or Performance Appraisal Criteria.

Minnesota is currently considering creation of a new job class, Administrative Engineer, above Principal Engineer, which would reflect the project manager's broader responsibilities. Meanwhile, the Michigan DOT rewards effective project managers (and other employees) with performance-based merit raises. The criteria used to determine these project managers' raises are directly tied to the outcomes of their projects. Washington State Department of Transportation offers a formal mentoring program and structured opportunities to rotate among functional areas as part of its project manager's development program.

Although there is room to grow in terms of articulating and encouraging project management career options, all of the states surveyed offer project management training, and most provide project management reference materials. There is consensus that project management training should reflect the broad range of the PM's duties, including all of the following elements:

- General project development and management training (e.g., as set forth by the Project Management Institute in its *Guide to the Project Management Body of Knowledge* (4)).

- Training in internal project management procedures, administration, and information systems.

- "Soft" skills, such as team building, negotiating, supervisory skills, and leadership development.

Information Technology

Given the size and magnitude of DOTs, whether measured in terms of capital budgets, operating budgets, geographic reach, or numbers of employees, effective information technology is critical. It is needed by project managers, who need the capacity to monitor hundreds, if not thousands, of tasks across multi-million dollar projects. It is also needed by program managers who must juggle multiple projects and needs within constrained funding while ensuring that the overall program is delivered as promised. Described in this section are information technology issues faced by state DOTs along with featured capabilities of one particularly effective system.

State DOTs are struggling to develop systems with the right functionality that are also user-friendly.

Carefully designed and consistently applied information technology can be a powerful support to project and program managers. However, according to DOT respondents, the implementation of project management technology has been an iterative process punctuated by false starts and ongoing debugging and refinement. Among the issues commonly faced are the following: (1) developing programs for which data input requirements are not onerous or redundant; (2) developing programs that yield useful information appropriate for audiences at various levels [e.g., task manager up to executive]; (3) getting project managers, functional managers, and staff to both input data in timely fashion and to use the software as intended. An informal but telling indicator of a system's quality is that the organization's most effective project managers exploit its capacities as a management tool. Relatively non-functional systems, in contrast, are distinctive in that top project managers devise elaborate "work arounds."

State DOTs use a wide variety of off-the-shelf and custom-made software to manage their projects and programs.

This finding is supported by the Midwest DOT Project Management Consortium, whose own survey revealed that "Software tools are across the board" (Midwest Department of Transportation Project Management Consortium, May 6-9, 1999, Milwaukee, Wisconsin). Several respondents stressed the importance of developing software as a means of supporting an existing, viable project management system—rather than assuming that a system should drive project management. Several DOTs, including Minnesota, New Mexico, Michigan, and Utah use systems with the same acronym, PPMS, but with widely varying functionality. Primavera, Microsoft Project, and AASHTO-developed software all have their adherents.

Utah's is an example of a state DOT that has effectively harnessed information technology to plan, coordinate, and control labor, time, and other resources at the project level. UDOT's Preconstruction Project Management Systems (PPMS), a custom-developed system, allows the agency to consolidate project-level data to the enterprise level, which in turn allows program managers to monitor and control resources such as funding, cash, and manpower. It is notable that this system is seen to be functionally effective despite complaints from some users about its technical "clunkiness" and perceived user-unfriendliness.

The data accrued through UDOT's PPMS is used in analyses to establish work standards, to evaluate labor requirements, and to perform multi-project resource loading to evaluate the "deliverability" of the capital program. These program management capabilities make it a valuable tool for senior executives as well as project managers. Selected PPMS capabilities are summarized in Appendix C.

Project Control

Reports such as those produced by UDOT's PPMS are used not only by project and functional managers, but also at program and enterprise levels. The Washington State DOT, which uses a project management system with analogous functionality, has also developed a Capital Program Management System (CPMS), which automates the roll up of project-level data to the enterprise level. Given that WSDOT's programming process requires that every project cost increase be offset by a commensurate decrease in some other project, the ability to monitor and control expenditures at the program level is very important. The PPMS allows program managers to "seek the most efficient means of utilizing the available funding and workforce resources provided by the Legislature, and others, to construct the projects that preserve and improve the state highway system." Program management staff at WSDOT headquarters run nightly reports that record and monitor any changes to project scope, cost, improvement type, project duration or construction season.

The CPMS compares these changes against threshold criteria. Any changes that break preset thresholds are flagged. The results of this analysis are reported in the "Nightly News" for monitoring and action by program management staff.

Threshold breaks are categorized on the following scale:

- Informational

- Minor

- Moderate

- Significant

- Major

While "informational" breaks trigger no specific action, "major" breaks require Project Screening Board Approval. Programming staff also use CPMS data to report enterprise financial status and capital program progress to the Transportation Commission, to the Legislature, and to other stakeholders. CPMS data are also used for operational purposes—as in balancing workforce needs with anticipated revenues and project schedules.

Integrating Work Units Across the Matrix

Matrix organization among DOTs runs a broad continuum from very weak to very strong (Missouri, which employs one-hat managers[8], is probably the strongest). Moreover, the particular place on the continuum occupied by any given DOT is dynamic and evolving. However, a consensus is emerging that while a weak matrix may work well for relatively small projects, management by project is seen as the most effective means of planning, coordinating, executing, and controlling large, complex projects (which constitute DOTs' riskiest, most visible efforts).

While matrix management among state DOTs runs a continuum from weak to strong, organizations are moving toward stronger roles for project managers.

This survey effort confirmed the findings of the Midwest DOT Project Management Consortium that no DOT is moving toward a weaker matrix, indeed, movement is toward stronger matrices, with a shift to single-hat project managers. Nonetheless, retention of functional expertise is seen as critical in continuing to provide public infrastructure that meets the highest standards of safety and quality. Indeed, functional managers are viewed as the keepers of technical quality. As such, matrix management is a challenge for project managers, who must often rely more on their ability to persuade, lead, and coordinate than on decision-making power. The desire to preserve functional managers' ability to manage the technical aspects of a given set of projects while allowing the project manager enough tools to keep the overall project on

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[8] Single-hat project managers are dedicated to the project management function; that is, they spent all of their time planning, coordinating, executing and controlling projects. Two-hat project managers, in contrast, spend part of their time managing projects and part of their time engaged in technical tasks, often as part of someone else's project.

schedule and on budget poses a real challenge to project managers, who not infrequently observe that they have a great deal of responsibility for project outcomes without commensurate authority to influence those outcomes.

Because technical managers are seen as the keepers of quality, most DOTs resist ceding too much authority to the project manager.

Although DOTs are moving toward stronger matrices, their reliance on technical managers for project quality means that they resist becoming truly "projectized." Finding ways to allow the project manager to control scope, schedule and budget without undue sacrifices in technical quality is a key concern for state DOTs.

To address this tension, DOTs have developed several means of what Dye Management Group, Inc. terms "working across the matrix," that is, facilitating cooperation across functional groups and between the project manager and functional groups. There are four such techniques have been identified in best practices research. These are chartering, cross-functional training; design/construction management partnership; and design/construction debriefs.

The Utah DOT cites chartering as a key means of establishing effective working teams. It is also viewed as a means of preventing scope creep. Chartering is a process in which all team members organize themselves to deliver a particular project. The Washington State DOT also used this process for project management purposes. A charter is a signed commitment developed by the project team that establishes the team's shared purpose and how members will work together. A description of Utah DOT's chartering program can be found in Appendix C.

Another means of integrating team members across the functional matrix has been developed at the Indiana Department of Transportation. This is a cross-functional training approach that brings together representatives of various functional groups in interactive workshops. Those attending these workshops are divided into groups which meet and list possible "project stoppers" in their various areas of expertise. The groups then reconvene to discuss how to minimize or eliminate these "project stoppers." A further description of this innovative cross-functional training approach can be found in Appendix C.

New Jersey DOT has developed a Project Manager/Construction Manager partnership approach. The same project manager is involved in the project from the end of concept development through construction. In the construction phase, NJDOT provides clear specification of the project manager's and resident engineer's respective duties and authority. See Appendix C for further discussion of this approach.

Project reviews or post mortems are another means of better integrating construction into design processes. According to Washington State DOT, failure to communicate construction experience to designers can cause a repeat of field problems, change orders, and the failure to capture valuable ideas and innovations. Along with cradle-to-grave project management, project debriefs are another way to continuously improve project PS&E, construction documents, and processes.

WSDOT project and functional managers convene debriefs when major structures projects approach 75 percent construction completion. Invitees include structure owners, design engineers, construction engineers, contractors, inspectors, and consultants. Debrief agendas include a review of major project changes, opportunities for both contractors and designers to ask and answer questions, and brainstorming and ranking of design elements that worked well and those that worked poorly. Debrief results are documented in a report and distributed to attendees and used as a tool for ongoing technical and process improvement.

Similar debriefings are conducted at Wisconsin DOT, whose Central Construction Bureau collects the results and compiles them in a searchable database for use by designers and construction engineers state-wide. Day-long debriefs relating to the design/construction interface are also performed at the Minnesota DOT, where designers and construction engineers assemble to share "war stories," discuss hot issues, and attend joint training.

Project Risk Management Techniques

Several state DOTs have developed innovative means of quantifying and containing project risk. To the extent that agencies can understand and mitigate key external risk factors up front, the management of any given project can be streamlined. Mitigating risk at the project level translates to benefits at the program level—chief among them the preservation of agency credibility, which suffers when major projects hit cost and scheduling problems.

The Minnesota Department of Transportation has successfully avoided problems in project delivery by establishing the project "footprint" very early in project development. The footprint determines the design, rather than the design determining the footprint, as is more often the case. In essence, the approach establishes the project's physical boundaries and allows the project manager to contain and manage environmental and right-of-way obstacles. For further discussion of this approach, see Appendix C.

The Washington State DOT has developed a method to evaluate and communicate risk throughout the project life cycle. WSDOT is spearheading an innovative means of developing baseline cost estimates. The reasoning behind WSDOT's Cost Estimate Validation Process (CEVP) is that a better up-front quantification of cost risk gives project managers better numbers to work with and gives program managers a better handle on resource availability at the enterprise level. With the CEVP, project cost estimates are both developed and communicated in new ways. A further discussion of the WSDOT's CEVP is found in Appendix C.

REFERENCES

1. *Program and Project Financial Management Needs Assessment (SPR 515).* Bellevue, Washington: Dye Management Group, Inc., prepared for the Arizona Transportation Research Center, Arizona Department of Transportation, June 2002.

2. *Project Development Process Manual.* Phoenix, Arizona: Arizona Department of Transportation, Highways Division, February 1995.

3. *Project Manager's Handbook.* Phoenix, Arizona: Arizona Department of Transportation, Intermodal Transportation Division, July 1996.

4. *A Guide to the Project Management Body of Knowledge.* n.p.: Project Management Institute, 2000.

5. *Performance Audit, Arizona Department of Transportation Urban Highways Program for Maricopa County.* n.p.: KPMG Peat Marwick under contract with the Auditor General of the State of Arizona, August 1991.

6. *Performance Audit, Arizona Department of Highway Planning and Engineering Functions.* Phoenix, Arizona: Report to the Arizona Legislature by Douglas R. Norton, Auditor General, State of Arizona Office of the Auditor General, Report No. 97-9, May 1997.

7. *Performance Audit, Arizona Department of Transportation Construction Management Function.* Phoenix, Arizona: Report to the Arizona Legislature by Douglas R. Norton, Auditor General, State of Arizona Office of the Auditor General, Report No. 97-17, October 1997.

8. *Performance Audit, Arizona Department of Transportation, A Review of the Maricopa County Regional Freeway System.* n.p.: Sjoberk Evashenk Consulting Firm under contract with Auditor General of the State of Arizona, July 2000.

