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AVOIDING DELAYS DURING THE CONSTRUCTION PHASE OF HIGHWAY PROJECTS

FINAL REPORT

**Prepared for
National Cooperative Highway Research Program
Transportation Research Board
National Research Council**

TRANSPORTATION RESEARCH BOARD

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16. Abstract Time delays during the construction phase of highway construction projects are reported herein. From on-site visits to six states, the research found the root causes of delay to be many and varied, requiring a comprehensive approach along with strong support from the top of the state highway administration. The report details seven fundamental principles that guide the evaluation of recommendations. These are cost-time-influence, priority, accountability, rewards, knowledge, efficiency, and innovative thinking. Recommendations are made that support these principles. Fortunately, the problem of untimely project completion is solvable. The management processes and technologies are readily available to state highway agencies. This report discusses how this can be done by presenting specific recommendations in six areas: business practices and procedures, contractor procurement, contract administration, construction input into design, utilities, and contractor management. In total, 40 recommendations are discussed. The recommendations are not radical ideas but, rather, have been tried by a number of SHAs. Others have been routinely used in other sectors of the construction industry for years. Some recommendations may require legislative action, but most do not. Where legislation is needed, alternative recommendations are available. Some recommendations can be implemented unilaterally by the SHA whereas others will require more time and coordination with outside parties and organizations.					
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TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	xiv
1. INTRODUCTION	1
INTRODUCTION	1
STATEMENT OF THE PROBLEM.....	1
OBJECTIVES	1
SCOPE	2
RESEARCH APPROACH	2
CHANGING ENVIRONMENT	3
Historical Perspective	3
SHA of the 21 st Century.....	3
Role of the FHWA	4
Change is Inevitable.....	4
USE OF THE REPORT	4
ORGANIZATION OF THE REPORT	5
2. FUNDAMENTAL PRINCIPLES OF PROJECT MANAGEMENT	6
FUNDAMENTAL PRINCIPLES.....	6
Cost-Time Influence	6
Priority	6
Accountability.....	6
Rewards.....	7
Knowledge	7
Efficiency.....	8
Innovative Thinking.....	8
COST-TIME INFLUENCE	8
PRIORITY	10
ACCOUNTABILITY	10
REWARDS	11
KNOWLEDGE	11
EFFICIENCY	11
INNOVATIVE THINKING	12
3. ROOT CAUSES OF DELAY.....	13
COMMENTARY ON ROOT CAUSES.....	13
4. RECOMMENDATIONS RELATED TO SHA BUSINESS PRACTICES AND PROCEDURES	14
BUSINESS PRACTICES	14
Recommendations.....	14
BUSINESS PROCEDURES.....	16
Recommendations.....	16

TABLE OF CONTENTS (Continued)

	<u>Page</u>
5. RECOMMENDATIONS RELATED TO CONTRACTOR	
PROCUREMENT AND CONTRACT ADMINISTRATION	21
CONTRACTOR PROCUREMENT AND CONTRACT ADMINISTRATION.....	21
Recommendations	21
Contract Administration.....	31
6. RECOMMENDATIONS RELATED TO INJECTING CONSTRUCTION	
INPUT INTO THE DESIGN.....	37
Conduct More Effective Constructibility Reviews.....	37
Use the CM Delivery Process.....	39
Include Contractors as Part of Constructibility Review Team	40
Establish a Lessons-Learned Database	41
7. RECOMMENDATIONS RELATED TO UTILITY LOCATION AND	
RELOCATIONS.....	42
BACKGROUND AND LITERATURE REVIEW	42
Communications and Relations	42
Locating Utilities	43
UNFORESEEN OR INCORRECTLY LOCATED UTILITIES	46
Use Subsurface Utility Engineering.....	46
DELAYS IN UTILITIES RELOCATING THEIR FACILITIES	52
SLOW RESPONSES TO BETTERMENTS	55
8. RECOMMENDATIONS RELATED TO CONTRACTOR MANAGEMENT	57
Background.....	57
Contractor Planning	58
A+B Bidding or Establishment of Completion Dates	58
Right-of-Way (ROW) Rentals	60
Liquidated Damages and Milestone Dates	60
Provide a Planning Phase.....	60
TIME-REDUCTION INCENTIVES.....	60
Time-Reduction Proposals.....	60
Organize a Project Review Team	61
CONTRACTOR SCHEDULING.....	61
Hire a CM to Review Schedules.....	61
Strengthen Contract Language Relative to Schedule Updates	62
Develop Standards of Practice	62
Use Alternate Scheduling Methods	63
CONTRACT INTERPRETATION.....	64
MAINTENANCE (SEQUENCING) OF TRAFFIC	64
9. IMPLEMENTATION.....	66
PREREQUISITES TO IMPLEMENTATION	66
1. Accept Fundamental Principles	66
2. Establish Top Level Support.....	66
3. Establish a System of Measurement	67

TABLE OF CONTENTS (Continued)

	<u>Page</u>
IMPLEMENTATION STEPS	67
1. Select Improvement Strategies	67
2. Develop Detailed Implementation Procedures	68
3. Proceed with Implementation	68
4. Evaluate the Outcome and Make Adjustments	68
USE THE LESSONS LEARNED BY OTHERS	69
Who Has Tried This?	69
Need for an Implementation Clearing House	69
10. SUMMARY AND CONCLUSIONS	70
APPARENT CAUSES OF DELAY	70
ROOT CAUSES OF DELAY	70
CONCLUSIONS.....	71
RECOMMENDATIONS.....	71
REFERENCES	73
APPENDIX A: LITERATURE REVIEW.....	A-1
APPENDIX B: INDUSTRY SURVEY.....	B-1
APPENDIX C: ROOT CAUSES OF DELAY	C-1
APPENDIX D: FHWA RECOMMENDATIONS FOR UTILITY RELOCATIONS.....	D-1
APPENDIX E: UTILITIES GUIDELINES AND BEST PRACTICES	E-1

LIST OF FIGURES

	<u>Page</u>
Figure 1. Recommendation Framework	7
Figure 2. Cost-Influence Curves	9
Figure 3. Relationship Between Schedule Slippage and Completeness of Engineering (Myers 1986)	10
Figure 4. Percentage of Projects Finishing Beyond the Original Contract Time (Thomas 1985b)	22
Figure 5. Average Time Growth by Contractor	28
Figure 6. Extent of Project Delay Due to Utilities (U.S. GAO 1999)	45
Figure 7. Legend of Utility Codes and Symbols	51

LIST OF TABLES

	<u>Page</u>
Table 1. Rating Sheet for Recommendation BPP-1.....	5
Table 2. Number of States Reporting Federal-Aid Projects Delayed by Utility Relocations (U.S. GAO 1999).....	44
Table 3. Technologies Used in SUE (Anspach 1995)	46
Table 4. States' Responses Identifying Reasons for Delays in Relocating Utilities (U.S. GAO 1999).....	53
Table 5. Factors Affecting Time Determinations (NCHRP 1995)	59

LIST OF RECOMMENDATIONS

	<u>Page</u>
Business Practices and Procedures	
BPP-1: Embrace the Widely Accepted Cost-Time-Influence Principle	14
BPP-2: Develop a Time Classification Scheme.....	15
BPP-3: Develop a SHA Employee Evaluation Procedure that Includes Time Accountability	16
BPP-4: Encourage the Widespread Use of Innovative Contracting Practices	18
BPP-5: The Experience and Expertise of the DRB Members should be More Fully Utilized	19
Contractor Procurement	
CP-1: Award A Single, Two-Phase Contract	21
CP-2: Require that Contractors Have Key Planning Documents Approved Prior to Commencing the Work.....	23
CP-3: Use a Realistic “B” Parameter in A + B Bidding	24
CP-4: Allow Flexible Start Dates	25
CP-5: Make Use of Right-of-Way or Lane Rentals.....	25
CP-6: Assign Liquidated Damages to Intermediate Project Milestones.....	26
CP-7: Develop Contractor Responsibility Procedures that Include Time Accountability	27
CP-8: Develop Designer Responsibility Procedures that Include Time Accountability	30
CP-9: Encourage and Accept Time-Reduction Proposals	30
CP-10: Make an Annual Award for the Best Designed and Executed Project.....	31

LIST OF RECOMMENDATIONS (Continued)

	<u>Page</u>
Contract Administration	
CA-1: Assign a Senior Project Manager to Lead the Team.....	31
CA-2: Develop an Overall Project Schedule and Monitor the Schedule Regularly	32
CA-3: Make Effective Use of Prebid Meetings and Walkdowns	33
CA-4: Organize a Rapid Response Team (RRT).....	34
CA-5: Develop a Training Course on Contract Interpretation and Administration.....	35
CA-6: Revise Project Closeout Procedures to Limit the Number of Punchlists.....	36
Construction Input	
CI-1: Make More Effective Use of Formal Constructibility Reviews.....	37
CI-2: Use a Construction Manager (CM)	39
CI-3: Include Contractors on the Constructibility Review Team	40
CI-4: SHAs Should Maintain a Lessons-Learned Database	41
Utility Locations and Relocations	
U-1: Use SUE On All Class 1 (Time-Sensitive) Projects.....	47
U-2: Use 3-D and 4-D CAD Models at Critical Intersections and Locations	49
U-3: Develop Guidelines Citing Specific Criteria Defining When Utilities Should Be Relocated.....	49
U-4: Develop Standards of Practice on How Utility Information is Conveyed	50
U-5: Reconstitute PCV Pipe So It Can Be Located Using Conventional SUE Technologies	52
U-6: Relocate Utilities Using Specialty Subcontractors.....	53
U-7: Revise Utility-SHA Agreement.....	54
U-8: SHAs Loan Monies to the Municipality Until Their Funding Request Is Approved.....	55

LIST OF RECOMMENDATIONS (Continued)

	<u>Page</u>
Contractor Management	
CM-1: Use A + B Bidding or Establish a Fixed Completion Date.....	58
CM-2: Hire or Retain a CM or Use the DRB to Review Project Schedules	61
CM-3: Provide Contract Language Requiring Schedule Updates at Regular Monthly Intervals.....	62
CM-4: Develop Guidelines or Standards of Practice on How to Critique a Project Schedule.....	62
CM-5: Make Use of Alternate Scheduling Methods	63
CM-6: NCHRP Should Develop Guidelines On The Use Of Linear Schedules and Promote Their Use	63
CM-7: Contractors Required to Develop Their Own Maintenance (Sequencing) of Traffic Plans	64

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EXECUTIVE SUMMARY

In this report, more than 40 major recommendations are made to eliminate or reduce time delays and associated cost impacts during the construction phase of highway projects. The emphasis of the recommendations is on minimizing the actual time the contractor spends on the project so as to reduce the inconvenience to the motoring public and private businesses. The recommendations in this report are the result of a nationwide study that identified the root causes of delay. On-site visits were made to six states: California, Florida, Georgia, New York, South Carolina, and Wisconsin. Based on discussions with district, resident, and project engineers, contract administrators, legal counsel, contractors, construction managers, and others, various recommendations are proposed to alleviate the root causes of delay.

The research found that the root causes of delay were many and varied and that there is no single “silver bullet” that will reduce the instances of untimely project completion. Rather, a comprehensive approach is needed that will require strong support from the very top of the state highway administration.

The report begins by outlining seven fundamental principles of good project management that should be followed. These are:

- Cost-Time-Influence
- Priority
- Accountability
- Rewards
- Knowledge
- Efficiency
- Innovative Thinking

These principles are used as a guide for recommending changes. Recommendations are made only when they support these principles.

By examining actual contractor claims and discussing these in depth during the site visits, the root causes of delay were identified. The root causes were not always obvious, and the researchers applied their knowledge of design and construction processes to arrive at the causes. Among the more common root causes of delay affecting most of the agencies visited were:

- SHAs embrace business as usual despite external forces that are forcing changes in the way highway projects are planned and executed.
- All projects are treated alike, meaning that critically scarce resources are spread equally over all projects, instead of greater resources being applied to where the needs are most critical.
- The construction knowledge available to SHAs is not always effectively used.
- There is limited construction input into many designs, which leads to errors and omissions, changes, and inefficient construction sequences.
- Current contracting policies and procedures are not always appropriate to projects on existing alignments where there is heavy traffic and the need to maintain business access.

- Unforeseen underground utilities and untimely utility relocations affect many projects.

There are many more specific root causes of delay identified in the report.

Fortunately, the problem of untimely project completion is solvable. The management processes and technologies are readily available to SHAs. This report discusses how this problem can be addressed by presenting specific recommendations in six broad areas. These are:

- Business practices and procedures,
- Contractor procurement,
- Contract administration,
- Construction input into design,
- Utilities, and
- Contractor management.

The recommendations are not radical ideas. Some have been tried by a number of SHAs; others have been routinely used in other sectors of the construction industry for years. A few recommendations may require legislative action, but most do not. Where legislation is needed, alternative recommendations are available. Some recommendations can be implemented unilaterally by the SHA, whereas others will require more time and coordination with outside parties and organizations.

To illustrate the nature of the recommendations, it is recommended that all projects be classified according to their time sensitivity and that the most resources be applied to the most time-sensitive projects (defined as Class 1 projects). On all Class 1 projects, specific measures should be taken to create a team environment between the SHA, designer, and contractor. Whenever possible, Class 1 projects should have construction input into the design, use two-phase contracts, require advanced contractor planning, be led by a senior SHA project manager, have a rapid response team assigned, use subsurface utility engineering (SUE), and be aggressive on schedule issues. The recommendations in the report detail how these aspects are achieved. Many more recommendations are given.

CHAPTER 1

INTRODUCTION

INTRODUCTION

A primary goal of state highway agencies (SHAs) is to serve the public by providing timely construction of highways with the least disruption to the motoring public and the local residential or business community. A significant annoyance to the public is when important projects are not started in a timely manner and when the actual progress of the construction work is longer than necessary, thereby prolonging the inconvenience. This report addresses how to avoid unnecessary inconveniences to the public as well as the motoring public by minimizing the construction duration.

Planning is key to avoiding construction delays. It is necessary for all parties to anticipate what can go wrong and to take measures to mitigate the situation. In this way, the parties become proactive instead of reactive.

STATEMENT OF THE PROBLEM

Time delays in highway construction projects are common. The root causes are varied and can be attributed to many parties, including the owner, designer, contractor, and utility. Yet, among the more common causes reported is that the agency, in response to external factors, initiates a project without proper planning. The designer is often not given adequate time to complete the design, or the site investigation is insufficient or outdated. The result is that the project may be let for bids with known flaws under the impression that the deficiency can be easily corrected with a change after the contract is awarded. Another problem that may occur is that the contract time of performance determined by the SHA may have been calculated incorrectly. Once the contract has been awarded, the contractor's planning horizon is often several weeks or less. Thus, there may be insufficient time to react to problems once they are identified.

The causes of delay are many. However, causes must be analyzed and developed in sufficient detail to allow effective strategies to be formulated. Past research has not achieved this level of detail, having stopped at defining apparent causes. Determining the root cause of delay is essential to developing mitigating strategies.

OBJECTIVES

The goal of this research is to detail practices and procedures that can be used to avoid or minimize the likelihood of construction delays to highway projects. Specifically, the objectives are to

- identify the root causes of delays in highway construction affecting the construction phase, and
- recommend practices, procedures, and methods that can be used by SHAs and contractors to avoid delays in completing highway construction projects and to mitigate the impact of delays and the associated costs.

SCOPE

Throughout this report, reference is made to delays in construction. Delays are defined as time extensions, without regard for the reason, that extend the period of inconvenience affecting the motoring public. The yardstick for measuring delays is the original contract time. The time frame required for planning and design is not at issue. The focus is on making sure any inconvenience to the public and local businesses is for the shortest possible amount of time.

The focus of this research is on delays in completion, which encompasses work stoppages and delays and other events that lead to extra work, rework, and changes in quantities. This focus supports the objective of mitigating impacts and costs, since many changes, etc. do not encompass work stoppages, but add extra work that will increase the time of performance.

While the focus of this project is on the construction phase, it is not possible to ignore the design phase, as many events occurring then will affect the duration of construction. Some aspects of the design phase are addressed in this report; however, the report should not be viewed as an in-depth examination of the design phase. Only certain aspects directly related to the construction duration are addressed.

RESEARCH APPROACH

The determination of root causes and proposed strategies or recommendations was done via several steps. First, a detailed literature review was performed. This literature review revealed that previous research had not examined root causes in sufficient depth. Because a root cause must be developed in sufficient detail to permit corrective action to be taken, previous research is devoid of satisfactory strategies and recommendations. The literature review is included in Appendix A.

Next, a comprehensive survey was sent to industry professionals including SHA engineers, designers, construction managers, and contractors. The survey was also distributed to representatives from other governmental agencies and trade associations. The results of the survey (see Appendix B) confirmed the findings of prior studies that the five major apparent causes of delay were utilities, differing site conditions (DSC), delays in environmental planning and permitting issues, design errors, omissions and changes, and weather.

The states of Florida, California, Georgia, South Carolina, New York, and Wisconsin were selected for on-site visits. Interviews were conducted with central office personnel (including legal counsel), district or regional personnel, and site personnel. Additional interaction was had with contractors, contractor trade associations, consultants, and construction managers. Contractor claims related to time extension requests were examined prior to the visit and served as the basis for discussing specific issues in detail. These discussions led to the identification of root causes of delay. While each state was unique and certain problems were more prevalent in some states than others, the root causes identified are common to all states and very little difference was noted in the severity.

From the root causes, the research team developed proposed recommendations using informal brainstorming sessions. The researchers drew heavily on their expertise in other construction industry sectors, particularly the industrial sector. Industrial construction is an

especially germane sector because of the complexity of projects and the general lack of tolerance for time delays. The root causes of delay were summarized by category.

The brainstorming sessions yielded 30 to 40 uniquely different recommendations. These were reviewed with SHAs and Federal Highway Administration (FHWA) representatives, designers, consultants, construction managers, and contractors. If recommendations were deemed to be unsuitable, they were deleted. Other recommendations were added or combined. Lastly, the research team reviewed the recommendations with the NCHRP 20-24(12) panel. The final recommendations are summarized in subsequent chapters of the report.

CHANGING ENVIRONMENT

The environment in which highway projects are designed and constructed has been changing over the last several decades. How these changes are affecting SHAs and the timely performance of their contractors is discussed below.

Historical Perspective

Historically, much of the effort needed to design and build a new highway was done in-house by the all SHA. This included the design, construction management, and inspection. Most construction projects were built on new alignments, and the right-of-way (ROW) acquisition was often large tracts of open land. The SHA was accountable to the legislature for the wise and prudent expenditures of funds.

SHA of the 21st Century

Beginning in the mid 1970s, the size of the workforce at SHAs began to dwindle. Today, the size of the staff of all SHAs (engineering and construction) has been reduced. One consequence is that the experience level has dramatically decreased. There is no indication that SHAs will ever return to the staffing levels of the 1970s. Similar trends have affected the experience level of designers.

Projects have changed, too. Most projects are on existing alignments such as freeway expansions, turning lanes, bridge replacements, resurfacing, and safety improvements. The ROW acquisition for these projects involves many small parcels of congested, improved, and expensive land. Projects on new alignments make up a smaller and smaller percentage of projects. To illustrate the effect of this change, a 1985 FHWA report listed differing site conditions as the number one cause of highway construction contractor delays and claims (Thomas et al. 1985a). There was no mention of utility locations and relocations. Today, the number one cause of delays is utility locations and relocations. This shift has led to changes in SHA organizations because of the need to communicate with numerous outside organizations. Today, there are many more participants in the construction project compared to two decades ago.

Federal legislation has increased the size of construction programs significantly. With more work to do and a smaller staff, it has become necessary to out-source much of the work. This out-sourcing includes design, inspection, and construction management services. This trend is seen to continue at a more rapid pace.

The SHA accountability has also changed. While there is still accountability to the legislature for prudent expenditures, SHAs are also accountable to the legislature for the impact of construction on local businesses and the traveling public. More and more local agencies (cities and counties) and citizen action groups demand accountability as to design, construction, delays, and impacts on local traffic.

Role of the FHWA

The FHWA plays an important role in the changes affecting the SHAs. The FHWA policies can promote and inhibit change. On the one hand, the FHWA promotes the use of new technologies like the effective use of subsurface utility engineering (SUE). At the same time, the FHWA may also inhibit change.

Change is Inevitable

The following major changes are occurring to SHA organizations:

- Reduced resources,
- Dwindling base of design and construction expertise,
- Fewer projects involving new alignments,
- More project participants,
- More out-sourcing,
- More coordination with outside agencies and organizations,
- More planning and design effort is required, and
- Greater accountability to the traveling public, private businesses, and citizen action groups.

SHAs are changing from “doer” organizations to “facilitator” organizations. Forces beyond the control of the SHA are bringing about these changes. The SHAs and the FHWA must respond to the changing landscape with new policies and procedures to allow for streamlined decision making.

SHAs and the FHWA have been slow to react to the forces that are causing changes in highway construction. The slow response may be caused by failure to recognize or understand the change, impediments by outside entities, or the natural tendency to resist change. The slow response by the SHA manifests itself in the root causes summarized in Chapter 3. The recommendations in this report are presented as a comprehensive and coordinated response to the changing landscape that defines highway construction.

USE OF THE REPORT

The recommendations in this report are organized according to the following categories:

<u>Code</u>	<u>Description</u>	<u>Chapter</u>
BPP	Business Practices and Procedures	4
CP	Contractor Procurement	5
CA	Contract Administration	5

CI	Contractor Input Into Design	6
U	Utility Location and Relocation	7
CM	Contractor Management	8

In general, the categories are grouped according to the party that is responsible for implementation. Following each recommendation is a rating indicating the significance of the recommendation according to the following four criteria :

- Does the recommendation address a root cause?
- Will the recommendation have significant impact on the timeliness of construction?
- Will the recommendation be easy to implement?
- Can the recommendation be implemented in the short-term?

Using these criteria, each recommendation was rated by the researchers using the rating sheet illustrated in Table 1. A star (*) is used to denote the rating of each criterion. The rating was done by the principal investigator.

Table 1. Rating Sheet for Recommendation BPP-1.