9. "Guidelines for Predesign of Major Capital Projects." Atlanta, Georgia: Georgia State Financing and Investment Commission and Office of Planning and Budget, April 2001.

10. *Caltrans Project Management Handbook. 3rd ed.* Sacramento, California: California Department of Transportation, April 1999.

11. *Results Oriented Cultures: Using Balance Expectations to Manage Senior Executive Performance.* n.p.: Government Accounting Office, GAO-02-966, September 2001.

12. *Execution Guide: Lending Practices in Capital Decision-Making.* n.p.: Government Accounting Office, GAO/AIMD-99-32, December 1998.

13. *Programming and Operations Manual M12-51.* Olympia, Washington: Washington State Department of Transportation, Planning and Programming Service Center, Program Management Office, May 2001.

14. "Project Management Training." Bellevue, Washington: Dye Management Group, Inc., presented to King County Department of Transportation Road Services Division, November 2000.

15. *Project Delivery System: A System and Processes for Benchmark Performance.* Denver, Colorado: CH2Mhill, 1996.

16. *Project Management Peer Review.* n.p.: Bechtel, U.S. Corps of Engineers, and U.S. Department of the Navy prepared for the California Department of Transportation, n.d.

17. Hendrickson, Chris and Tung Au. *Project Management for Construction.* n.p.: Prentice Hall, 1998.

18. *Capital Program Management Project Management Manual.* Trenton, New Jersey: New Jersey Department of Transportation, November 1996.

19. *Project Scoping Manual.* Salem, Oregon: Oregon Department of Transportation, Project Systems Unit, n.d.

20. *The Project Management Control Tower.* n.p. The Hampton Group. Accessed October 3, 2002. <http://www.4pm.com>

21. *Capital Outlay Support Workload Development Peer Review Action Plan.* Sacramento, California: California Department of Transportation (Caltrans), March 17, 1997.

22. Fleming, Quentin W. and Joel M. Koppelman. "Earned Value Management," PM, March-April, 2002.

23. *Earned Value Management Homepage.* Accessed November 10, 2002. <http://www.acq.osd.mil/pm/>

24. *ISO 9001 2000 Translated into Plain English.* n.p. Praxiom Research Group, LTD. Accessed November 10, 2002. <http://www.praxiom.com/iso-9001.htm>

25. Jones, Melvin E., Evelyn M. Darling, and Abbie R. Goodman. *Design Quality Research: Definition, Benefits, Measurement, Model, Testing.* Boston, Massachusetts: Engineering Center, Prepared for Massachusetts Highway Department, December 1999.

26. AASHTO Standing Committee on Quality. Accessed November 26, 2002. <http://www.transportation.org/quality>

APPENDIX A: INTERVIEWEES

Critical issues for the overall project management study were identified through Dye Management Group, Inc.'s interviews with ADOT staff and consultants involved with project management and delivery functions. These interviews were in addition to an initial e-mail survey. The following were interviewed as part of the data collection process for completing this task report and Dye Management Group, Inc. appreciates their support and participation.

Name	Title	Office
David Alloco	Technical Business Manager	Utility & Railroad Engineering Section, ADOT
John Bagnall	Management Analyst III	Program and Project Management Section, ADOT
Mike Bruder	Senior Project Manager	Yuma/Phoenix Districts, ADOT
Arnold Burnham	Section Manager	Priority Programming Section, ADOT
Anthony M. Cabrera	Senior Project Designer	Entranco
Carla Carter	Consultant	Carter and Associates, Inc.
Jeff Carpenter	Alternative Project Delivery Manager	Washington State Department of Transportation
Dakota Chamberlain	Project Management Division	Port of Seattle
Tamara Clarke	Traffic Engineering Specalist	ADOT
Doug Cosper	EDP Database Specialist III	Program and Project Management Section, ADOT
Bahram Dariush	Senior Project Manager	Prescott/Kingman Districts, ADOT
Rich DeBoer	Project Manager	Roadway Design, ADOT
Tom DiPaolo	Assistant Chief Engineer	Massachusetts Highways
Fred Doehring	Project Development Group	Utah Department of Transportation
Don Dorman	District Engineer	Flagstaff District, ADOT
Rick Duarte	Program Manager	Environmental Planning Group, ADOT
Debra Einweck	Rest Area Design Project Manager	Roadside Development Section, ADOT
Bill Evans	Project Manager	Valley Project Management, ADOT
Douglas Forstie	State Materials Engineer	Materials Group, ADOT
Bob Gasser	Roadway Development Team Leader	Environmental Planning, ADOT
Richard Gramlich	Director of Project Management	New Jersey Department of Transportation
Steve Hansen	Manager/Senior R/W Agent	Right-of-Way Group, ADOT
William Higgins	Deputy State Engineer	Operations Program, ADOT
Bruce Hubal	Project Management Development	Bechtel Corporation
Paul Hurst	Manager	Value Analysis Section, ADOT
Itty P. Itty	Project Manager	Bridge Technical, ADOT
Orlando Jerez	Project Manager	Statewide Project, ADOT

Name	Title	Office
Steve Jimenez	Assistant State Engineer	Valley Project Management, ADOT
Hari Khanna	Section Manager	Program and Project Management Section, ADOT
Michael Kies	Senior Project Manager	CH^{2}M Hill
Vince Li	Project Manager	Valley Project Management, ADOT
Jennifer Livingston	Senior Project Manager	Flagstaff District, ADOT
John Louis	Assistant State Engineer	Roadway Design Group, ADOT
Liz Magoon	Consultant	Elizabeth Magoon & Associates
Mike Manthey	State Traffic Engineer	Traffic Engineering Group, ADOT
Sam Maroufkhani	Deputy State Engineer	Development Program, ADOT
Larry Maucher	Senior Project Manager	Tucson District, ADOT
Ron McCally	Project Manager	Valley Project Management, ADOT
Bob McPartlin	Project Management	Minnesota Department of Transportation
Bob Mickelson	Project Manager	Statewide Project, ADOT
Bob Miller	Assistant State Engineer	Statewide Project Management Office, ADOT
Herman Mozart	Program Manager	Predesign Project Management Section, ADOT
Ginger Murdough	Partnering Section Manager	Partnering Section, ADOT
Chris Ortega	Project Management Manager	New Mexico Highway and Transportation Department
Laurel Parker	Project Manager	Statewide Project, ADOT
Jim Reeves	Project Manager	Pavement, ADOT
Joe Romero	Project Manager	Valley Traffic Engineering, ADOT
Rob Samour	Resident Engineer	Phoenix Construction District, ADOT
Joe Simek	Project Manager	Washington State Department of Transportation
John Sterner	Senior Project Manager	Statewide Project Management, ADOT
Craig Stone	Urban Corridors Team	Washington State Department of Transportation
Jeff Swan	District Engineer	Holbrook District, ADOT
Mark VanPortFleet	Design Division Head	Michigan Department of Transportation
Mary Viparina	Senior Project Manager	Valley Traffic Engineering, ADOT
Joe Warren	Project Manager	Valley Project Management, ADOT
Sandra Weber	Professor	Arizona State University
Jim Weingartz	Project Management	Minnesota Department of Transportation
Berwin Wilbrink	Transportation Group Manager	Jacobs Engineering
Elisa Wise	Scheduler	Program and Project Management Section, ADOT
Dick Wright	State Engineer	State Engineer's Office, ADOT
Mike Zimnick	Construction	Salt River Construction, ADOT

APPENDIX B: SAMPLING OF PERFORMANCE MEASURES FROM THE MINNESOTA DEPARTMENT OF TRANSPORTATION, THE NEW MEXICO HIGHWAY TRANSPORTATION DEPARTMENT, AND THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

SELECTED "BEST PRACTICES" PROJECT MANAGEMENT PERFORMANCE CRITERIA

Contained in the following pages is a sampling of performance measures from the Minnesota Department of Transportation (MnDOT), the New Mexico Highway and Transportation Department (NMHTD), and Washington State Department of Transportation (WSDOT) that capture project level outcomes.

ADOT, like these peer agencies, publishes its performance results. APSR numbers are available and updated monthly. The New Mexico Highway and Transportation Department presents its performance criteria and results quarterly in its *Compass* document, which is about 150 pages amply illustrated. Performance criteria related to preconstruction in particular are found in Minnesota Department of Transportation's *Preconstruction Performance Annual Report*, which is about 20 pages long and contains both text and graphics.

Best Practices Performance Criteria Address Scope, Schedule, Budget, and Quality

These examples from Washington, New Mexico, and Minnesota underscore the point that agencies considered to be leaders in project management use multi-faceted performance criteria around the areas of project and programs. By including performance criteria referencing measures of financial efficiency, such as "Award Amount to Engineer's Estimate," and "Average Interstate Construction Cost per Mile," agencies have the necessary pieces in place to balance considerations of bid schedule against cost and program flexibility.

These sample performance criteria from New Mexico, Minnesota and Washington State are organized into four categories: Budget/Finance Efficiency, Programming Efficiency, Schedule Management, and Resource Efficiency.

Budget/Finance Efficiency

- **Highway Construction Program Cash Flow.** Expenditures through the quarter ending June 2002 are on target, achieving approximately 96% of budgeted cash flow. This is also another indication that WSDOT is delivering the program that has been funded (WSDOT).

- **Award Amount to Engineer's Estimate.** Individual awards were on average 7.5% below the engineers' estimates (WSDOT).

- **Final Cost to Award Amount.** Looking at individual contracts, the average amount by which final cost exceeded the award was 1.8% with a standard deviation of 12.9% (WSDOT).

- **Final Cost to Engineer's Estimate.** Final cost fell below the engineering estimate by an average of 4.7% (WSDOT).

- **Average Construction Cost Per Day by Contract Time.** Monitor cost per day for project completion to determine the impact to the traveling public (NMHTD).

- **Bid Amount Within 10% of Engineer's Estimate.** The accuracy of the Engineer's estimate is a measure of how efficiently the Department uses available funds for the construction of highways and bridges (NMHTD).

- **Actual Cost vs. Low Bid Amount.** An indicator of the completeness of the plans, comprehensiveness of the standards and specifications, construction methodology and construction management (NMHTD).

- **Average Interstate Construction Cost Per Lane Mile (NMHTD).**

- **Average Non Interstate Construction Cost Per Lane Mile (NMHTD).**

Programming Efficiency

- **Projects Included in Work Plan/Study Plans Prior to STIP.** Target: 95% of Major Construction, Bridge Replacement, and Reconstruction projects will be included in work plans and study plans prior to appearing in STIP (MnDOT).

- **Percent of Six-Year STIP Funding Compared to Need.** Compares the cost of projects planned in the STIP with total project needs in the first six years of the Long-Range Plan (NMHTD).

- **Long-Term Project Development Timeliness.** Some 85% of all trunk highway projects will be let no later than the end of the original FY they were first entered into the program (MnDOT).

- **STIP Timeliness.** A total of 90% of all MnDOT projects in 1st year of current approved STIP will be let in that planned FY.

- **Balanced Letting Schedule.** Monthly goal percentages will be met in 9 of 12 months state-wide annually (MnDOT).

- **Percentage of Projects Let as Scheduled Three Months Previously.** Shows how well the Department is doing in planning and managing the project development process and projecting anticipated project letting dates. An accurate letting schedule allows the Department to efficiently use design resources and contractors to make financial management decisions to plan their resources (NMHTD).

- **Percentage of Projects Let as Scheduled One Year Previously.** Provides a clear indication of how well the department is planning and managing its resources. A stable letting schedule allows contractors to make financial decisions and plan their resources. Contractors depend on a monthly letting schedule to continue other working operations (NMHTD).