Recommendation	Addresses a Root Cause	Significant Impact	Easy to Implement	Short Time Frame
BPP-1: Endorse the Widely Accepted Cost-Influence Principle	<input type="radio"/> No	<input type="radio"/> Low or none	<input type="radio"/> May require legislation or high need for coordination	<input type="radio"/> Will be a long-term solution
	<input type="radio"/> Somewhat	<input type="radio"/> May have a modest impact	<input type="radio"/> Intermediate coordination	<input type="radio"/> Will require some time
	<input type="radio"/> Yes, one or more	<input type="radio"/> Yes, high impact	<input type="radio"/> Can be easily done	<input type="radio"/> Can be done in a short time frame

ORGANIZATION OF THE REPORT

Chapter 2 of this report describes some fundamental principles of project management. These principles form a basis for assessing the impact of the recommendations made throughout this report. In Chapter 3, the root causes of time delays to highway construction are listed. These are organized into business practices and procedures, contractor procurement, contract administration, contractor input into design, utilities, and contractor management. The next five chapters of the report cover recommendations in these areas. Chapter 4 addresses business practices and procedures, Chapter 5 covers contractor procurement and contract administration, and Chapter 6 makes recommendations on how to provide contractor input into design. Utilities are covered in Chapter 7, and contractor management is addressed in Chapter 8. Chapter 9 is the implementation plan and Chapter 10 gives a summary, conclusions, and recommendations for future research.

CHAPTER 2

FUNDAMENTAL PRINCIPLES OF PROJECT MANAGEMENT

A synthesis of root causes of delay led to the development of a hierarchy in which recommendations can be made. This hierarchy is shown in Fig. 1. Practices and procedures affect all the aspects of project execution and there are recommendations made in these areas. Specific recommendations are also made in the four technical areas shown. The report is organized according to the hierarchy in Fig. 1. The first two levels of the analysis scrutinized root causes related to SHA business practices and procedures. From these analyses, it became apparent that there were certain management principles that needed to be accepted by upper level managers before specific recommendations would stand a chance of success, and failure to accept these principles will likely negate any advantage that might accrue from specific recommendations.

FUNDAMENTAL PRINCIPLES

The following fundamental principles are used as a guide for critiquing the suitability of various recommendations. Throughout the course of the interviews, it became apparent that many of the fundamental principles listed below are not followed. It is essential that these principles be adopted as prerequisites for the successful application of any of the recommendations detailed in the subsequent chapters.

Cost-Time-Influence

More time spent during design planning and identifying problems will reduce construction time. A widely recognized principle is that spending more time and money during planning and design will reduce the time and cost required for construction by avoiding unforeseen conditions, reducing to a minimum design errors and omissions, and developing schemes that will support the most efficient approach to construction.

Priority

Timely completion of projects must be a priority. The SHA must take the lead in establishing timely completion as a priority within its own organization and with its consultants and contractors. Timely completion should be a major consideration when implementing policies, management procedures and specifications. Critical resources should be applied to projects based on the importance of the project.

Accountability

All members of the project team must be accountable for their performance. A team concept must be embraced, and one person should be appointed as team leader to shepherd the project throughout the process of execution or delivery. In many agencies, a single project manager is not the practice and may not be feasible. Here, there needs to be a time period of overlap between the design and construction manager in order to provide a seamless transition. Certainly, the construction manager needs to be involved before the design is finalized, and the

design manager needs to continue through the early part of construction. Open channels of communication need to be maintained.

Performance of the team with regard to timely completion of the project should be measured for all members of the project team: SHA personnel, consultants, contractors, and outside agencies. Individuals and organizations should be accountable for timely completion.

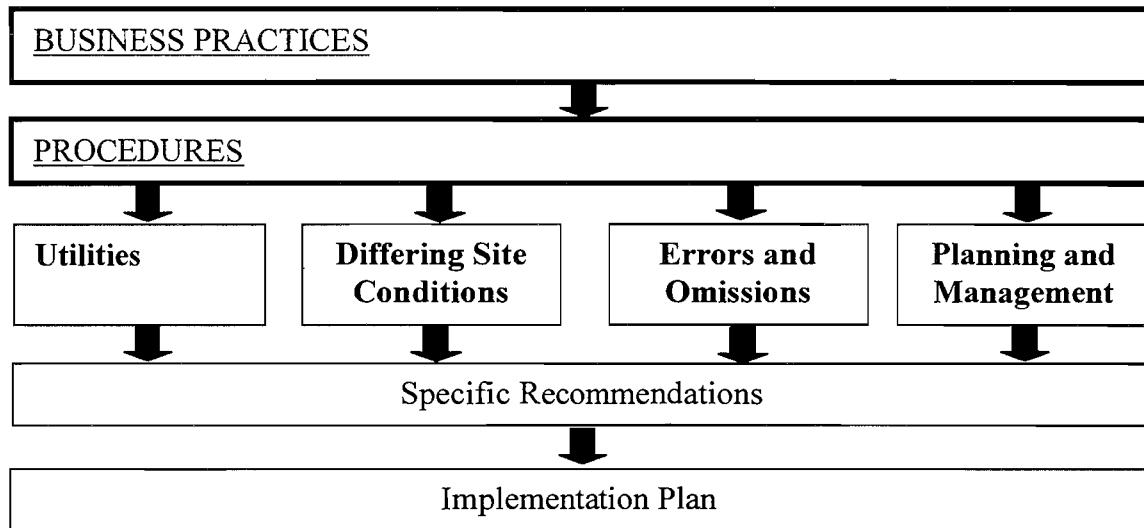


Figure 1. Recommendation Framework.

Rewards

Reward systems must reward superior performance. Accountability must be matched with systems that provide rewards (primarily non-monetary) for superior time performance. This should be considered when developing contractor and consultant qualification procedures, contract award procedures, contractor and consultant payments for additional work, contractor and SHA and consultant project evaluations and performance incentives.

Knowledge

Superior knowledge and skill must be available at all steps in the project development and delivery. Reduction of errors and omissions requires the knowledge and skill that is obtained from experience. The shrinking experience base within the SHA and design consultant communities must be captured and leveraged for all participants through training and access to Information Technology. Project development and design must have access to construction knowledge and input.

Efficiency

Organizational structure and processes must support delay avoidance and mitigation. Sound and timely decisions are essential to reduce delays. The organizational structure with regard to communications, decision authority, and process must support the earliest possible resolution of project problems.

Innovative Thinking

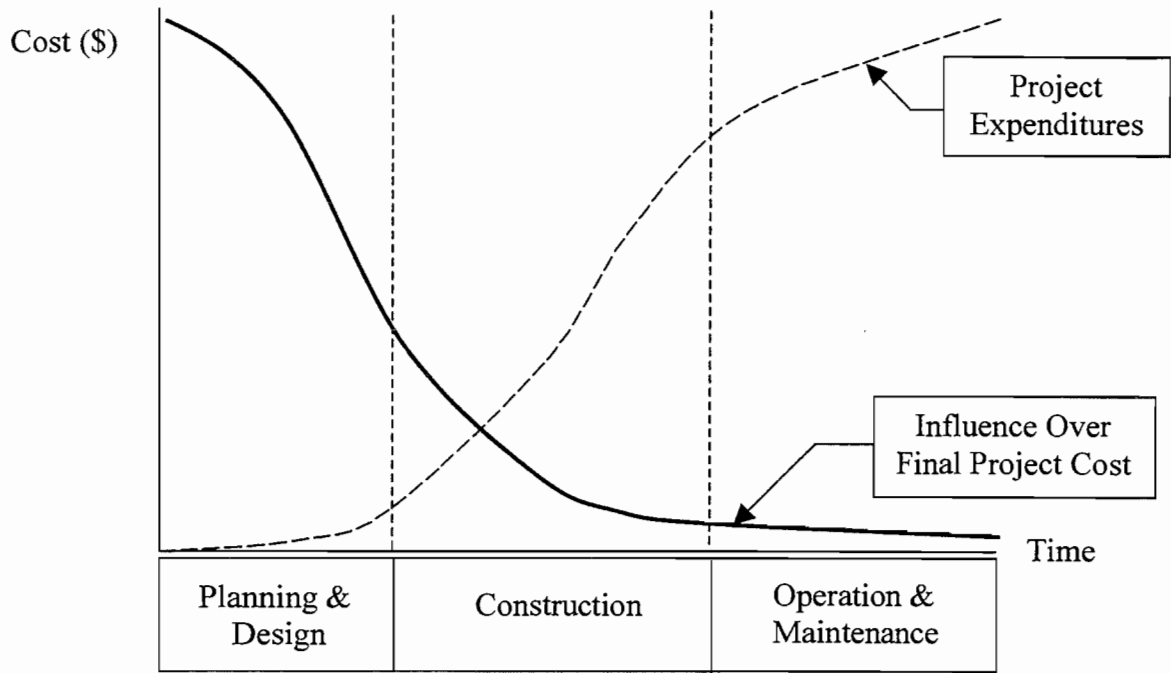
Innovative thinking is an important axiom to risk aversion. Many organizations possess a large degree of inertia with regard to doing things the same way. Change can be associated with risk. There is a premium on not doing anything that will create risk to the agency. Unfortunately, this often means that new ideas that have minimal negative consequences or risk do not have room to emerge. Obtaining substantial improvements in performance often requires doing things in a fundamentally different way.

Change and the 21st century. Change is slow in coming to many SHA organizations. As stated by TRB Circular 386, the dominant goal that guides the awarding of highway contracts is to minimize risks and reduce costs (TRB 1991b). Yet, in recent years and into the 21st century, a rapidly emerging goal on many projects is timely completion. A common complaint about SHAs is that they are guided primarily by the way things have been done in the past. Many responsible persons in the highway agency have found it difficult to respond to the changing environment over the last 25 years. For instance, the approach of some relative to subsurface utilities, is to “tell the utility where the highway is going and get out of our way.” In this regard, time as a primary project criterion is a relatively new goal, and applying modern management principles from other construction sectors is not readily understood or accepted. Resistance to change is real.

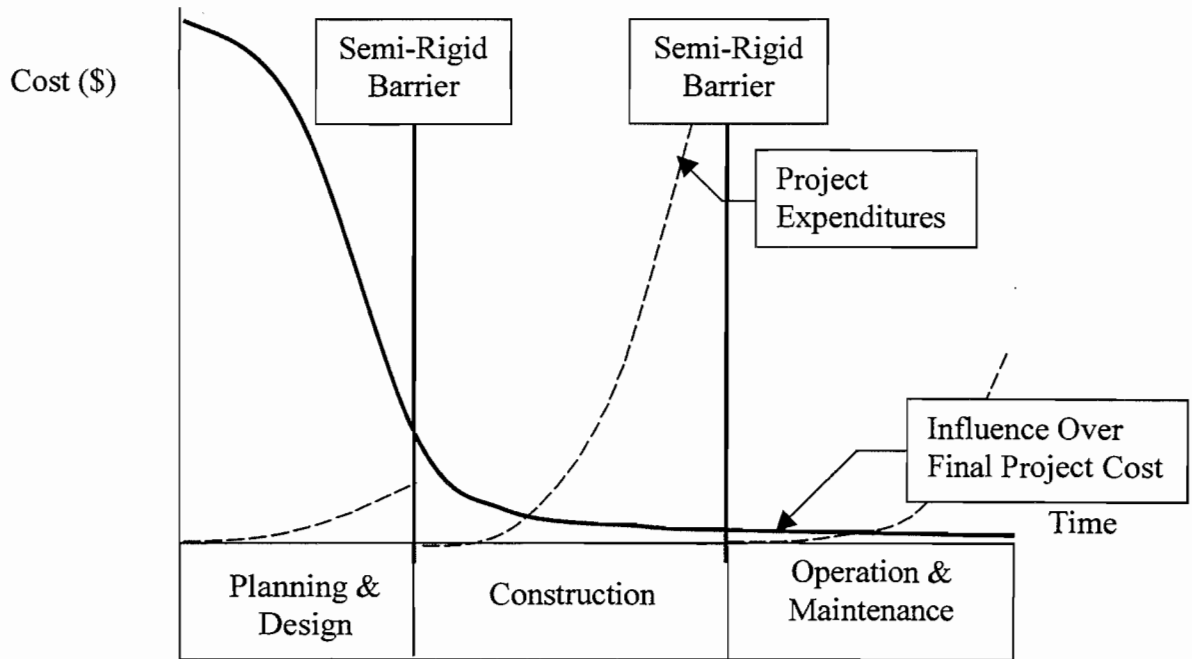
COST-TIME-INFLUENCE

A well-recognized principle in design and construction is that time and monies spent in design will save monies and time in construction. This concept is embodied in Fig. 2 (Barrie and Paulson 1992). Fig. 2(a) shows the widely accepted view that in the design phase, the opportunity to make decisions to influence the final project cost is greatest. Yet, the expenditure of project funds is comparatively minimal, typically about 10% of the capital budget. In fact, regulations may preclude the designer from spending the time and monies necessary to make the project less expensive, more timely, and of higher quality. The typical SHA model is shown in Fig. 2(b) where budgets do not permit the expenditure of more on design and less on construction. Each organizational entity (e.g., planning and design, construction, and maintenance) has its own budget and may have little influence on decisions made across departmental barriers. A true project team is needed to facilitate early decisions that will save monies later, yet such a team environment does not always exist. It is no coincidence that one of the highest cited causes of delay and cost overruns on highway projects is errors and omissions in the contract drawings.

Fig. 2 relates mainly to project costs. Very few data are available to establish a similar relationship for project time. However, in a study published by The Rand Corporation (Myers et al. 1986), the authors show the schedule slippage as a function of the amount of time overlap



a) Widely Accepted Cost-Influence Curve.



b) SHA Cost- Influence Curve.

Figure 2. Cost-Influence Curves.

Efficiency

Organizational structure and processes must support delay avoidance and mitigation. Sound and timely decisions are essential to reduce delays. The organizational structure with regard to communications, decision authority, and process must support the earliest possible resolution of project problems.

Innovative Thinking

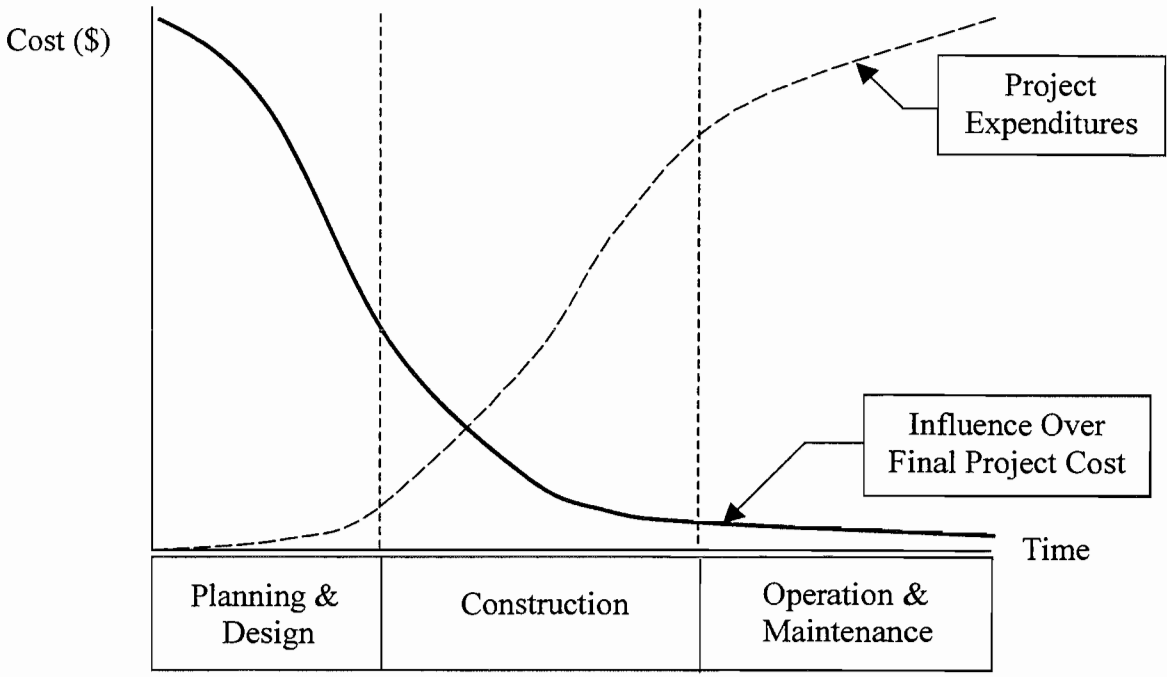
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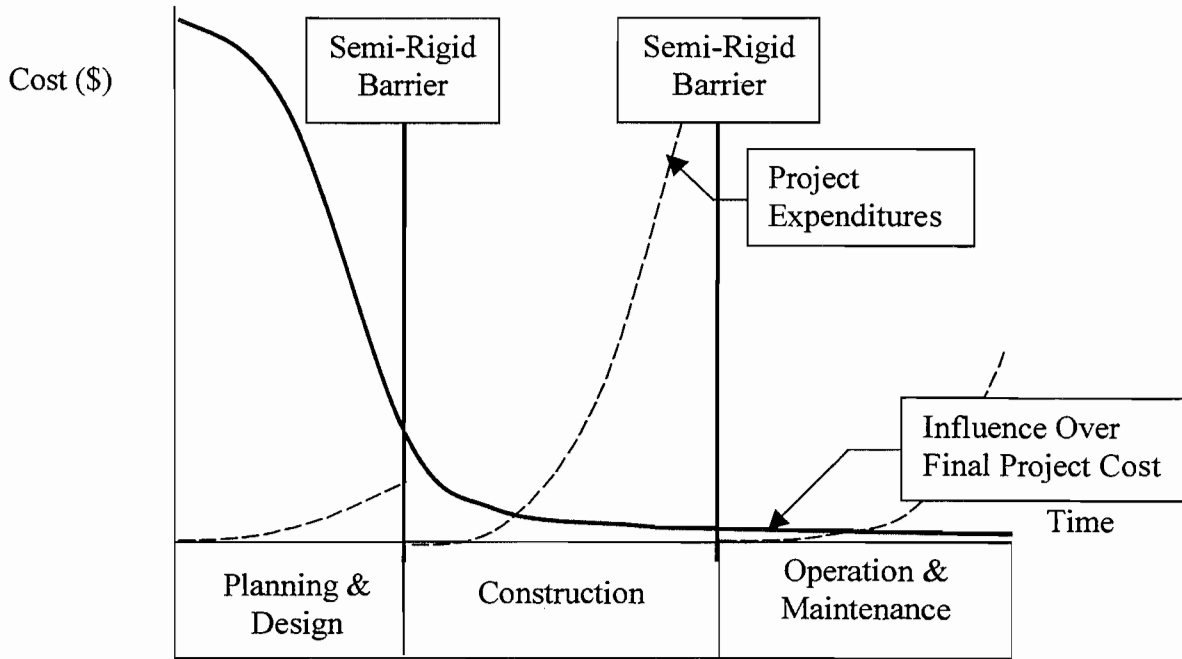
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b) SHA Cost- Influence Curve.

Figure 2. Cost-Influence Curves.

between engineering and construction. While not directly comparable to the present discussion, Fig. 3 does show that for the 29 industrial-type facilities there is extreme difficulty in maintaining the construction schedule when engineering is accelerated, incomplete, or inaccurate. Less than 25% of the projects did not experience schedule slippage, and in each instance, the engineering effort was not expedited. This concept does have application to highway construction because many highway designs are expedited, and schedule slippage is more problematic with expedited designs.

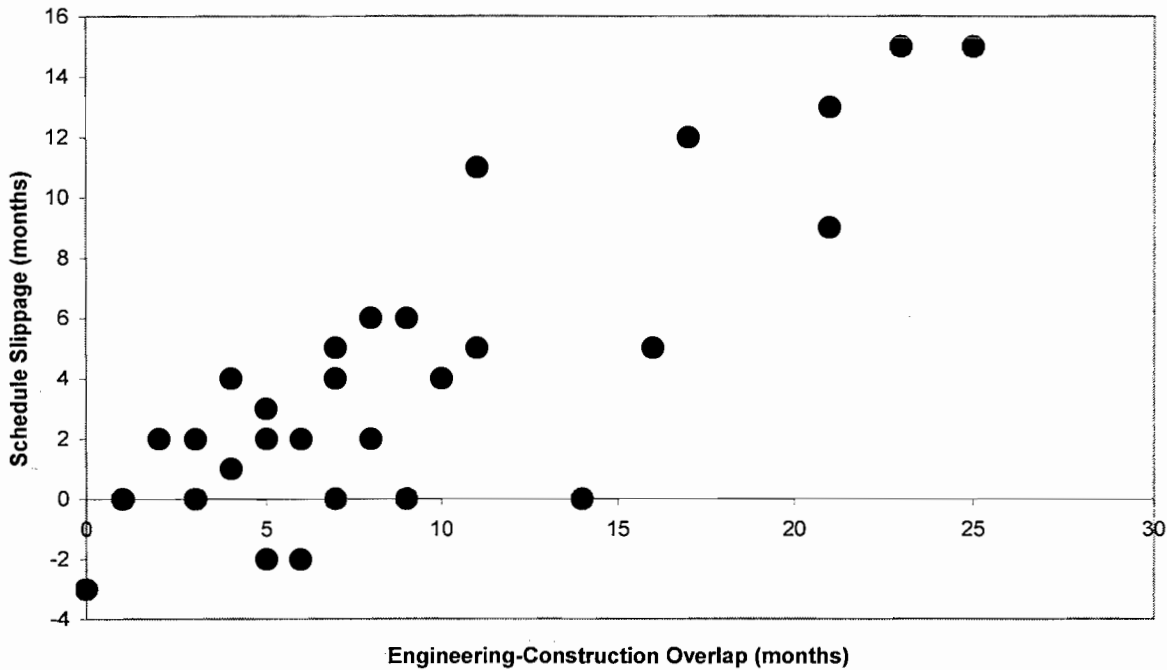


Figure 3. Relationship Between Schedule Slippage and Completeness of Engineering (Myers et al. 1986).

PRIORITY

No obvious system of project priorities was identified during the site visits, meaning that generally all projects are treated alike. At the central office level, it may be decided that a particular project is unique and deserves high priority regarding time. However, this urgency is not clearly communicated to the project level, which means that all projects are treated alike, or nearly so. The result is that the resources are not always applied on the basis of the urgency of the project. A few high-profile projects are the exception.

ACCOUNTABILITY

The design-bid-build approach consisting of the SHA-designer-contractor can sometimes limit the ability of the project team to deliver projects in a timely manner. But the process must be properly managed. This view is true even if the design is done in-house by the SHA. To understand the way the limitation works, consider the design-build approach. A team environment, particularly with the contractor and designer, is created because the success of the contractor-designer team is predicated on the success of the project—that is, timely completion.