- **Programmed Cost vs. Actual Cost.** Indicator of how accurate the planning values are in comparison to the actual cost (NMHTD).

- **Cumulative Average Budget and Cumulative Obligation.** The letting schedule is an important tool to ensure full utilization of the program. The schedule is constrained, so available budget can be adjusted to match cash flow needs (NMHTD).

- **Actual Bids vs. Programmed Amounts.** Compares programmed funding amounts vs. contractor bid amounts. Because STIP program amount includes gross receipts tax at the prevailing rate and construction management at 8%, contractor bids are increased accordingly using the final detail estimate (NMHTD).

- **Number of Programmed Projects Let/Dollar Value of Programmed Projects Let** (NMHTD).

Schedule Management

- **Meeting WSDOT's Scheduled Advertising Dates.** WSDOT is meeting the planned advertisement date on over 90% of the projects that are being advertised for bids (WSDOT).

- **Preliminary Design Timelines.** When scoping is completed, 70% of major construction, reconstruction, and bridge reconstruction projects will have environmental documentation and final geometric layout activities done on time (MnDOT).

- **Time to Finalize Projects: Physical Completion to Submittal to Funding for Final Payment.** The sooner projects can be finalized after completion of the physical work the sooner the contractor can be paid and funds released for other projects (NMHTD).

- **Number of Projects with Liquidated Damages and Time Extensions.** Indicator of the quality of plans, construction management, determination of contract time, and the ability to complete a project on time (NMHTD).

- **Project Duration.** A goal of 70% of major construction projects will be open to traffic within five years after environmental documents and final geometric layout approvals have been obtained (MnDOT).

Resource Efficiency

- **Construction Limits.** At least 80% of major construction, reconstruction, and bridge projects will have construction limits 24 months, 18 months, or 14 months prior to letting, depending on project complexity (MnDOT).

- **Direct Purchase Right of Way.** At least 75% of parcels will be acquired through direct purchase (MnDOT).

- **Ratio of Operations Budget to Administration Budget.** Compares overhead to operations budget as a means of monitoring efficiency (NMHTD).

- **Ratio of Reconstruction and Construction Budget to Preservation Budget.** Adequate funding must be provided to both types of work to ensure a reasonable balance (NMHTD).

APPENDIX C: SURVEY QUESTIONNAIRE, SUMMARY OF RESPONSES FROM BENCHMARKING STATES, AND INNOVATIVE PRACTICES BY STATES IN IMPROVING PROJECT MANAGEMENT

SURVEY QUESTIONNAIRE

The following questionnaire was sent to various state departments of transportation to survey and identify best project management practices. A survey of the responses follows immediately after the questionnaire. States were selected because these were thought to represent benchmarking values in best practices for project management.

The states responding are:

1. Massachusetts
2. Michigan
3. Minnesota
4. New Jersey
5. New Mexico
6. Utah
7. Washington

Arizona Department of Transportation
Best Project Management Practices Survey

SURVEY QUESTIONS

The Arizona Department of Transportation (ADOT) is conducting a survey to identify best project management practices—among not only state departments of transportation—but also among other owners and developers of large infrastructure projects. In support of this effort, Dye Management Group, Inc. is conducting this survey for ADOT to assess how other organizations lead, organize, manage, and control projects—individually, and at the overall program level.

We appreciate your assistance.

Name of Interviewee	
Position/Title	
Address	
Phone	
FAX	
E-mail	

OVERALL PROJECT MANAGEMENT APPROACH

1. How would you characterize your organization's overall approach to project management?
   a) Strengths?
   b) Improvement areas?

2. How would you describe your organization's "project management culture?"

3. What elements (organization, executive leadership, IT, etc.) do you consider most important in supporting a project management culture?

4. How does executive management express the importance of project management?

PROJECT MANAGEMENT PRACTICES

5. Please summarize the "project manager's" responsibility at different points in a project lifecycle? Where does their responsibility begin and end?

6. For each of the following phases in a project's life cycle we would like to discuss the project managers' responsibility for managing scope, schedule, cost, and quality.

   – In addition, we would like to learn what controls are used to manage these responsibilities.

	Project Management Function			
Project Phase	**Scope**	**Schedule**	**Cost/Budget**	**Quality**
Prior to STIP inclusion				
In STIP through letting				
Construction				

7. What handbooks, manuals, forms and checklists do project managers in your organization have for guidance? Are they up-to-date? Are they followed consistently? *(May we get copies?)*

8. How are the respective roles and responsibilities of project managers and functional managers determined in your organization on a project basis? To what extent is a division of labor, responsibility, authority, and accountability standardized?

9. What role do project managers play in staffing their project teams?

10. Are the roles and authority of project managers in your organization clear, consistent, and widely accepted?

PERFORMANCE OBJECTIVES AND ACCOUNTABILITY

11. Does your organization use performance measures for project management? If so, what are they, and how are they used?

12. How do these measures promote accountability?

13. What are the strengths and weaknesses of your organization's performance measurement system?

14. Do you measure how long it takes to get projects into construction? (cycle time?) If so, what data do you use, and what have you found in terms of how long it takes?

HUMAN RESOURCES

15. What level of technical expertise is required among project managers at your organization?

16. What does your organization do to recruit, train, develop and retain project managers?

17. How would you describe your organization's supply of effective project managers to the demand?

      a) In terms of FTEs (workload)?

      b) In terms of skills and knowledge?

      c) Do you have standard numbers of projects per PM? Is this weighted in some fashion? (e.g., team size?)

18. Does your organization offer a career path for project managers? Is it supported by:

      a) Job classifications and salary schedules

      b) Progressive training?

19. How does your organization allocate workload among project managers, functional managers and staff at the program level?

MANAGEMENT INFORMATION, REPORTS AND TOOLS

20. What reports do project managers receive (or can they generate) to help them manage their projects?

Report Name	Type of data	How often?	Issues/comments
Project Baseline •			
Project Budget •			
Project Cost •			
Resources (e.g., labor, equipment) •			
Project Schedule •			
Progress •			
Quality •			
Risk •			

(May we get copies of financial, accounting, project reports?)

To what extent would you say that project managers utilize available data to:

      a) Plan,

      b) Monitor, and

      c) Control their projects?

21. How would you rate the "user friendliness" of data currently available to project managers in terms of:

      a) Usefulness of the information?

      b) Ease of access (e.g., one-stop shopping)?

      c) Format and readability?

PROJECT RISK MANAGEMENT

22. Is risk management performed by project managers as a conscious and discrete element of their PM role?

23. If so, what form does it take?

24. Is this level of effort appropriate? Why or why not?

PROJECT PROCUREMENT MANAGEMENT

25. Does your organization have accountability controls in place to ensure quality products and timely delivery of project on the part of consultants?

26. If so, please describe.

27. What kind of training in procurement management is available, and to whom in the organization? *(Can we get copies of any training manuals or forms used for project procurement management?)*

SUMMARY OF RESPONSES
FROM BENCHMARKING STATES

MASSACHUSETTS

Overview

Massachusetts Highway Department (MassHighway), like the other state departments of transportation surveyed, is seeking ways to cope with an aging workforce that is shrinking in size while delivering projects that are increasingly complex. Their complexity is increasing in terms of environmental impacts and regulation; the need to create or expand capacity in densely developed urban areas; and advanced technologies. Unlike the other states surveyed, however, the MassHighway was selected for study not on the basis of its project management program, which is fairly traditional by DOT standards (matrix management, frequent consultant supervision, handoff at construction). Rather, the agency is included in this survey of best practices because of the agency's research in highway design quality.

- MassHighway partnered with the American Consulting Engineers Council of Massachusetts beginning in 1998 to explore in systematic, statistically valid ways the relationships between commonly encountered problems, including schedule and cost variance and extra work orders, and highway design quality. The effort included interviews with dozens of project delivery and construction experts from within MassHighways, from the consulting community, and from 15 other DOTs nationwide. The results of this effort were published in a report entitled *Design Quality Research: Definition, Benefits, Measurement, Model, Testing*,[9] published in December 1999.

Quality Definition

Acknowledging that definitions of quality are many and that they vary according to individual's or agency's shared values, the research team adopted the following definition of highway design quality:

- "The totality of characteristics and features of all preconstruction engineering processes, tasks, and deliverables that bear on satisfying stakeholders' needs."

- It's notable that stakeholder needs here refer to and include all AASHTO design standards.

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[9] *Design Quality Research: Definition, Benefits, Measurement, Model, Testing*. Melvin E. Jones, Evelyn M. Darling, and Abbie R. Goodman. The Engineering Center, for Massachusetts Highway Department (Contract Number 97410), December 1999.

Design Quality Research Findings

The researchers considered design quality at two points in time: during the design process itself and when the design is executed (i.e., in construction).

Design Quality in the Design Phase

During the design phase, the researchers found that cost and schedule variance from the established baseline were the most useful predictors of design quality. As such, they affirm the usefulness of the Project Management Institute's cost variance and schedule variance formulas as reliable indicators of two key aspects of project quality: (1) resource efficiency; and (2) scope, cost and schedule integration.

Cost variation is calculated as the difference between the budgeted cost of deliverables produced and the actual cost of deliverables produced (earned value, in essence). Meanwhile, schedule variance is calculated as the difference between the budgeted cost of deliverables produced and budgeted cost of deliverables scheduled. Cost variances can indicate problems whether they exceed or lag the planned baseline.

- Overruns can indicate problems including:

  - Tasks are not consistent with plans and budgets.

  - Staffing costs are more or less than planned.

  - Staff is making unsupported assumptions and causing rework.

  - Project manager is not holding staff meetings and work is not coordinated.

  - Subcontractors' products not fit for use.

- Meanwhile, cost underruns can indicate:

  - Too little time spent because the solution is not enough to satisfy requirements (understated scope).

  - Quality reviews may be neglected.

  - Risky assumptions may have produced shortcut solutions.

  - Staff is inexperienced.

  - Requirements may not be fully understood.

  - Costs may not include all of subcontractors' costs.

Design Quality in the Execution Phase (Construction)

In many respects, the true quality of a given highway design is put to the test by building it—at which point omissions, errors, and unforeseen conditions can come to light. The researchers considered several means of measuring design quality in the post-design phase and found two of them to be particularly good indicators of design quality: (1) variation among construction bid prices and (2) design-related extra work.

Variation in Construction Bid Prices

The research team found that variations among construction bid prices reliably indicate design quality. Quality plans, specs and contract documents reduce bidders' uncertainties, prompt more competitive bidding, and lead to narrower differences among bidders' prices. "Good" documents are interpreted as low risk; and "bad" documents are interpreted as high risk. Bidders express their opinions of risk in their price proposals. Variations in bid prices are precursors of design related extra work during construction. Projects having more competitive bids have fewer design related extra work orders at lower cost than projects having wide bid variations.

Extra Work Orders

The research team found that extra work orders are another reliable indicator of highway design quality—but only in cases where they are required because of design errors or omissions (as opposed to unforeseen conditions or added scope). The researchers found that isolating design-related extra work orders provides a useful complement to the bid variation measure. A Design-Related Extra Work Index (D-REWI) to capture design-related extra work orders can be computed as follows:

$$D\text{-}REWI = [1.0 - (\text{design related extra work \$/ low bid price})]$$

Composite Design Quality Index

Ultimately, the researchers advocate a Composite Design Quality Index that takes into account variation in construction bids, schedule variation, qualitative assessment of consultant performance, design-related extra work, and variation in bidders' quantity estimates.

The five elements of this composite index, along with their respective weightings, are listed in Table 10. The researchers found that variations in contractors' bids provide the strongest, most reliable indicator of quality—as such this factor is assigned the highest weighting, followed by design-related extra work.

Table 10: The Weighted Elements of a Composite Design Quality Index

Schedule performance Index (a form of earned value)	SPI	BCDP/BCDS budgeted cost of deliverables produced/budgeted cost of deliverables scheduled	15%
Consultant Performance Evaluation Index	CPEI	[Overall CPE score/10] Qualitative measure of client satisfaction with consultant performance—based on existing rating criteria and instrument	15%
Bid Variation Index	BVI	[1.00-(STDEV of bids/low bid)]	40%
Design related Extra work Index	D-REWI	[1.00-(design-related Extra Work Orders/low bid price)]	25%
Quantity Estimates Index	QEI	[1.00-($ sum of absolute quantity variation/low bid price)]	5%

The overall index for measuring quality can be expressed as follows:

Composite Design Quality Index =

(40%)(BVI) + (25%)(D-REWI) + (15%)(CPEI) + (15%)(SPI) + (5%)(QEI)

MICHIGAN

Overview

Over the past decade, the Michigan Department of Transportation (MDOT) has changed significantly. Its capital budget has tripled to over $1.5 billion, the percentage of work done by consultants has risen to over half of the total, and the agency has seen FTEs cut in half. MDOT has adopted management by project as a conscious means of delivering a larger capital program more efficiently.

While both New Jersey and Michigan have adopted strong matrix project management, New Jersey has chosen to centralize this function, whereas Michigan is actively decentralizing—not only project management authority, but programming authority as well. Interviewer Mark VanPortFleet describes the matrix at MDOT as falling between weak and strong, with the project manager filling more of a coordinator role, which could be strengthened as part of increased decentralization effort. MDOT operates out of seven region offices and 26 Transportation Service Centers (TSCs), each covering about a county. It is at the TSC level that most projects (with the exception of very complex projects that require special technical expertise) will be managed.

The devolution of authority to allocate resources and control projects makes it even more important for the agency to develop standard data collection and project management tools that span geography, phase, and function. These tools are needed so that project-level information can be rolled up to the state-wide level for capital program and operations management.

Insofar as retirements are part of the smaller MDOT staff, with more work going to consultants, it is important that project management knowledge be institutionalized and applied consistently. MDOT has such a tool in its information technology system, the PPMS, which it first introduced over a decade ago and which has been through several iterations. MDOT is also a leader in construction management information technology, as reflected in an enterprise award from *CIO Magazine* for its innovative construction inspection software development.[10]

Role of the Project Manager

MDOT project managers are typically assigned just prior to scoping, and historically, there has been a handoff at the conclusion of design. However, MDOT is working to better integrate design and construction phases, in part through its decentralization process. With project management at the TSC level, those responsible for the design and construction of a given project will work in the same building and will be more directly responsible to the same constituency. In addition, there are plans to have both project manager and resident engineers sign final plans.

Support Mechanisms and Tools

MDOT has had its Program/Project Management System (PPMS) in place for over a decade, though it has had several major upgrades. "We are now over a decade into development so we have a good idea of what we are doing and why," says VanPortfleet. The system is organized around two levels, the first of which is a rollup of project level tasks and milestones. The top tier is used primarily for program management. The second tier, organized around 80 to 100 standard tasks and milestones, is used at the project level. PPMS documentation is extensive, but user-friendly, and it provides the ability to cross-reference 32 work units and project manager responsibilities by task.

MDOT has designed the PPMS to reduce the managerial complexity of preconstruction by defining standard tasks that can be linked together to form networks that outline the dimensions of any MDOT project. These networks are then used by project managers to form the basis of project schedules and budgets. They are used in aggregate by executive management to forecast and allocate labor, funding, and other resources.

Another support for project managers is provided by MDOT's mid-level managers, who monitor their direct reports' progress toward schedule and budget goals. Project managers meet with their superiors biweekly to go over PPMS-generated progress reports. VanPortfleet notes that mid-level managers, who are responsible for the project outcomes of their subordinates, help project managers to anticipate problems and to advocate for them, when needed, as in getting time, attention or data from the technical specialties.

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[10] MDOT received an award from *CIO Magazine* in February 2001 for its Field Manager program, which allows construction inspectors to upload forms and download data remotely, greatly reducing paperwork burdens for both field inspectors and back office staff.

Strengths

      Accountability. In 2000, Michigan Department of Transportation developed performance factors for key managers. These performance measures are tied directly to their subordinates' project management outcomes. MDOT rewards effort in project managers and their mid-level superiors with pay for performance.

      Project Management Institute Training. Michigan Department of Transportation offers a unique training program that was tailored for them by the Project Management Institute. This training relates general principles of project management to MDOT organizational structures and business processes.

      Focus on Project Readiness. VanPortFleet noted that MDOT has a goal of letting 95 percent of its construction projects between October and March, so that they can enter the construction process in timely fashion. This requires that projects be lined up and ready prior to letting. This helps ensure that the agency does not lose a construction season to delays, that they can reduce equipment idle time, and have more programming flexibility.

Issues

      Data Integrity. Although MDOT has made data entry and maintenance part of employees' performance appraisals, getting timely, accurate data from project managers and functional managers remains challenging.

      Project Manager Retention. Recruiting qualified project managers is a challenge for MDOT, as it is for many other DOTs. Though MDOT has experimented with headhunters, they typically focus on developing project managers from within. MDOT has classified engineers who serve as project managers at a higher level to reflect the position's responsibilities and to make the job more attractive.

MINNESOTA

Overview

      Minnesota Department of Transportation (MnDOT) is distinctive in that the agency is organized around program delivery. Its three main divisions are Management Operations, Program Delivery, and Program Support. MnDOT's strives to apply "one basic process to all projects." Although details vary depending on project type, size, and complexity, MnDOT's Highway Project Development Process demonstrates this common approach.

      Under MnDOT's decentralized approach, projects are managed at the district level, but project management policy guidance, coordination and support come from headquarters. MnDOT's project management function, as well as the information technology tools that support it, are relatively mature. As such, the agency has reached a point at which it makes sense to revisit the established project management function with

an eye to streamlining it. As such, MnDOT is scrutinizing every aspect of its project development process to find ways to make it more efficient.

Role of the Project Manager

MnDOT's project managers are assigned following "preprogram scoping," and they maintain involvement through to the letting date. Once the project is let, a construction engineer takes over contract management, although there are efforts at MnDOT, as at other DOTs, to better integrate design and construction phases.

MnDOT uses a matrix approach to project management in which project managers usually have both functional as well as project management responsibilities. Project managers who combine their project management with technical responsibilities are referred to as "two-hat" project managers. Responsibility for quality at MnDOT resides explicitly with the functional work units.

Support Mechanisms and Tools

As noted, MnDOT is organized around program delivery. The Engineering Services Division supports project managers through the following activities:

- Setting up scoping meetings

- Documenting project scope, environmental and economic impacts

- Research

- Benefit/Cost analysis

- File maintenance

- Document preparation

- Assistance in establishing and updating schedules

- Assistance in cost tracking

MnDOT is developing an improved project management information system (ARTEMIS) that will improve the agency's ability to identify and correct project and program bottlenecks and perform resource leveling at the enterprise level.

Strengths

Project Delivery Streamlining. Over the past several years, MnDOT has analyzed project development bottlenecks and opportunities to improve cost and schedule management efficiency. MnDOT's streamlining effort is intended to develop design and construction projects more quickly without losing sight of cost, quality, or community

values. Reducing the number of "handoffs" in the project development process, reducing the time required for reviews and approvals, and increasing the number of project development steps that can be pursued concurrently, are among the means that MnDOT envisions using to improve its Highway Project Development Process. To date, over 40 areas of opportunity have been identified.

One example of MnDOT's streamlining initiatives entails a footprint template concept for project design, which centers on predefining the physical boundaries of a given interchange or roadway widening project. By setting the template in advance and designing to those constraints, right-of-way acquisition can begin earlier in the design process, thus shortening the time required to get the project out to bid.

Performance Measures Support Streamlining Efforts. MnDOT's Preconstruction Performance Measures, listed in Table 11, reflect the maturity of the agency's highway development process. Each of the performance measures addresses a known issue, challenge or barrier in terms of delivering projects individually and programs in aggregate. Because MnDOT has identified and analyzed the impact of these barriers at each step in preconstruction, they can set realistic targets for overcoming them that are supported by specific business process improvements.

Table 11: MnDOT's Preconstruction Performance Measures

Measure	Purpose	Target
Planning	Projects are included in work plans/study plans prior to appearing in STIP.	95% of Major Construction, Bridge Replacement and Reconstruction projects will be included in work plans and study plans prior to appearing in STIP.
Preliminary Design Timeliness	Complete Environmental Document and Final Geometric Layout Activities on Time in Preliminary design.	When scoping is completed, 70% of Major Construction, Reconstruction and Bridge Reconstruction projects will have environmental document and final geometric layout activities completed on time.
Construction Limits	Establish project's construction limits 24 months, 18 months, or 1 months prior to letting, depending on complexity—this is required for timely R/W procurement.	80% of Major Construction Reconstruction and Bridge projects will have construction limits set prior to letting.
Direct Purchase R/W	Direct purchase avoids the extra outlay of money and energy to acquire by eminent domain.	75% of parcels will acquired through direct purchase.
Long-Term Project Development Timeliness	MnDOT has a six-year STIP—and finds it difficult to manage program delivery in the out years.	85% of all trunk highway projects will be let no later than the original FY first entered into the STIP.
STIP Timeliness	Most critical measure to public and to districts.	90% of all MnDOT projects in 1st year of current approved STIP will be let in that planned FY.

Measure	Purpose	Target
Project Duration	MnDOT is considering whether this is the right performance measure; (1) duration is less important to the public than missing an opening date; (2) lack of funding is a factor in stretching projects out.	70% of Major Construction projects will be open to traffic within five years after environmental documents and final geometric layout approvals have been obtained.
Project Design Turn-In Timeliness	Having projects ready for letting in advance increases the agency's ability to let projects in a measured way and to make the best use of funding sources.	80% of all projects will be turned in by established target dates (x weeks prior to letting, by type of job) prior to letting.
Balanced Letting Schedule	Numbers of projects let compared to monthly goal, measured as percentage of the year's number of total lettings. This measure is a "top priority for the Chief Engineer."	Monthly goal percentages will be met (+/- 2.5%) in 9 of 12 months state-wide annually.
Plan Quality for Bid	Plans are subject to review and rating by a team of district, metro staff, and consultants. They use three categories: exceptional, average, and poor.	40% more or plans will be of Exceptional Quality and 10% or less of the plans will be of Poor quality.
ROW Process Time	Intent is continuous improvement in ROW acquisition. MnDOT acknowledges that bottlenecks upstream of the ROW office (e.g., in planning, public involvement, and design) can contribute to delays.	ROW process time will be reduced by an average of 10% from FY 2002 to FY 2003, measures from the construction limits complete/footprint delineated" milestone data to "ROW available" milestone date.

Issues

Ambiguity Around Project Management Priority. According to MnDOT interviewees, an issue with the agency's two-hat project managers is that they are sometimes unsure as to how to allocate their time between their project management and functional duties. One way to address this, now underway, is to reflect the balance of employees' responsibilities in their performance appraisal criteria.

Workforce Retention and Development. MnDOT is considering creation of a new job classification, Administrative Engineer, to reflect project managers' level of responsibility and to make the position more visible and more attractive.