Lack of accountability and misplaced priorities are common problems in highway construction. Under the present design-bid-build arrangement, only the contractor is accountable for the timely delivery of the project. The designer is accountable for completing the contract documents by a specified time. If inadequate plans lead to cost overruns and time extensions, the designer is not generally accountable because the design contract has been fully executed. A comment heard repeatedly during the site visits was that contracts were let with known errors because deadlines had to be met. The solution to errors or omissions was to “let construction take care of it.” Thus, the design-bid-build arrangement creates a situation where each party is accountable for different objectives, which negates a true team environment.

Contractors are held accountable for timely completion, but time extensions are readily granted for unforeseen circumstances. Contractors are not held accountable to look ahead and mitigate unforeseen events that frequently lead to delays. SHA employees are not held accountable for timely completion either. Timely decisions are not always forthcoming, and SHA practices requiring the contractor to adhere to its own schedule are not uniformly applied.

REWARDS

The reward system does not positively reward all parties for timely completion. Instead, the contractor is negatively rewarded with liquidated damages. Sometimes, bonuses may be offered, but without the designer and SHA being similarly rewarded, timely completion may be difficult to achieve without a time extension. There is a need to provide non-financial, positive rewards for all team members when timely completion is achieved.

What is needed on time-sensitive projects is a team concept where each team member is held accountable for the successful attainment of timely project completion. It is not sufficient to optimize the subparts with the view that the overall project goals will be optimized in the process.

KNOWLEDGE

Another problem often heard is that “construction knowledge is not incorporated into the design.” There are many reasons for this occurring. First, both SHAs and designers have lost construction expertise through retirements and changes in employment. The increased volume of work has made this situation much worse. The pressure to let projects quickly further limits the SHA from incorporating construction knowledge into the design. The SHA may not make the best use of the knowledge that is readily available.

EFFICIENCY

The SHA organization must change from a bureaucratic organization having a primary goal of cost reduction to one that includes also the goal of timely completion. Consistent with the change from “doer” to “facilitator” organizations, the SHA has less control and there is more reliance on others. The organization needs to be efficient and provide for rapid responses to technical and managerial problems.

INNOVATIVE THINKING

Based on discussions with SHA officials, contractors, and consultants during the site visits, it was sometimes apparent that there was an old school attitude that “we tell them (utilities) where we are going and it is their responsibility to get out of our way.” Further, there is a lack of innovative thinking in many quarters that places a high premium on “business as usual.” Young project engineers and managers are frustrated by an intransigent attitude of some senior managers and are more likely to seek employment elsewhere, thus further exacerbating the problem. In support of this observation, TRB Circular 363 (TRB 1991a) has identified three major barriers to innovation. These are:

- Resistance to change,
- Risk potential, and
- Cost factors.

Thus, before substantial progress can be made on timely completion of highway projects, the barriers to doing things differently must be taken down.

Certainly there have been a number of new initiatives in the past 10 years. The TRB Task Force on Innovative Contracting Practices summarized a number of innovative practices that had been tried under the FHWA’s Special Experimental Project No. 14 (TRB 1991b). The report detailed practices, recommendations, and research needs in four major categories:

- Contract bidding procedures,
- Material control enhancements,
- Quality considerations, and
- Insurance and surety.

Of particular interest to this project are the recommended practices in contract bidding. The TRB Task Force recommended greater use of A + B bidding, lane rentals, warranties, constructibility reviews, incentives and disincentives, and other strategies. This project spawned other NCHRP research into innovative contracting practices, constructibility reviews (Anderson et al. 1997a), warranties (Hancher 1994), and quality-based prequalification (Minchin and Smith 2001), among others. Many of the recommendations and developments in these studies have been put into practice with varying degrees of success. However, not all projects are suited for warranties, design-build contracting, A + B bidding, etc. It would appear that the design-bid-build arrangement discussed earlier will continue to be the primary SHA mode of contractor procurement. Thus, innovative ways to improve the design-bid-build process are the principal focus of this report.

CHAPTER 3 ROOT CAUSES OF DELAY

The root causes of delay were determined through interviews with industry representatives. In some instances, the root cause was not identified per se by any one individual or organization but, rather, emerged from the researchers' perception in repeatedly hearing similar problems and statements. Also, the researchers relied on their understanding of practices in other construction industry sectors and good management principles.

ROOT CAUSES OF DELAY

The root causes of delay are summarized in Appendix C. These are organized in accordance with the framework established in Fig. 1. Seven categories of root causes are shown. These were identified by the researchers through on-site interviews and from discussions related to specific contractor claims. Addressing these root causes forms the basis for the recommendations made throughout the remainder of this report.

COMMENTARY ON ROOT CAUSES

As can be seen, the root causes of delay are many and varied. Some relate to specific areas of concern like utility locations and relocations, while others relate to broader generalities like the SHA philosophy and business practices. Most relate in some way to the misapplication of the fundamental principles in Chapter 2.

The breadth of the root causes indicates that there is no "silver bullet" to alleviate the problem of untimely completion of highway projects. Making the contractor accountable for planning ahead will not work unless the plans are made more constructible. Making plans more constructible will not suffice unless the subsurface utilities are correctly located. Correctly locating utilities is only a partial solution if utility companies will not move existing utilities in a timely manner. Many other similar scenarios could be developed. Clearly, comprehensive solutions are required.

CHAPTER 4

RECOMMENDATIONS RELATED TO SHA BUSINESS PRACTICES AND PROCEDURES

This chapter provides recommendations relative to SHA business practices and procedures. These recommendations create an environment in which area-specific recommendations, such as utilities, differing site conditions, errors and omissions, and contractor management practices will have the greatest opportunity for success.

BUSINESS PRACTICES

The term business practice refers to the philosophical way that business is done. In the context of this report, it refers to the approach to planning, designing, and executing highway construction projects.

In Chapter 1, the major changes affecting SHAs were briefly summarized. Failure to react quickly to these changes manifests itself in the root causes relative to business practices identified in Appendix C. These root causes are the basis for the recommendations listed below.

Recommendations

Promote Cost-Time-Influence

Recommendation BPP-1: Embrace the Widely Accepted Cost-Time-Influence Principle. This principle states that more effort in planning and design will lead to cost and time savings in construction.

Rating:

- | | |
|---|-----|
| ▪ Addresses root cause | *** |
| ▪ Will have a significant impact | *** |
| ▪ Can be implemented with relative ease | * |
| ▪ Can be implemented in the short term | ** |

The cost-time influence principle states that if more time and monies are spent in planning and design, construction cost and time will be reduced. A corollary to this principle is that the design goal is to make the design accurate and easily constructible, and the design is not driven by unrealistic deadlines. One solution to the deadline problem is to start sooner. This principle has been widely accepted for many years in certain sectors of the construction industry, particularly industrial construction (Barrie and Paulson 1992). A few reports have also cited project statistics that support the principle (see Fig. 3). This principle was discussed in depth in Chapter 2.

The research found that the cost-time principle was not widely followed. Rather, designs were driven by significant pressure to meet deadlines for project lettings at the expense of accuracy and constructibility. This rush is sometimes driven by the need to take advantage of federal or state funding constraints, but at other times the reason is political. A common

complaint heard throughout this research was that projects were let for bids with known errors but it was left to construction to correct the problem. The field is the worst place to correct a design problem, and the toll on project cost and time is enormous. Extra work takes more time, and the SHA loses the benefit of competitive pricing on the work.

The upper echelons of the SHA should strongly embrace this principle. It should be adopted as a new paradigm for the 21st century. This paradigm is consistent with the current contracting environment where there are numerous projects and many are in high-traffic and congested environments. More planning and design effort is required.

Rethinking how projects are executed will be needed. More time will likely be needed on the front-end of planning and engineering to minimize the construction time. One barrier to implementing this principle is the pressure from legislative and citizens' groups to retain the deadline concept. There must be a concerted effort to sell the principle, and SHA officials must resist the pressure to succumb to the old deadline way of doing business. Some budgetary issues will probably need to be addressed.

Define Class 1 Projects

Recommendation BPP-2: Develop a Time Classification Scheme. The scheme should be applied to each project based on the time sensitivity of the project. The most time-sensitive projects (Class 1) will have the greatest resources applied to ensure timely completion. This recommendation will allow SHAs to react to the increased accountability to the public and private businesses.

Rating:

▪ Addresses root cause	***
▪ Will have a significant impact	***
▪ Can be implemented with relative ease	**
▪ Can be implemented in the short term	**

The research found that most projects were treated alike. Even when determined to be time-sensitive, decisions at the project level were usually based on the lowest-cost solution, often at the expense of time. Time extensions were frequently granted with little regard for time sensitivity. The research found that the same practices and procedures are applied to most projects. One problem for the SHA is that there are insufficient resources within the SHA to be equally and effectively applied to all projects. What is needed is to define a classification of projects for which the scarce resources are applied where the need is most urgent.

A three-level classification scheme is proposed. The classification scheme will permit the SHA central office, and in some instances the district or regional office, to communicate to persons responsible for planning, designing, and executing projects at the desired level of time sensitivity. This communication should be from the upper management level. The classification should allow the SHA to focus critical resources on the most important projects. The proposed classifications are:

Much has been said and written about creating a project team environment on highway construction projects. Partnering is one effort to create a more harmonious team environment on highway projects. Some research conducted on private work indicates that the team chemistry is a very important determinate for project success.

One element of a team environment that is essential for success is that each participant shares accountability for the same thing—in this instance, for the timely completion of the project. Such is typically not the case in highway construction. Specifically, designers are usually responsible for issuing the plans by a certain date, the contractor is responsible for timely completion, and the SHA is responsible for contract administration. It seems difficult to create a true team environment unless all participants are accountable for the same thing, that is, timely completion. Partnering alone does not overcome this deficiency, particularly since partnering does not take effect until after the award of the contract.

This project did not involve the study of employee evaluation procedures. However, in discussions with SHA project personnel, there was no indication that employee evaluations are based on the successful outcome of the project.

Employee evaluation procedures for Class 1 projects should incorporate outcome-based performance criteria so that SHA administrators and project engineers will be accountable for the timely completion of the project. State employees will have an incentive to look ahead to anticipate problems and to work with the designer and contractor to arrive at timely solutions. To ensure satisfactory performance evaluations, SHA employees should participate in constructibility reviews and other activities designed to promote timely completion.

The timely completion of a project should be tied to the original completion date specified in the contract except in rare areas where the delay is truly beyond the control of all parties. Time extensions should not be counted because all parties should be looking ahead to foresee problems before they become critical.

One concern is that employees and inspectors may ignore cost and quality issues just to finish on time. This concern needs to be addressed through other criteria in the evaluation procedures. Not all employees will want to risk promotions, etc. on the performance of others and they may choose not to participate in Class 1 projects.

Adopt Innovative Contracting Practices

Recommendation BPP-4: Encourage the Widespread Use of Innovative Contracting Practices. There are numerous contracting practices that can promote constructibility and timely completion. Among these are the design-build and construction manager approaches. Additionally, there are A + B bidding, lane rentals, incentives and disincentives, no excuse bonuses, and others. These approaches should be promoted within the agency, and guidelines on when to use each practice should be developed.

Rating:

- | | |
|---|----|
| ▪ Addresses root cause | ★★ |
| ▪ Will have a significant impact | ★★ |
| ▪ Can be implemented with relative ease | ★ |
| ▪ Can be implemented in the short term | ★ |

TRB Circular 386 described some of the more innovative practices in contractor procurement that should be considered by SHAs (TRB 1991b). Many of these practices have been applied by various states. However, their use has not been widely accepted. Even in states where used, the practices are sometimes applied to only a few projects. When applied, they are not part of a comprehensive plan to alleviate the problem of untimeliness.