NEW JERSEY

Overview

New Jersey Department of Transportation (NJDOT) has adopted a centralized, strong matrix approach to project management. The agency created a project management department in 1996 under its Capital Program Management division. The

importance placed on project management by NJDOT is reflected in the organization chart. The director of project management is a peer with the director of design services, both of whom report to the Deputy Commissioner for Capital Program Management. According to Richard Gramlich, Director of Project Development, the drive to organize around project management came from the Commissioner, which was a significant factor in overcoming cultural resistance to the change in orientation. Coinciding with this shift in 1996 was an early retirement opportunity, which led to the loss of some 500 NJDOT employees, many of whom were resistant to the change. According to Gramlich, "Project management drives the capital program."[11]

NJDOT's project managers work out of a centralized project management office, which raises fewer issues in a densely populated state with limited square mileage than it would in a state with far flung offices. Project managers typically handle from five to ten projects at a time, with a mix of feasibility assessments, design, and construction assignments.

Role of the Project Manager

NJDOT, like Utah, strives to make the project manager the single point of contact from conceptual feasibility through construction. Project managers at NJDOT become involved in projects relatively early—prior to scoping. Project managers are assigned just following development of the Problem Statement. The project manager is then responsible for managing the scoping process—from selection of a scoping team through scope preparation (which reflects 15 percent to 25 percent of design). They manage project scope, schedule and budget throughout design, whether it is done by consultants or in-house, they are involved in advertising and letting the project, and they maintain involvement through construction, including oversight of field personnel.

NJDOT has established an innovative means of integrating the original project manager into construction management without losing the benefit of the construction engineer's specialized skills. NJDOT has accomplished this through a systematic analysis of the design and construction processes, along with clear specification of the project manager's and resident engineer's respective duties and authority at each decision point. A detailed discussion of this division of labor is contained in the body of this report.

Support Mechanisms and Tools

Project Managers at NJDOT work closely with and are supported by specialized work units within the division, including a Scope Development Bureau and a Project Scheduling Unit, the latter of which assists the project manager in developing design schedules, budgets, and work breakdown structures. NJDOT issued a *Project Management Manual* that specifies the project manager's responsibilities by phase and task in 1996; this document is still in use.

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[11] Scheduled telephone interview conducted by Dye Management Group, Inc.

Primavera is the project management application used at NJDOT. Project managers receive Primavera training, leadership development courses, and specialized training sessions taught by senior staff to help project managers deal with specific issues.

Strengths

Information Technology. Gramlich counts among the department's strengths its IT system, which provides project managers tools for monitoring and controlling their schedules and budgets. Although the system functions smoothly now, Gramlich noted that the original consultant team hired to develop it in the mid-1990s did not understand the agency's constraints in terms of procurement regulations, which led to fits and starts in terms of developing a useful tool. The system has since been through significant upgrades.

Continuity Through the Life Cycle. Having a single point of contact—beginning at scoping and extending through construction—is a factor, Gramlich holds, in the department's ability to deliver projects more quickly and efficiently. This is due in part to the fact that a single point of contact, the project manager, reduces the chance for losses of momentum between functions and phases. It is also related to the individual's accountability from scoping through construction. A person who will eventually be responsible for constructing a project on time and on budget may well approach scoping in a more disciplined way. In making the project manager responsible for signing any necessary field and change orders, lessons learned in the construction phase readily become part of the project manager's knowledge base as s/he faces the next design effort.

Accountability. NJDOT has gone farther than most DOTs in terms of tying individual project managers' performance appraisals to project outcomes. At NJDOT, project managers' goals, job descriptions, performance factors and their weighting are tied directly to project outcomes. The following illustrative goals, job responsibilities and performance factors are taken from an actual NJDOT Performance Assessment Review.

Major goals of the unit:

- Effectively manage and deliver all assigned capital projects through Final Scope Development, Design and Construction.

- Actively participate in the project development of all assigned projects in the Feasibility assessment.

Major individual goals:

- Effective management and delivery of the following Capital projects:

    − Route 36, Highlands Bridge.

    − Route 88 Clifton Avenue.

    − Route 71 Wall Street.

- Consistent contribution to the achievement of the major goals of the work unit.

Meanwhile, the project manager's essential job responsibilities may be specified as follows:

- Effective delivery of assigned capital projects.

- Develop, obtain approval, and update all assigned project schedules.

- Develop, obtain approval and maintain all assigned project budgets.

- Update all required project databases.

- Prepare and submit for approval correspondence and or information requested to respond to the public, local officials, legislators, and government officials.

- Develop coordinate and implement a project-specific public involvement action plan for all assigned projects.

- Ensure acceptable quality of all project submissions and deliverables.

Contained in Table 12 are the performance factors and weightings used in assessing project manager performance at NJDOT.

**Table 12: NJDOT Performance Factors and Weightings
for Project Manager Appraisal**

	Rating (1-3)	Weight	Factor Points (Rating x Weight)
Goal Achievement		25	
Quality of Work		25	
Timeliness		25	
Decisiveness		5	
Communication		5	
Job Knowledge/Skills		5	
Human Resource Management		5	
Team Building		5	
TOTAL		**100**	

Issues

Recruiting and Retention. Existing project managers carry heavy loads, yet it is difficult for the agency to replace retiring engineers and add new ones in time to meet demand.

Information Technology. NJDOT is seeking ways to refine its project management and capital program reports to make them more useful and easier to understand for executive management and the Legislature. The department is also working to enhance the system's resource-leveling capabilities.

5. NEW MEXICO

Overview

New Mexico is a largely rural state with a transportation capital program that is small compared to most others. However, New Mexico Highway and Transportation Department's (NMHTD) focus on management by project as a means of maximizing limited resources at the program level illustrates the value of management by projects to programs of various sizes.

Role of the Project Manager

Project managers at NMHTD are deployed from both headquarters and district offices. About two-thirds of the agency's projects are managed centrally within the Design Division, and this portion falls about equally between Consultant Project Managers, who oversee consultant-led design efforts, and Project Development Engineers (PDEs), who oversee in-house design work. PDEs are responsible for technical design work as well as project management, which entails the usual coordination with the agency's specialty groups; with outside agencies for permitting; and the public interface. NMHTD employs 18 PDEs, each of whom manages from five to 15 projects. The remaining third of NMHTD projects are handled at the district level by Technical Support Engineers. These projects are typically less technically complex (e.g., pavement overlays).

Project management at NMHTD is design-centered. PDEs assume responsibility for projects following completion of the Project Evaluation Report, which marks the transition from planning to design. PDEs remain responsible for project scope, schedule, budget and quality through the preparation of final plans, specifications and estimates (PS&E), at which point the baton is passed to the agency's Construction Bureau, where it is assigned to a Construction Liaison Engineer.

Support Mechanisms and Tools

NMHTD's Program/Project Management System (PPMS) is a web-enabled system that was recently upgraded (August 2002) to integrate the agency's existing Primavera scheduling system with modules that allow the agency to correlate projects

with funding sources and to perform resource leveling and drawdowns across projects, work units, and programs. The system's Report Manager function interfaces with all subsystems and provides a single source for data reporting needs.

Strengths

NMHTD is distinctive in the extent to which it has established program-level performance measures based on project-level outcomes. These performance measures are a subset of the agency's overall performance measures (of which there are 17 in all—together they constitute NMHTD's "Compass").

- Smooth roads to provide safe, efficient travel

- Safe transportation system—reduction in vehicle crashes

- Access to divided highway

- Intermodal facilities

- Adequate funding and prudent management of resources

- Less traffic congestion and pollution

- Maintenance of highway and facilities

- Improved communication, external

- Cost effective, quality transportation systems

- Employees

- Increased transportation alternatives

- Timely completion of construction/maintenance projects

- Improvement program

- Economic benefits to New Mexico

- Stable letting schedule

- Transportation Leader

- Internal communications

Each of the key measures is further broken out in Table 13. Each of these measures is reported in a quarterly report[12] that explains each measure's significance and data source. The well organized document contains many graphics to convey data trends simply. While many DOTs have established performance measures on which they report regularly, NMHTD is distinctive in that it captures multiple, sometimes competing aspects of program delivery, which gives them a more balanced approach. For instance, by reporting both the percentage of projects let as scheduled as well as programmed cost vs. actual cost, there is a means of checking for the fact that rushing projects through letting may have costly repercussions down the line in the form of rework or omissions.

In fact, the interviewees noted that the agency is revisiting whether "stability" in the letting schedule is even a desirable outcome. NMHTD, like Michigan Department of Transportation, is weighing the value of programming flexibility against the "value" of conformance to a preset letting schedule.

Issues

Integration of Design and Construction phases. While NMHTD has not moved to adopt cradle-to-grave project management, ways to better integrate design and construction are being considered. In fact, project scoping report agreements are now signed by the PDE, the District Engineer, and the Construction Liaison Engineer.

Is letting flexibility a useful performance measure? As noted, the department is considering whether to replace or revise the "stable letting schedule" performance measure in favor of one that would reflect the value of programming flexibility.

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[12] *Compass Third Quarter*, July – September 2001, New Mexico Highway & Transportation Department.

Table 13: Project/Program Delivery Results Tracked by NMHTD

Result	Adequate funding and prudent management of resources	Timely completion of construction/ maintenance projects	Realistic STIP to better manage limited resources in order to meet more of customers' needs	Stable letting schedule to better manage limited resources in order to meet more of customers' needs
Measure	• Percent of 6-Year STIP funding compared to needs. • Time to final projects—physical completion to submittal to funding for final payment. • Ratio of operations budget to administration budget. • Ratio of reconstruction and construction budget to preservation maintenance budget.	• Average construction cost per day by contract time. • Innovative construction contracting (e.g., Incentive/ Disincentive, A+B Bidding). • Number of project with liquidated damages and time extensions.	• Number of programmed projects let. • Dollar amount of programmed projects let. • Actual bids vs. programmed amounts. • Bid amount within 10% of Engineer's Estimate. • Actual cost vs. low bid amount. • Programmed cost vs. actual cost. • Five-Year planned CIP projects vs. actual grants.	• Percentage of projects let as scheduled three months previously. • Percentage of projects let as scheduled six months previously. • Percentage of projects let as scheduled one year previously. • Federal-aid program federal limitation, cumulative average limitation, and cumulative obligation. • State program: Cumulative average budget and cumulative obligation.

UTAH

Overview

The Utah DOT (UDOT) embarked upon a systematic effort to effect management by project in the mid-1990s. Historically, UDOT, like most other DOTs, was organized first by the region and then by function. Under this system, major project phases—preconstruction design, construction, and operations—were also segregated. Under this structure, specialists from various functional units worked but briefly on projects. Handoffs—between functional units and between phases—were many. Among the issues that UDOT faced under this situation were a lack of internal work coordination, which led to problems in both design and construction, and lack of a single point of contact for given projects or facilities, which the public found frustrating.

In essence, the reasons for shifting to a project management approach were to improve project quality and coordination internally, which would increase the efficient use of limited resources and also create a better informed, more responsive means of relating to public customers.

UDOT thus revised its organizational structure—not wholesale, but by creating a matrix project management function that complements the existing functional hierarchy within the regions. This approach can be characterized as a "strong" project manager approach. At each region, there is a cadre of project managers and a cadre of functional managers, each of whom reports through the Region Director. Under this structure, project managers have the same level of authority as functional managers.

The other key to UDOT's approach was the creation of a central project management support unit at headquarters. Headed by Fred Doehring, who represented UDOT in the interview, this unit serves the following functions:

- Provides policy and procedural guidance related to project management.

- Develops and refines organizational framework for managing independent project groups.

- Monitors and manages PM workloads across regions—transferring resources as needed to ensure balance.

- Maintains and manages the Program and Project Management System, including training.

- Represents project managers in issues that require attention from headquarters.

- Evaluates effectiveness of PM function.