New practices and procedures should be part of a comprehensive approach directed to solving a specific problem, for example, the problem of untimely completion. In developing a comprehensive plan, the problem should be studied thoroughly. A well-worn saying worth repeating is that “a problem that is well understood is half solved.” When a problem is well understood, the breadth is exposed and comprehensive solutions can be proposed. Non-comprehensive solutions tend to limit the effectiveness of a strategy.

New and innovative approaches should be applied to alleviate a particular problem, not just because they are new or different. As an illustration, one state in this study has been using the bid-averaging method of determining to whom a project is awarded. The average of all bids is computed and the contract is awarded to the firm with the bid closest to the average. Unfortunately, some contractors have subcontracted the project to the lowest bidder anyway. The state pays a higher price while it still has the low bidder performing the work at the low bid price. The practice is innovative, but not all innovative practices are good.

Not all practices are applicable to all projects. For example, on some projects, incentives may work, while on others, they may not. Guidelines should be developed on how innovative practices should be applied.

Fully Utilize Dispute Review Boards (DRBs)

Recommendation BPP-5: The Experience and Expertise of the DRB Members should be More Fully Utilized. DRB members can contribute to the project by offering recommendations relative to specific problems and by looking ahead to foresee other problems that may escape the contractor or SHA. They can offer suggestions on how to more fully use project resources, how to be more efficient and timely, and how to produce a higher-quality product.

Rating:

- Addresses root cause ★
- Will have a significant impact ★
- Can be implemented with relative ease ★★★
- Can be implemented in the short term ★★★

Dispute Review Boards (DRBs) typically consist of three experienced construction professionals selected by the contractor and the SHA. These professionals are appointed at the beginning of the project and are paid for their services. The board visits the project during construction at regular intervals or as requested. The board receives regular project updates and hears details of disputes between the contractor and SHA. Because of the regular visits, the board is often aware of potentially troublesome situations from their inception. Having heard both sides of an argument in an informal setting, the board renders a decision regarding contractor entitlement relative to cost and time. Decisions are generally made during the course of the project, thus timely resolution is the norm. While the decision is non-binding, it is usually followed. Thus, the DRB allows the parties to focus on completing the project rather than on gathering facts about a claim.

The research found that not all states were using DRBs. States not using DRBs should consider doing so. The research also found instances where the DRB was not particularly effective. Too little time was spent at the site and the DRB did not examine compliance with the contract. For instance, schedule updates were not requested.

Because the board is knowledgeable of construction practices, an informed decision can be made. However, it is often difficult to reconcile the events on the job with detailed contract language and legal aspects of the contract. Therefore, decisions may differ from what would be the case if the dispute were heard before a judicial tribunal. Another downside is that the SHA legal counsel will likely handle fewer contract disputes and may fail to gain the experience necessary to handle a large, complex dispute when the need arises. Thus, outsourcing for legal services may be appropriate.

Because DRBs consist of seasoned construction professionals who visit the site regularly, it seems wasteful to limit their usefulness to the project to only hearing about contract disputes. It is recommended that the role of the DRB be enlarged to offer suggestions on ways that the project performance can be improved. The recommendations of the DRB would be advisory and a written report would not be required. If the DRB offers suggestions, observations, and advice, future problems may be avoided, which may reduce the number and duration of delays. There is

precedent for this role of the DRB because in prior years, this function was fulfilled in part by the FHWA.

The expanded role of the DRB is more important as the project becomes more complex and distressed. Experience has shown that the first casualty of a distressed project is day-to-day planning. The result is that the problems inhibiting progress are “right under the contractor’s nose” and are readily obvious to attentive outside observers. The benefits of fully utilizing the expertise of the DRB have been cited by project participants, and in one instance a benefit-cost ratio of 20:1 was reported.

It has been proposed by some that the expanded role of the DRB should be assumed by a group separate from the DRB, possibly an in-house team. This could be readily accomplished, although the need for a separate group is not entirely clear. The DRB should be able to expand its membership as needed for this special role.

CHAPTER 5 RECOMMENDATIONS RELATED TO CONTRACTOR PROCUREMENT AND CONTRACT ADMINISTRATION

The recommendations in this chapter should be addressed by the chief engineer with appropriate input from legal counsel. The recommendations relate to the way construction services are procured and how the construction contract is administered.

CONTRACTOR PROCUREMENT AND CONTRACT ADMINISTRATION

This discussion on the procurement of construction services refers to the manner in which construction services are acquired. This includes bidding and contractor selection criteria, and how the contractor scope of services is packaged.

Recommendations

Award a Single, Two-Phase Contract

Recommendation CP-1: Award A Single, Two-Phase Contract. In Phase 1, the contractor does all the preplanning necessary to ensure that disruptive events are avoided. To complete Phase 1, the contractor should have an approved schedule, obtain all permits and easements, have all submittals approved, have an approved maintenance of traffic (MOT) plan, relocate certain specified utilities, etc. The contractor is not allowed to proceed with Phase 2 field construction until all Phase 1 tasks are satisfactorily completed. The primary clock time is applied to Phase 2, but there can be a time limit on Phase 1.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	***

The current practice is that when a highway construction contract is awarded, a notice to proceed (NTP) is issued. The NTP typically instructs the contractor to begin work within a specified number of working days or by a specific calendar date. Job trailers are delivered, barrels and signs are erected, equipment is transported to the site, and clearing operations begin. Some advance planning is done before the NTP, but much of the detail planning and organizing is done after the contractor has mobilized at the site.

In comparison, industrial outage or turnaround construction is intensely planned. Everything is considered, plans are reviewed, submittals are approved, the schedule is reviewed closely, contingency plans are made, all materials are available and organized, etc. Even though the outage work is complex, the schedule is almost always met. The key determinant for success is planning.

Conversely, in highway construction, there is a rush to show that work is under way. Mobilization and the start of work may begin without the schedule and plan being finalized, the submittals likely have not been approved, cost and time reduction incentives may not have been submitted, and revised maintenance of traffic plans may not have been developed, utilities may not have been relocated, and so forth. It is no coincidence that highway construction is often plagued by delays in completion since work often begins without adequate planning.

The extent of the problem is illustrated by a 1985 FHWA report on scheduling practices. Of more than 1,700 contracts from 5 states, almost 45% of the projects finished beyond the original completion date. The results are shown in Fig. 4. The report went on to state that based on an analysis of 63 projects in New York State, if a project was behind schedule after 10% of the original contract time had elapsed, the likelihood of that project finishing on time was only 31% (Thomas et al. 1985b). Quite clearly, more emphasis needs to be placed on early planning.

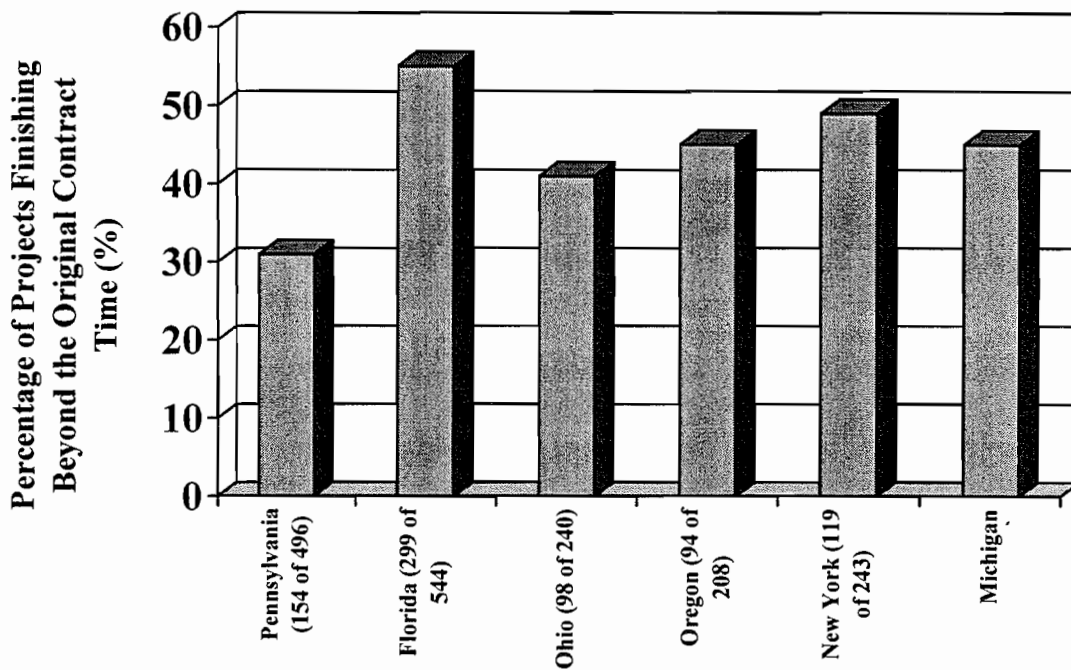


Figure 4. Percentage of Projects Finished Beyond the Original Contract Time (Thomas et al. 1985b).

The research on this project found that in many instances, little had changed since 1985. The mindset of SHAs and contractors was to show quick progress, often at the expense of late completion. Mobilizing and erecting barricades to commit the monies was often given priority over advance, detailed planning.

A single, two-phase contract is proposed to provide adequate time for planning. A two-phase contract means that during Phase 1, the contractor is not allowed to interfere with the motoring public until he or she is ready to vigorously attack the project. An added advantage to the contractor is that the start time for the project can be adjusted to accommodate the contractor's workload.

The contractual requirements for Phase 1 need to be specified, including the planning tasks that must be completed and the basis for payment for Phase 1 activities. A few work items may be permitted during Phase 1 that have limited effect on the public, such as utility relocations, purchasing and storage of key materials, constructibility reviews, VE proposals, cost and time reduction proposals, revised maintenance of traffic plan, etc. There may be liquidated damages associated with Phase 1, but the amount will need to be determined differently than for Phase 2 (construction phase). Importantly from a budgetary standpoint, the SHA will have committed the monies to construct the project.

Require Preplanning During Phase 1

Recommendation CP-2: Require that Contractors Have Key Planning Documents Approved Prior to Commencing the Work. These planning activities should be Phase 1 functions. The contractor should be required to have an approved project schedule, have key submittals approved, and have approved (or disapproved) value engineering and maintenance of traffic proposals. Evidence that key materials have been ordered and projected delivery dates may also be required.	
Rating:	
Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	***

Industrial outage projects are very intense, but are almost always successful in that the schedule is met. The reason is that these projects are intensely planned. In contrast, many other projects, including highway projects, are not planned to the same extent. Often, contractors mobilize without an approved project schedule, key submittals not submitted, permits not received, value engineering proposals and revised maintenance of traffic plans not fully developed, and many other unresolved issues. Many of these projects do not meet the specified completion date. The key determinant for success is planning.

There are a number of other planning documents that could be required. The important issue is that the contractor has time to do the advance planning necessary to ensure a successful project. These items could be included as a pay item in the contract. Only when these items have been completed would the contractor be allowed to impede the traveling public.

A + B Bidding

Recommendation CP-3: Use a Realistic “B” Parameter in A + B Bidding. The B parameter should be based on actual cost to the DOT, including cost to the user and local businesses that may be affected.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	**

In A + B bidding, the A value is the contractor’s cost to build the project. The B value is a daily cost that is determined by the SHA that is multiplied times the time t proposed by the contractor. For a \$10 million project taking 200 working days at a B rate of \$1,000 per day, the contractor’s bid would be calculated as \$10.2 million. This figure would be used to determine the low bidder. In this instance, the contractor would only be paid 10.0 million, but the contract would be written to require performance in 200 working days. The liquidated damage amount would be \$1,000 per day. The practice of A + B bidding has become popular in recent years.

In A + B bidding the contractor determines the time required to complete the project. However, the SHA determines the importance of time by specifying the value of the parameter “B.” If the value is high, the contractor plans the work carefully because a small amount of time can make a large amount of difference in the overall bid amount. If “B” is small, then time is not particularly important in determining the low bidder.

The research on this project found that in the six states visited, there was no clear methodology for establishing the daily “B” value. Most officials admitted that the value used was low but that a higher value would draw criticism from the state contractor association. The daily time cost is most often calculated in the same manner as the liquidated damages amount, and for most A + B projects it is used as both the “B” value and the liquidated damages amount.

The traditional cost of the “B” value is the motorist user cost, which is the cost to the motorist as a result of any transit time delay incurred because of the construction. However, many SHAs have begun to broaden the range of cost components used in determining daily project costs. Research conducted by the University of Florida has shown that “user cost” calculations, in addition to motorist cost, now include accident costs, environmental cost, and the cost to impacted businesses (Ellis and Herbsman 1997). However, the study found that states usually did not include all costs, for example, extra administrative costs.

Some research into the most appropriate value of the “B” parameter is justified. If the “B” parameter is too large, contractors may be able to make a windfall on the “A” portion of the contract. If too small, then the time component becomes less important than desired. Different values would seem appropriate for Class 1 and Class 2 projects.

A contractor may need more time to bid a Class 1, A + B project so time and methods can be carefully evaluated. Florida has gone from 1 to 2 months for bidding. However, the experience of New York tends to contradict this notion.

Flexible Start Dates

Recommendation CP-4: Allow Flexible Start Dates. Flexible start dates will allow the contractor to select when he or she wants to start a project within a certain time window so as to make more effective use of critical resources.

Rating:

Addresses root cause	★
Will have a significant impact	★
Can be implemented with relative ease	★★★
Can be implemented in the short term	★★★

One problem often cited was that contractors had a lot of work on hand and their resources were stretched thin. This sometimes leads to contractors not prosecuting the work on certain portions of the job until the resources are available. Contractors may begin the work to satisfy the contractual requirements, but may be awaiting other equipment or key personnel to finish another project.

It is recommended that contractors be given a window of up to 60 days in which to start the work. This approach had been used in some states with success. It is particularly helpful where contractors need to procure materials that require long lead times. Flexible start dates would also seem to be applied in conjunction with a two-phase contract (CP-1). Budgetary issues may cause some concern, so the window of opportunity needs to be carefully selected.

Right-of-Way (ROW) Rentals

Recommendation CP-5: Make Use of Right-of-Way or Lane Rentals. ROW rentals charge the contractor a daily rate for the use of the ROW, either as a work area or as a storage area.

Rating:

Addresses root cause	★
Will have a significant impact	★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

It is quite common for a motorist to drive through a 3-mile-long highway project and see clearing and other work completed on certain parts, but the only work taking place is on one 300-yard section. The public does not understand this situation and may perceive that the contractor is not prosecuting the work aggressively. To alleviate this perception problem, SHAs should apply right-of-way rentals in the same way as lane rentals have been applied. A specified amount per day would be charged as long as the contractor occupied the portion of the right-of-way. The shorter the time frame, the less the contractor would be assessed. The right-of-way rentals would encourage contractors to complete portions of the work as quickly as possible and turn the completed work back to the SHA.

This recommendation would mitigate some problems with erosion control and other issues like noise. It would encourage the contractor to be on-site for as short a time as possible.

This would be particularly true if the charges were applied to the area where job trailers were located.

Liquidated Damages and Milestone Dates

Recommendation CP-6: Assign Liquidated Damages to Intermediate Project Milestones. These damages would not be as much as the liquidated damages assigned to the total project. When that portion of the project is completed, it could be turned over to the SHA.	
Rating:	
Addresses root cause	★★
Will have a significant impact	★★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

In all SHA construction contracts, a liquidated damages amount is specified. This value is usually expressed as so many dollars per day. The contractor is assessed this daily amount for every day of unexcused delay in completing the project. The liquidated damage amount is a damage assessment, not a penalty. Courts will not enforce the liquidated damage amount unless the amount bears some relationship to the actual damages incurred for late completion.

In almost all cases, the liquidated damages are applied to the final completion date. The damages can also be assessed to intermediate milestone dates. This has been done in a few instances by SHAs. For instance, the liquidation damage assessment on the roadway repair of the Golden Gate Bridge in San Francisco was assessed as so many dollars per lane per 10 minutes after a certain time and the assessments were made each workday. However, such variations are not common.

Since many highway projects fall behind schedule early in the job, it would seem attractive to tie liquidated damages to milestone dates early in the job. Some creative thinking would be needed to develop damage amounts for being late early in the job. Undoubtedly, it will be argued that if the project finishes on schedule, then there were no damages and the assessment should not be levied. This issue was argued before the court in Bethlehem Steel Corporation v. City of Chicago (1965). The Court stated that the liquidated damages relate to the damages that are foreseeable at the time the contract was signed, and therefore the fact that there may have been no damages was irrelevant to the dispute. The importance of this decision and similar decisions in other states is that the liquidated damages can be assessed even if the project is ultimately completed on schedule.

Contractor and Designer Qualification

Recommendation CP-7: Develop Contractor Responsibility Procedures that Include Time Accountability. Institute a qualification or responsibility system based on time. For a contractor to bid on a Class 1 “time sensitive” project, the contractor must have a Class 1 rating. To achieve a Class 1 rating, contractors need to have completed previous Class 1 projects on time. Importantly, the datum for being on time is the original completion date.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	*

An important axiom for timely completion is to create a team environment in which each participant is accountable for the same thing: timely project completion. Recommendation BPP-3, which is to develop SHA employee evaluation procedures that include time accountability for Class 1 projects, is the first step in making the SHA a part of the team. Recommendations CP-7 and CP-8 describe how to bring the contractor and design consultant into the team.

Most states use some form of prequalification (Thomas and Smith 1994). Others are precluded by statute from prequalifying contractors, so the procedure calls for post-qualification as part of a responsibility evaluation as a way of ensuring contractor responsibility. A few states maintain that a contract performance bond is sufficient.

Qualification procedures examine four areas of inquiry. These are: financial capability, managerial and technical ability and past experience, performance evaluation (on projects for the evaluating SHA), and business practices.

Research has shown that there is considerable variation in the way states conduct performance evaluations. Some evaluations are very detailed and others quite simplistic. In most instances, the evaluator and the related procedures are such that the contractor is not penalized unless his or her performance is exceedingly poor (Thomas and Smith 1994). The research on this project found that the issue of time in the evaluation was not rigorously evaluated. Contractors were evaluated on whether they completed the project in the extended time allowed. In no instances were projects in other states evaluated for the contractor’s past performance. The researchers conclude from the analyses and discussions with SHA officials that timely completion, especially against the original contract completion date, is performed in a cursory manner if at all.

In industrial outage or turnaround construction, the pool of bidders and designers is limited to only those whom the owner is certain will perform as promised. In this type of work, time is of the essence. Participants that do not perform in a timely manner are excluded from future bidding opportunities. Thus, the past performance of contractors and designers is carefully scrutinized. What emerges is a team in which each party stands to gain or lose depending upon the timeliness of completion. The emphasis on timely completion as a

qualification criterion creates an exclusive group in which members of the group will exert an all-out effort to remain a member of the group. In this way, the qualification criterion ensures that timely completion will be achieved.

In 2000 Dr. Ralph Ellis, of the University of Florida, conducted a study of project success factors influencing Florida Department of Transportation project success. The investigation reviewed the results of 150 projects of varied size and type. The projects were performed by 27 different construction contractors and designed by 15 different designers. Analysis of the performance data suggests a high correlation between the contractor or designer and the project outcome with regard to time and cost performance. Nine of the 27 contractors accounted for 80% of the total time growth. Three of the 15 designers had an average cost growth of more than twice the average. The size of the database may not be large enough to develop specific ratings of individual designers and contractors, but it clearly suggests that performance differences do exist and that they can be measured. Figure 5 presents the average time growth for each contractor. Similar results were generated when the analysis was done on the basis of designers.

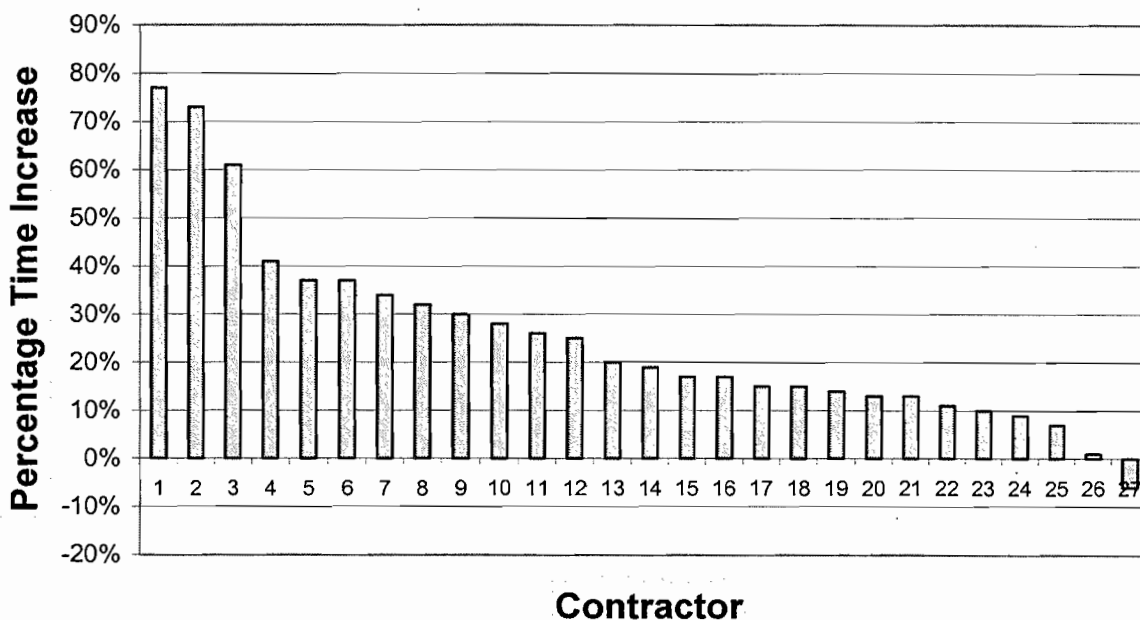


Figure 5. Average Time Growth by Contractor.

The goal of the SHA relative to Class 1 projects should be similar to the industrial situation. CP-7 proposes a classification scheme based on timely completion (the yardstick is the original contract completion date). Those contractors completing Class 1 projects within the original time are classified as Class 1 contractors. To construct a Class 1 project, a contractor must be a Class 1 contractor. In this way, contractors having a history of marginal time performance are excluded from constructing the most time-sensitive (Class 1) projects.