Role of the Project Manager

Relative to other state DOTs, project managers at UDOT have considerable authority *vis a vis* functional managers, and they are involved in planning, maintaining, and controlling scope, schedule, budget and quality throughout the project life cycle to an unusual degree. In most state DOTs, the project manager is assigned once the project is programmed into the STIP, with his or her responsibility ending at the conclusion of design. At UDOT, however, project managers start at the "concept phase" (pre-STIP) and they remain through construction, and even through the first year of maintenance. While several states, as we shall see, are starting to further integrate design and construction, UDOT has gone farther than many in addressing the disjunction between design and construction and between construction and maintenance.

Support Mechanisms and Tools

Utah rolled out its custom-developed system, the Preconstruction Project Management System (PPMS), in 1996. PPMS provides integrated functionality at both project and program levels. PPMS enables UDOT project managers to develop project schedules and networks on the basis of attribute definitions; and it allows program

managers to consolidate project level data to the enterprise level, which allows them to monitor and control funding, cash, and manpower resources.

The data accrued through UDOT's PPMS is used in analyses to establish work standards, to evaluate labor requirements, and to perform multi-project resource loading to evaluate the "deliverability" of the capital program. These program management capabilities make it a valuable tool for senior executives as well as project managers. Notably, UDOT employees fill out time sheets in which they indicate time spent on projects and tasks. Timesheet bookkeeping is integrated with the PPMS, as is the payroll system, which allows project managers to track their budgets with more precision than in many other public agencies.

Project management training and resources at UDOT are extensive, and they include a *Project Management Guide*, which was introduced in 1996. This guide provides a consolidated source of information on project delivery from inception through startup. Included in the guide are the following major headings:

- UDOT-specific Administrative Processes

- Major Activities in Concept Development

- Major Activities in the Preconstruction Phase

- Major Activities in the Construction Phase

- Major Activities in Managing Consultant and Construction Contracts

- Overall Management and Oversight of the UDOT STIP

- Project Quality Management

Strengths

Strong Project Manager Approach Creates Sense of Ownership. Mr. Doehring observes that UDOT's project managers work diligently to deliver high quality products on time because they are both empowered to do so and held accountable.

Project Management is an Employee Retention Tool. Project management is a recognized, attractive career path that appeals to the Department's most ambitious and effective professionals. Doehring reports that turnover among project managers is not a major issue at UDOT, as it is at many other agencies. UDOT has developed specific job classifications and performance appraisal criteria for its project managers.

Issues

Overwork. UDOT is divided into four regions, each of which has six project managers. Project managers carry heavy loads, possibly to the point that projects suffer.

Lack of Consensus Regarding the Role of the Project Manager. Despite UDOT's existing training and project management documentation, which is very specific with regard to divisions of labor on tasks, activities, and phases, the matrix structure leaves some ambiguity with regard to the respective roles of the project manager and the function manager. If anything, this is an indication that matrix management is an innately subtler and more ambiguous form of project control than is a hierarchical structure.

Information Technology. Although the functionalities of UDOT's PPMS enable the department to manage projects and their program overall, users complain about its "clunkiness," and Doerhing confirms that it lacks the flexibility to reflect the changing ways that UDOT does business. The department is considering means of adapting the system to enable separate networks to reflect different types of UDOT projects (e.g., separate networks for EA/EIS projects, maintenance projects, design/build).

WASHINGTON

Overview

WSDOT's organizational structure is somewhat unique among DOTs. Administrators are assigned to areas, and managers are assigned to roadways within those areas. Project managers and project engineers at WSDOT report to the engineering managers. This organization replaces an historic division first by geography and then by function (design, construction, operations). The rationale behind the change was to make the agency more accountable to the public, members of which experience roadways in their geographic and functional totality—regardless of what are to them arbitrary agency distinctions.

Role of the Project Manager

Project managers at WSDOT work under a weak matrix model. They are housed within decentralized design offices. WSDOT's two-hat project managers perform technical design work, coordinate the functional specialties, and interface with outside agencies as well as the community. They are assigned at the project scoping phase, and they turn projects over to construction engineers once the final PS&E package has been approved.

Support Mechanisms and Tools

Guidance for project managers is located in various WSDOT publications, including the agency's *Design Manual*, its *Plans Preparations Manual*, its *Construction Manual*, and its *Agreements Manual*. The agency also maintains on-line libraries for forms and checklists. No single source describes the project manager's roles and responsibilities by project type, phase, activity, or task—or relationships between the agency's dozens of work units.

Data from WSDOT's project management information technology system, STARS, are collected and reported in periodic "Sunshine Reports," which contain task-level milestone detail on all WSDOT projects. These reports provide a variety of other

data concerning each project, including project team members, funding sources, and responsible administrators.

WSDOT rolls up project-level data to the program level using its Capital Program Management System (CPMS). Program management staff at WSDOT headquarters run nightly reports that record and monitor any changes to project scope, cost, improvement type, project duration or construction season. The CPMS compares these changes against threshold criteria. Any changes that break preset thresholds are flagged. Exceptions are reported in the "Nightly News" for monitoring and action by program management staff.

Strengths

WSDOT has pioneered and refined several notable project delivery innovations, two of which are discussed below.[13]

Risk Management. The Washington State DOT, which counts among the state's most urgent needs eight "mega-projects" (multi-billion dollar range), is spearheading an innovative means of developing baseline cost estimates. The Cost Estimate Validation Process (CEVP) helps WSDOT manage risk by identifying and analyzing project risks and unknowns, and it helps preserve public confidence in the agency by helping the public understand the risks inherent in given projects. The reasoning behind WSDOT's CEVP is that a better up-front quantification of cost risk will give project managers better numbers to work with and will give program managers a better handle on resource availability at the enterprise level. With the CEVP, project cost estimates are both developed and communicated in new ways.

The CEVP, which can be conducted at various points in the project life cycle, takes place in an intensive workshop setting, not unlike a value engineering exercise. Each project is examined by a specially convened team of expert engineers, from both public and private sectors, who examine the project systematically to identify, describe, and quantify the impacts of major risk factors and unknowns.

Using state of the art risk assessment practices from around the country and elsewhere in the world, the team considers the probabilities and cost impacts of the range of risks identified. The team uses statistical techniques to account for factors including data quality. The output of the CEVP is a set of project cost probability ranges that reflect the percentage of design completed. CEVP results are communicated in various formats, depending on the audience's appetite for detail.

Chartering. WSDOT project managers develop formal charters for every project. These charters are signed commitments by the project team, including the various functional specialties, that establish the team's shared purpose, project boundaries, group and individual responsibilities, critical success factors, and how members will work together. Chartering provides an additional tool in integrating individual and work unit

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[13] Other innovative project delivery methods used by WSDOT include A + B Bidding, Lane Rental, Flexible Start Date, Interim Completion Dates, and Lane Rental.

efforts across functional lines. It helps team members, who may be serving on multiple project teams, understand the priorities of particular projects, so they can better juggle competing demands on their time. It provides a written commitment to project parameters at the kickoff, which reduces the likelihood of substantive project problems such as scope creep, loss of focus, or omissions once the project is underway. It also serves as a stand-alone document that succinctly communicates the project's purpose, leadership, and team members to internal and external stakeholders.

Issues

Funding Constraints. WSDOT continues to seek ways to demonstrate the agency's effective stewardship of limited public funding in the face of growing demand for transportation infrastructure and capacity. Recent initiatives cutting WSDOT funding sources, combined with an unsuccessful state-wide gas tax increase vote, have increased the pressure to deliver projects efficiently.

Weak Matrix Structure. WSDOT's weak matrix structure makes it difficult for project managers to control their project schedules and budgets when they encounter bottlenecks with on or more specialty groups.

INNOVATIVE PRACTICES BY STATES
IN IMPROVING PROJECT MANAGEMENT

This Appendix also contains a series of discussions of innovative practices that were found being used by various state Departments of Transportation during the best practices research. These are discussed in greater detail here than they are in the main body of the report. These practices and approaches are innovative in nature and show considerable promise for project management. They are placed here for those readers who have an interest in pursuing them in greater detail. Basically, there are seven separate discussions of innovative practices. These seven discussions are:

1. The Utah Department of Transportation's PPMS Capabilities.

2. The Oregon Department of Transportation's Project Management Guidebook.

3. The Utah Department of Transportation's Chartering Program.

4. The Indiana Department of Transportation's Cross-Functional Training Approach.

5. The New Jersey Department of Transportation's Project Manager/Construction Manager Partnership Approach.

6. The Minnesota Department of Transportation's "Footprint" Approach.

7. The Washington State Department of Transportation's Cost Estimate Validation Process (CEVP).

THE UTAH DEPARTMENT OF TRANSPORTATION PPMS CAPABILITIES

Utah's is an example of a state DOT that has effectively harnessed information technology to plan, coordinate, and control labor, time, and other resources at the project level. UDOT's Preconstruction Project Management Systems (PPMS), a custom-developed system, allows the agency to consolidate project-level data to the enterprise level, which in turn allows program managers to monitor and control resources such as funding, cash, and manpower. It is notable that this system is seen to be functionally effective despite complaints from some users about its technical "clunkiness" and perceived user-unfriendliness.

The data accrued through UDOT's PPMS is used in analyses to establish work standards, to evaluate labor requirements, and to perform multi-project resource loading to evaluate the "deliverability" of the capital program. These program management capabilities make it a valuable tool for senior executives as well as project managers. Selected PPMS capabilities are summarized below.

Selected Functionalities of UDOT's PPMS Schedule

The first point at which a Utah DOT project manager is assigned to a project is the Concept Phase, the purpose of which is to define the project in enough detail to submit it for the state's STIP. In this phase, the project manager develops a concept schedule and budget.

The individual project manager does not build his schedule from the ground up with whatever experience and reference materials he might happen to have. Rather, the PPMS generates an estimated critical path project schedule. This schedule is structured around a set of sequential activities based on the project manager's input of a long list of project attributes onto an electronic form supplied by PPMS. This attribute list prompts the project manager to specify miles of new roadway, the level of environmental documentation required, the number and type of utility relocations required, and many other project attributes. A full list of these data inputs is listed in Table 14. Below is an example of such a sequenced activity list—critical path items are designated with a ">". The project manager may manually override any PPMS-generated aspect of the schedule in order to reflect constraints, issues, or opportunities particular to the project.

1. >Conduct Design Review
2. Prepare RR/Utility Agreements
3. Complete RR/Utility Agreements
4. Make R/W Appraisals
5. >Acquire R/W
6. Prepare for PS&E Review
7. >Make PS&E Revisions/Additions
8. >Assemble Final Plan Set
9. >Appraisal Design Study Report
10. >PS&E Complete

Table 14: UDOT's PPMS Attributes List, Used to Establish Project Schedule

Kilometers of	New or Reconstructed roadway
	Spot Improvement
	Hydraulics
	Curb and Gutter
	Overhead Utilities
	Consolidation Analysis
	Traffic Control
	Rehabilitation
	Resurfacing
	Storm Sewer
	Parallel Railroad
	Underground Utilities
	Traffic Control-Major
	Traffic Control-Moderate
	Traffic Control-Minor
Number of	Intersection New or Reconstruction
	Interchange New or Reconstruction
	Major Channel or Ditch
	Structural Walls
	Detention or Retention Ponds
	Highway Lighting Sites
	Interchange Rehabilitation
	Signal Sites
	Utility and Railroad Agreements
	Water Surface Profiles
	Bridge Hydraulic Studies
	Highway Lighting Agreements
Applicable or Not Applicable	Federal Involvement
	Pavement Design
	Mapping Required
	Roadway Geotech
	Hydrology Required
	Right-of-Way Required
	Concept Design Exception
	Design Exception
	Consultant Signal/Lighting Survey
	Slope Stability Analysis
	Mitigation Point Discharge
	Value Engineering

Right-of-Way (Number of)	Residential Ownerships
	Industrial Ownerships
	Unused Ownerships
	Relocations
	Commercial Ownerships
	Agricultural Ownerships
	Frontage Road Ownerships
	Condemnations
Environmental (Applicable or Not Applicable)	Categorical Exclusion (CE)
	Environmental Assessment
	Memorandum of Agreement
	Environmental Impact Statement (EIS)
	Noise Study
	Public Hearing
	Wetland Mitigation
	Seeding
	Consultant Services Required
	Endangered Species
	Hazardous Waste Cleanup
	Cultural/Paleontology Survey
	Landscaping
New Structures (Number of)	Single Concrete-Long Span <42 M
	Single Steel-Long span <42 M
	Twin Steel-Long Span <42 M
	Piers <9 M
	Bridge with Horizontal /Curve
	Bridge with Cofferdam
	Twin Concrete-Long Span < 42 M
	Single Steel-Long Span >42 M
	Piers >9 M
	Bridge with Internal Bent
	Pipe Headwalls (non-standard)
	Pipe Headwalls (standard)
	Concrete Boxes
	Overhead Sign, Structures
Bridge Rehabs (Number of)	Approach Slab Repair
	Abutment Repair
	Slope Protection Repair

The input of project attributes is the single most important specification with PPMS because these attributes not only structure the project schedule, they also shape the cost and resource estimates that flow from it.

Cost and Resource Management

The PPMS schedule provides a starting point for cost estimates and later project budgets by generating an estimate of the number of hours and days required for each activity. The project manager, in consultation with functional managers, can then assign activities to various work units.

UDOT employees complete timesheets each pay period (though they are urged to do so on a daily basis) on which they enter hours worked by project number and activity. The payroll system is tied in with PPMS, which allows the project manager to track project schedule and budget. Similar mechanisms are used to manage consultant schedules and budgets. This basic data allow UDOT's project managers and functional managers to run a variety of analyses to monitor project schedules and budgets. For instance, project managers can compare budgeted hours to actual hours charged by project activity. Lack of hours charged may indicate that progress is not being made (among other possibilities) while hours over budget may indicate scope creep, technical problems, poor performance, or other situations that require management attention.

The PPMS is also used to help functional managers monitor and control the resources for which they are responsible. Any functional manager's staff members may be supporting activities on dozens of separate projects. PPMS is used to generate reports that indicate each individual's and each work unit's available hours versus hours committed to project activities. This capability allows functional managers to understand and thereby manage the nature and timing of demands on their staff. They can determine if they need more FTEs, or need to authorize overtime, or need to hire consultants, and, if so, where and for how long.

THE OREGON DEPARTMENT OF TRANSPORTATION'S PROJECT MANAGEMENT GUIDEBOOK

Delivering a major transportation project is complex endeavor that can span years, cost millions of dollars, require thousands of tasks, and involve dozens of work units and stakeholders. Figure 4 below, taken from the Oregon Department of Transportation Project Development Guidebook, illustrates this complexity – despite the fact that it only covers a portion of the project delivery lifecycle (planning through design) without coverage of construction. Nonetheless, these phases alone involve 12 major activities, 10 overarching processes, and 24 different sets of participants and work units.

1.0 PHASES	1.1 Planning and Management Systems	1.2 Program Development	1.3 Project Alternative Selection	1.4 Project Design

2.0 MAJOR ACTIVITIES	2.1 Trans. System Planning	2.2 Mgmt. System Analysis	2.3 Identif'tion of Potential Projects	2.4 Preliminary Feasibility Analysis	2.5 Prioritizat'n & Selection	2.6 Project Structuring & Detailed Feasibility Analysis	2.7 Preliminary Site Surveying, Mapping, & Reporting	2.8 Alternative Solution Dev'ment & Selection	2.9 Detailed Site Surveying, Mapping, & Reporting	2.10 Permitting & Right-of-Way	2.11 Plans, Spec's, & Estimates Dev'ment	2.12 Contractor Selection

3.0 PROCESSES

3.1 Project Decision Structure
3.2 Project Financial Plan
3.3 Intergovernmental Agreements
3.4 Public Input and Involvement
3.5 Environmental
3.6 Project Scoping
3.7 Right-of-Way
3.8 Project Team
3.9 Review
3.10 Permitting

4.0 PARTICIPANTS AND UNITS

Participants

4.1	OR Transportation Commission
4.2	ODOT Management
4.3	Regions, Areas, and Districts
4.4	Project Leaders & Project Teams
4.5	Regulatory & Resource Agencies
4.6	Local & Regional Jurisdictions
4.7	Elected Officials
4.8	General Public

Units

4.9	Transportation Planning
4.10	Business Management
4.11	Preliminary Design
4.12	Environmental Services
4.13	Geometronics
4.14	Geo\Hydro
4.15	Right-of-Way
4.16	Railroad and Utility

4.17	Traffic Management
4.18	Roadway Engineering
4.19	Pavement Services
4.20	Bridge Engineering
4.21	Bicycle and Pedestrian
4.22	Financial Services
4.23	Maintenance
4.24	Office of Project Delivery

Figure 4: ODOT's Project Development Guidebook Succinctly Specifies Each Work Unit's Roles by Project Phase and Major Activity

Given this complexity, it is very important at ODOT as at other DOTs, that each unit's roles and responsibilities, by phase and activity, be spelled out. It is not unusual for DOTs to have well specified roles and responsibilities for project managers. What is notable about ODOT is that the guide also specifies the roles and responsibilities of all the other work units with which the project manager must coordinate. Using the matrix in Figure 4, the project manager, or any other project team member, can quickly determine his or her role at any project phase for any of the major activities. Moreover, all of this information is cross-tabbed. By providing this level of specification, it is less likely that efforts will be duplicated, that important activities will "fall between the cracks," or that misunderstandings will arise.

Because roles and responsibilities are spelled out clearly, project managers and their teams need not waste time negotiating divisions of labor and procedures every time they start a project or task. Moreover, this classification ensures that work units throughout the enterprise follow a consistent approach, which enables effective data collection and analysis for program management purposes. "As any seasoned program

manger knows, there are many excuses that arise when program status is assessed and progress measured. Frequently, these excuses point to a lack of structure in the program. Program mangers must be able to implement enough structure or convince workers to accept ownership of their tasks and view them as top priority efforts."[14]

Documentation/Guidance as to Roles, Responsibilities, and Authority Should Be Attractive, Easy To Use, and Current.

The utility in frameworks such as ODOT's lies in their ease of use and accuracy. They must therefore be updated and refined when they no longer reflect best practices, and regular training must be provided to ensure that guidelines are understood and applied. Moreover, it is important that individuals and managers be held responsible for operating according to the guidelines, even as they contribute to their continual improvement.

Choosing a single activity from the ODOT matrix, 2.11, Plans, Specifications and Estimates Development, is a reasonable way of working through the framework to understand its structure and utility. The ODOT Guidebook organizes project delivery along several parameters, as illustrated in Figure 4.

By project phase:

- Planning and Management Systems.

- Program Development.

- Project Alternative Selection.

- Project Design.

Each project encompasses two to four major activities. For example, Project Design entails the following:

- Detailed site surveying, mapping, and reporting.

- Permitting and right-of-way selection.

- Plans, specifications, and estimates development.

- Contractor selection.

Finally, the ODOT guidebook provides specific information on each of the 24 work units' and participants' duties and functions within each phase and within each major activity. Activity 2.11, Plans, Specs and Estimates falls under the project Design

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[14] Robbins, Gioia, "White Paper: Harnessing Program Management to Empower State and Local Governments." Accessed November 22, 2002. <http://www.Robbinsgioia.com/library/whitepaper/state-localgoverment.pdf>

Phase. The work units that contribute to this activity, including Roadway Engineering, Traffic Management, Pavement Services and Bridge Engineering, are listed alongside their duties in Table 15.

Table 15: Specification of Work Unit Roles in ODOT Plans, Specifications, and Estimates Development

ODOT Management	Oversees and approves the development of project plans, specifications, and estimates.
Project Leaders and Project Teams	Provide expertise in finalizing the project bid documents.
	Preliminary Plans. Create preliminary plans under the supervision of a registered PE to review the overall project design. Preliminary plans for all aspects of the project—such as bridges, signals, illumination, erosion control, wetland mitigation and roadside development—should be distributed at the same time. Advance Plans and Special Provisions. Create advance plans and special provisions to ensure that appropriate changes have been made in the design shown in the preliminary plans. This allows review of the special provision and for comments on any drafting errors. This stage is the last official review opportunity for most stakeholders so all elements of the project must be included. Final Plans, Specs and Estimates. Finalize and distribute the project plans, specifications, and estimates.
Regulatory and Resource Agencies	Regulatory Compliance. Some regulatory and resource agencies assist with the project plans and specs to comply with federal and state regulations.
Local and Regional Jurisdictions	Project Bid documents. Jurisdictions review and provide input on the final plans, specs and estimates.
Business Management Section	Report Assembly and Distribution. Assembles plans, specs, and estimates produced by Project Team staff and distributes them to other members and units.

Geo/Hydro	Analysis and design of the subsurface and hydraulic components of a project.
	Preliminary Material Source Plans.
	Location maps with existing or proposed contour lines, typical cross-sections, quantity summaries, construction notes and post-construction rehabilitation measures.
	Submit permit applications to Oregon Department of Geology and Mineral Industries.
	Advance Material Source plans.
	Final Material Source Plans.
	Preliminary Erosion Control Plans.
	Protection of slopes and topsoil during construction, construction notes and details regarding placement of sediment barriers, drainage inlet protection, silt fences, seeding.
	Advance Erosion Control Plans.
	Final Erosion Control Plans.
	Preliminary Water Quality Plans.
	Advance Water Quality Plans.
	Final Water Quality Plan.
Right of Way	Reviews and provides input on the final project plans, specs and estimates.
Railroad and Utility	Reviews and provide input on the final project plans, specs and estimates.
Roadway Engineering	Distributes the preliminary plans; prepares and distributes advance and final plans and special provisions; conducts a plans-in-hand review, makes plan changes and updates as needed; prepares the engineer's cost estimate, and completion time estimate; obtains final agreements for local projects; finalizes funding arrangements; obtains formal approval of plans, specs and estimates on federally funded projects; receives a utility timing and status report; and prepares and distributes final plans and specs which may include, but are not limited to: • Roadway (title sheets, details, and typical sections) • Roadside development • Erosion control • Bridge • Signals • Wetland mitigation • Traffic control • Signs • Illumination • Materials sources • Striping

Traffic Management Section	Work Zone Restrictions.
	Traffic analysis to determine potential for construction-related delays.
	Recommendation on liquidated damages if construction not completed within timeframe.
	Benefit-Cost analysis for detours.
	Minimum storage length calculations for intersections.
	Preliminary, Advance, and Final ITS Plans.
	Preliminary, Advance, Final Illumination Plans.
	Preliminary, Advance, and Final Sign Plans.
	Preliminary, Advance and Final Signal Plans.
Pavement Services	Final Pavement Design.
	Recommends pavement and base types and depths for the proposed design. Report includes analysis based on pavement and materials properties and anticipated truck traffic.
	Field testing of the project site.
	Samples and test materials.
	Perform design analysis.
Bridge Engineering	Develop bridge design from the "type, size, and location" stage to the 90% compete set of bridge plans for review.
	Bridges viaducts, retaining walls, sound walls, sign bridges, Bridge replacement or rehab.
	Bridge plans include plan and elevation sheets, hydraulic data, profiles, foundation data, stage construction plans, footing plans, construction notes.
Bicycle and Pedestrian	Final project bid documents.
	Review and provide input on the final project plans, specs and estimates.
Maintenance	Review and provide input on final project plans, specs and estimates.

THE UTAH DEPARTMENT OF TRANSPORTATION'S CHARTERING PROGRAM

The Utah DOT cites chartering as a key means of establishing effective working teams to work across the matrix. It is also viewed as a means of preventing scope creep. Chartering is a process in which all team members organize themselves to deliver a particular project. The Washington State DOT also used this process for project management purposes. A charter is a signed commitment developed by the project team that establishes the team's shared purpose and how members will work together; as such, charters typically include the following:

- Project sponsor.

- Project manager.

- Team members.

- Project vision.

- Project mission.

- Project boundaries.

- Operating guidelines (e.g., agenda preparation and distribution, meeting attendance, frequency, etc.).

- Critical success factors.

- How consensus will be ascertained.

- Group and individual responsibilities.

Team members commit to the provisions of the charter by signing an endorsement, such as the following: "By signing this Project Charter, I commit to meeting the objectives of the project within the constraints of project scope, schedule, budget, and quality. As a member of the project team, I have reviewed and approved the attached Concept Report, Budget, Schedule, and Quality Plan." Establishing a team charter, signed by all team members, has multiple benefits:

- It provides an additional tool in integrating individual and work unit efforts across functional lines.

- It helps team members, who may be serving on multiple project teams, understand the priorities of particular projects, so they can better juggle competing demand on their time.

- It provides a written commitment to project parameters at the kickoff, which reduces the likelihood of substantive project problems such as scope creep, loss of focus, or omissions once the project is underway.

- It provides a project charter as a stand-alone document that succinctly communicates the project's purpose, leadership, and team members' names to internal and external stakeholders.

THE INDIANA DEPARTMENT OF TRANSPORTATION'S CROSS-FUNCTIONAL TRAINING APPROACH

Another means of integrating team members across the functional matrix was developed at the Indiana Department of Transportation, which has developed interactive workshops that bring together representatives of various functional groups. Participants (typically 25-30 per session) are assigned into one of six groups, each representing a major functional area:

- Preliminary Engineering

- Environmental

- Design

- Land Acquisition

- Contract Preparation

- Funding

The groups, working independently, are tasked with listing "project stoppers" for the functional area their group represents. In the Indiana experience, imperfect communications, staff availability, and changing standards are the most frequently cited project stoppers. The groups reconvene to review the lists from each group, discuss why these barriers arise, and how they could be minimized or eliminated. The training has been found to be quite useful in several respects:

- In and of itself, it creates a forum for cross-functional communications.

- It helps members of different functional groups understand the others' constraints and challenges.

- It helps participants understand the impact of their actions and communications on other groups and project progress.

- It demonstrates the importance of communications in project planning, execution, and control.

THE NEW JERSEY DEPARTMENT OF TRANSPORTATION'S PROJECT MANAGER/CONSTRUCTION MANAGER PARTNERSHIP APPROACH

New Jersey DOT has a strong project manager function, wherein the same PM is involved in project management from the end of concept development (or the beginning of scoping) through construction. The PM's role to the point at which the contractor is selected is not unlike that of many other state DOTS in terms of his oversight, coordination and control. However, NJDOT has established an innovative means of

integrating the same project manager into construction management without losing the benefit of the construction engineer's specialized skills. NJDOT has accomplished this through a systematic analysis of the design and construction processes along with clear specification of the project manager's and resident engineer's respective duties and authority at each decision point in project construction.

At NJDOT, a transportation "need" is translated into a "concept" and then developed by planners until it has reached a state of gestation referred to as a "problem statement," at which point it is assigned to a project manager for scoping objectives. The product of project scoping at NJDOT is a scope statement that comprises 15 to 25 percent of final design. The assigned project manager is then responsible for managing this scope through the phases of design, advertisement, and contractor selection.

It is at the construction phase that the PM's role shifts as he or she enters into a management partnership kind of with the assigned Resident Engineer (RE), who is responsible for the day-to-day administration of contract activities "with direction from the project manager until the project is accepted by the Operations and Maintenance Division." Under the NJDOT model of strong matrix project management, "The project manager remains responsible for overall project coordination and for the project scope, schedule and budget during construction." The overall roles of the PM and the RE are compared in Table 16, while their respective duties in specific project functions, including schedule, cost, and quality control, are listed in Table 17.

Table 16: Overall Roles of the Project Manager and Resident Engineer at Project Construction Phase: the New Jersey DOT Approach

Project Manager	Resident Engineer
Direction to the RE until the project is complete and accepted by Operations and Maintenance division or the local owner.	Day to day administration of contract activities under supervision of the Regional Construction Field Manager with direction from the PM.
The PM remains responsible for overall project coordination and for the project scope, schedule, and budget during the construction phase.	PM's prime interface Ensure that contractor's performance is satisfactory and in accord with contract.
More specifically, the PM is responsible for overseeing field construction personnel to ensure that the project remains on schedule and within the approved budget.	Serve as PM's communication conduit when communicating with the contractor and other outside parties.
Provides guidance to RE in coordinating with outside agencies, governmental entities, and other Department Bureaus.	PM's eyes and ears on the construction site.
Provides information, direction, design input, and technical assistance to RE as needed to maintain project progress.	Documentation of all construction activities and issues.
Coordinating and distributing all change of plans issued by Design to the field.	
Oversees change order and claim negotiations in process.	

Project Manager	Resident Engineer
Brief the RE on special issues prior to construction start (since RE has generally not followed the project through its full development).	Inform the PM of day to day activities and issues which would affect decisions regarding project scope, schedule, budget, and quality.
Monitor activities through regularly scheduled site visits.	

Table 17: The Roles of the Project Manager and the Resident Engineer in Project Schedule, Cost, and Quality Control: the New Jersey DOT Approach

	Project Manager	Resident Engineer
Schedule Monitoring	Ensure that there is no conflict between contractor's progress schedule with the NJDOT master schedule or other commitments. Once RE recommends approval, see that any significant milestones are incorporated into the NJDOT Master schedule. Approve schedule.	Review contractor's progress schedule to assure that it complies with the contract completion dates. Review overall logic of activity sequencing . If schedule update indicates that contractor is falling behind schedule, see that a new schedule is submitted along with a corrective action plan; advises PM and request comments.
Cost Monitoring	Monitor payment progress to assure that it's consistent with the work performance and within budget. Review RE's final payment and approves requests or revisions. Approve final payment estimate for processing.	Prepare contractor's monthly payments and forwards them to accounting for the issuance of a check with copy to PM. Finalize project's "as-built" quantities for contract items and extras. Prepare final payment for processing.
Quality Assurance	During preconstruction, hold a kick off meeting in which Project Specific Quality Assurance Plans (PSQAPs) are requested from each service unit. Develop an overall PSQAP Monitor PSQAP to verify that process is being followed, documented and updated as required. Update PSQAP to include approved contractor, consultant, supplier and subcontractor Quality Programs.	Receive, review and approve contractor, consultant, supplier and subcontractor quality programs. Solicit review and comment from PM and from Bureau of Quality Management.
Progress Reporting	Review weekly progress report.	Prepare weekly progress report.
Project Closeout	Oversee the process. Provide concurrence and approval when necessary. Resolve disputed deficiencies resulting from final inspections. Regional Field Manager and Regional Construction Engineer have review and approval authority.	Initiate the process. Process all necessary paperwork and obtain all necessary approvals. Conduct Final Inspections. Prepare Memorandum of Record noting further corrective action resulting form the final inspections.

THE MINNESOTA DEPARTMENT OF TRANSPORTATION'S "FOOTPRINT" APPROACH

The Minnesota Department of Transportation has successfully avoided problems in project delivery by establishing the project "footprint" very early in project development. In this approach, the design is determined by the footprint, as opposed to the typical situation in which the footprint is determined by the design. In essence, this approach first establishes the project's physical boundaries. By designing the facility to the constraints of this footprint, as opposed to letting the dimensions unfold the project manager can better contain and manage two of the thorniest risks in project development: environmental and right-of-way obstacles. This approach has notable advantages:

- Right-of-way purchases can be started and completed earlier in the process, which reduces both cost and schedule risk.

- Environmental permitting can also be started and completed earlier in the project, without risking major complications that result from design developments that impinge on new land area.

MnDOT estimates that this approach is viable for about 80% of widening projects. Factors that weigh against its use include the following:

- Project design needs to deal with complicating factors such as wetlands mitigation; special ditch, ponding, and channel change areas; or spur dikes or guide banks at bridges.

- The project is located in a highly urbanized or commercial area, in which right-of-way costs are both greater and more variable.

- A new alignment is required.

- Local support for the project is uncertain, which increases the likelihood of alternative design.

MnDOT's footprint template approach is organized around 30 percent, 60 percent, and 90 percent design milestones, as shown in Table 18.

Table 18: MnDOT's Footprint Template Approach

30% Design	Define preliminary construction limits defined, addressing both access and drainage.
	Lay out right-of-way.
	Prepare preliminary acquisition plans.
	Commence pre-acquisition activities.
60% Design	Furnish plan sheet information for use by direct purchase agents.
	Based on feedback from landowners, design changes can be readily made (within the "footprint" approved at 30%).
90% Design	All design changes have been completed.
	All parcels that can be purchased through direct negotiation have been acquired.
	Prepare balance of parcels for acquisition by eminent domain.

Source: Right of Way Footprint Concept, Program Delivery Streamlining Task Force, Presented November 15, 2000 by Karl Rasmussen, State Land Management Engineer. MnDOT website.

THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION'S COST ESTIMATE VALIDATION PROCESS (CEVP)

The Washington State DOT, which counts among the state's most urgent needs eight "mega-projects" (multi-billion dollar range), is spearheading an innovative means of developing baseline cost estimates. The reasoning behind WSDOT's Cost Estimate Validation Process (CEVP) is that a better up-front quantification of cost risk will give project managers better numbers to work with and will give program managers a better handle on resource availability at the enterprise level. With the CEVP, project cost estimates are both developed and communicated in new ways.

The CEVP, which can be conducted at various points in the project life cycle, takes place in an intensive workshop setting, not unlike a value engineering exercise. Each project is examined by a specially convened team of expert engineers, from both public and private sectors, who examine the project systematically to identify, describe, and quantify the impacts of major risk factors and unknowns.

Using state of the art risk assessment practices from around the country and elsewhere in the world, the team considers the probabilities and cost impacts of the range of risks identified. The team uses statistical techniques to account for factors including data quality.

The output of the CEVP is a set of project cost probability ranges that reflect the percentage of design completed. CEVP results are communicated in various formats,

depending on the audience's appetite for detail. Summary sheets provided to the public, for instance, include the following information:

- Project description and benefits.

- Schedule assumption to adjust estimates to "midpoint of construction."

- Dates for inflation.

- Project cost probability ranges at current state of design.

  – Stated in dollar ranges, which reflect limits of estimating precision at the planning stage.

  – Risk considerations are identified and described.

  – Likelihood of project construction schedule being met has been taken into account and schedule based adjustments made to reflect the smaller purchasing power.

- Major risk factors and unknowns to which cost estimates are subject.

- Summaries are provided for "all project implementation" and also for scenarios where part of project could be undertaken.

- Backup detail for conclusions is provided.

The CEVP has several benefits:

- Identifying and understanding better project risks and unknowns, without which risk cannot be minimized or managed effectively.

- Helping the public and elected officials to understand the risks inherent in specific projects prevents credibility losses and even failure when cost estimates rise.