The Class 1 rating scheme does not replace the normal procedures for qualifying contractors. For states that do not prequalify contractors, the Class 1 criteria can be incorporated into the responsibility criteria. To accommodate out-of-state contractors, the procedure may require that those contractors provide evidence of timely completion on projects from other states.

Of the contractors interviewed during this research, most expressed a strong willingness to bid under a system described by recommendations BPP-3, CP-7, and CP-8 provided some of the other recommendations detailed in this report are also implemented. Importantly, the system would have positive effects on project performance. For example, contractors would no longer be content to operate with short planning horizons of, say, two weeks. Instead, the planning horizon would be more like four weeks or more. The same would be true for the SHA, which would mean that both parties would be looking farther ahead to anticipate and remove constraints. Thus, timely responses to field problems would be forthcoming.

To illustrate the impact of planning ahead, an actual example may be useful. In one state, a bridge is being replaced. The work requires the construction of a temporary bridge and two new abutments. On one abutment, there appears to be a sinkhole, but no boring was taken in this location. Neither the contractor nor the state has taken an exploratory boring to determine if the abutment will need to be redesigned. Both parties are content to wait until the work on that abutment begins to assess the design. Most likely, the abutment will need to be redesigned and the project will be delayed. If the contractor's Class 1 rating and the SHA employee's performance evaluation were at risk, this situation would not occur.

One precautionary note needs to be interjected regarding the development of procedures. The law recognizes that an awarding agency can establish qualification procedures as desired so long as the procedures are not arbitrary or capricious (Thomas and Smith 1994; Minchin and Smith 2001). Specific groups cannot be excluded from bidding for arbitrary reasons. Otherwise, the agency can establish procedures as it desires. The "relative superiority" concept, however, has been determined to be against public policy (City of Inglewood-Los Angeles County Civic Center Authority v. Argo Construction Co. 500 P.2d 601; Gerard Construction Company, Inc. v. City of Manchester 415 A.2d 1137). The agency cannot develop a rating scheme and select the contractor with the highest rating. Qualification protests may increase, but these recommendations are well within the authority of the DOT. Therefore, legal advice is needed to before qualification procedures are implemented.

Design consultants performing work for SHAs undergo qualification evaluations similar to contractors, although the criteria are somewhat different. The designer criteria seem less objective than the contractor criteria. In some of the states, the evaluation of designer performance was not especially rigorous. With regard to errors and omissions, field evaluations varied greatly. The evaluation of timeliness was not based on the timely completion of the project, but rather, was based on the timely delivery of the contract documents.

Recommendation CP-8: Develop Designer Responsibility Procedures that Include Time Accountability. Institute a Class 1 rating program similar to the Class 1 contractor rating. Only those designers with a Class 1 rating are allowed to design a new Class 1 project. To maintain a Class 1 rating, previous Class 1 projects need to be completed on time. The yardstick for timely completion is the original time allowed in the contract.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	*

Recommendation CP-8 proposes an evaluation scheme similar to the contractor classification scheme CP-7. A designer would need to have a Class 1 classification in order to be selected to design a Class 1 project. One important condition for this recommendation to work is that establishing a fixed date for design submission needs to be rethought. The emphasis should be on getting the design right. Rushing to an unrealistic deadline and making mistakes in the process will defeat the entire process. The adaptation of recommendations BPP-1, BPP-2, BPP-3, CP-7, CA-2, CI-1, and others is essential to the success of recommendation CP-8.

This recommendation will not be well received by the design community because they do not want their qualification to be affected by someone that they do not control. Designers must be assured that other recommendations in this report are being adopted that will ensure that timely completion is highly likely if each party performs at his or her best. Further, designers need to be assured that the design will not be issued until it is ready. One of the problems with current practice is that designers are pressured to meet a deadline, which means that the design is often issued with known errors with the caveat of "let construction take care of any problem." This recommendation will hopefully alleviate this problem because designers will be accountable for good-quality plans and contractors will be accountable for planning ahead to avoid delays.

Encourage and Accept Time-Reduction Proposals

Recommendation CP-9: Encourage and Accept Time-Reduction Proposals. These proposals are value engineering proposals for reducing the contract time.

Rating:

Addresses root cause	***
Will have a significant impact	*
Can be implemented with relative ease	***
Can be implemented in the short term	***

Contractors may not always be encouraged to propose time reductions to the extent that cost reductions or value engineering proposals are encouraged. The SHA should encourage such

submissions. However, this recommendation may not be particularly useful considering the other recommendations made in this report. It may be better suited to Class 2 and 3 projects. It may be necessary to modify the project specifications and to develop a schedule of savings and payments related to time reductions. The proposal could be submitted under the Value Engineering (VE) clause already included in the contract.

Project Recognition

Recommendation CP-10: Make an Annual Award for the Best Designed and Executed Project. This award could be presented jointly by the SHA, ARTBA, AGC, and NSPE. The criteria should cover design, construction and contract administration.

Rating:

Addresses root cause	--
Will have a significant impact	★
Can be implemented with relative ease	★★★

There needs to be greater incentives than just performance evaluations. Positive rewards are better than negative rewards. Current practice often recognizes projects for only one aspect of the work, such as appearance or innovative design. However, the overall project may not be satisfactory for a variety of reasons. An award for total project performance would bring attention to the need to perform as a team.

The criteria should be strict so that a project is deemed truly outstanding in all respects. If no project is deemed superior, then the award should not be given. Public satisfaction should also be a consideration.

Contract Administration

Appoint a Senior Project Manager

Recommendation CA-1: Assign a Senior Project Manager to Lead the Team. A senior project manager should be assigned to oversee planning, design, and construction. This person should also be in charge of the constructibility review team. The team leader may be from a construction management firm.

Rating:

Addresses root cause	★★
Will have a significant impact	★★
Can be implemented with relative ease	★
Can be implemented in the short term	★

Recommendations BPP-3, CP-7, and CP-8 will create a team environment in which all parties have the same goal. A senior, experienced project manager that oversees the entire process should lead the team. This individual should be appointed early in the process, perhaps

during planning. The team leader should have the understanding of the way the project was planned, interactions with the public, etc. so that the overall schedule can be maintained.

The research found that in some states, project managers were not assigned until after the contract was awarded. Sometimes, a project manager was selected sooner, but sometimes the project manager had so many projects to manage that he or she was a project manager in name only. There was little or no opportunity to inject his or her expertise into the project planning or design and to lead the process.

The same person (not just the same firm) should oversee the entire process. The position of senior project manager should be established as a defined position in the SHA. A project manager in charge of a Class 1 project can probably handle only one or two projects at a time, so the SHA may need to hire construction management consultants to fill this role. A construction management consultant will add cost to the project.

Develop an Overall Project Schedule

Recommendation CA-2: Develop an Overall Project Schedule and Monitor the Schedule Regularly. The schedule should include planning and design activities and should be an integrated schedule such as the use of the critical path method (CPM).	
Rating:	
Addresses root cause	**
Will have a significant impact	**
Can be implemented with relative ease	*
Can be implemented in the short term	*

A common complaint throughout the construction industry is that designers are not overly sensitive to time schedules. This criticism is only partly true. However, a more serious concern is that design schedules are more difficult to develop than construction schedules. Inaccurate schedules mean that the design work is often pressed against a fixed submission date. A commonly heard complaint is that there is insufficient time to perform certain additional functions that can potentially save the SHA time and money.

More realistic schedules need to be developed. The overall project schedule needs to be integrated with the planning and construction schedule.

Prebid Meetings and Project Walkdowns

Recommendation CA-3: Make Effective Use of Prebid Meetings and Walkdowns (site visitations during the design phase).

Consideration should be given to making the prebid meetings mandatory for Class 1 projects. At the meeting, the project requirements should be explained in detail so that at the conclusion of the meeting, there is little doubt as to what conditions are present and the work that is required. Project walkdowns should be required of the designer and SHA representative at specific time milestones during designs. There should be no excuse for the design not working because of some preexisting condition that is clearly foreseeable.

Rating:

Addresses root cause	★
Will have a significant impact	★★
Can be implemented with relative ease	★★★
Can be implemented in the short term	★★★

Project walkdowns or job-site tours are conducted for the benefit of designers and the SHA and should include the designer and subconsultants, construction, utility contractor, and traffic engineer. It should be led by the senior project manager at times appropriate during the planning and design process. An appropriate time would be in conjunction with the constructibility review meetings. The purpose of the tour is to observe the physical site so that constraints to the work can be observed. This will minimize the likelihood of surprises during construction. Multiple walkdowns are encouraged.

It is customary to have meetings with prospective bidders (contractors) early in the bid development phase. The purpose of the meeting is to answer any questions raised by the contractors relative to the contract requirements or project conditions. Written minutes are sent to all contractors who have received the bid documents before the bids are submitted. In this way, important questions are answered. All contractors have the questions and SHA responses. There is no favoritism. Unfortunately, prebid meetings are only marginally effective because most contractors do not ask questions for fear of revealing some perceived competitive advantage.

SHAs should approach prebid meetings on Class 1 projects differently. The main purpose should be to tell the contractor what is required and as much about the conditions as are known. This format will require a shift in thinking by the SHA regarding prebid meetings. Instead of going to the meeting prepared to listen and to respond to questions, SHA officials should prepare a detailed agenda that covers in detail every aspect of the job. In this way, the uncertainties of the job are exposed and not left to chance, and the low bidder is not the contractor who forgot to include something in the bid. Consideration should be given to mandatory attendance at the prebid meeting for certain projects. Failure to attend would disqualify the bidder.

The research found that sometimes, project walkdowns were not done until after the contract was awarded. This is the wrong time to learn that the design will not work. At other times, key persons were not in attendance or the walkdown was done too late for design changes to be made. As a result of ineffective walkdown and prebid procedures, surprises and unanticipated conditions were often encountered.

Organize a Rapid Response Team

Recommendation CA-4: Organize a Rapid Response Team (RRT). Organize a rapid response team of SHA and other technical experts whose goal is to be on the project the day after a request is made and to render a workable decision to a technical problem within 48 hours.

Rating:

Addresses root cause	★★
Will have a significant impact	★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

Construction projects are inherently subject to surprises and unforeseen events. It is not possible to eliminate all the uncertainties in construction. Therefore, it is important to institute procedures that will ensure that when unforeseen events occur, a timely resolution is reached.

In reviewing contractor claims, it was observed that there was often a significant time lag from the time a problem was noted until a workable solution was decided upon. The activities involved may or may not have been a controlling activity. It was stated that when the services of the regional, district, or state engineers were required, the response time was often slow and the situation often presented the opportunity for a research inquiry rather than creating a sense of urgency.

When requested, a rapid response team (RRT) should be dispatched to the site. The goal of the team is to help alleviate delays caused by unforeseen situations. They should arrive at the site within 24 hours of being contacted and should have as a goal to render a decision within 48 hours. A procedure may need to be developed detailing when and how the team should be brought to the site. Maybe the contractor can request that the project manager bring the team to the site. The team needs to have authority to make changes that will result in change orders or directives. Perhaps the team needs to be empowered with dollar limits. The RRT leader would be obligated to put the directive in writing.

The RRT leader may be a materials or geotechnical engineer or designer. It should be organized at the district or regional level but may include persons from the central office. The team needs to be established at the beginning of the project

Contract Interpretation and Enforcement

Recommendation CA-5: Develop a Training Course on Contract Interpretation and Administration. The course should cover the following topics as a minimum:

- Notice requirements
- Oral change orders
- Interpretation of ambiguous clauses
- Differing site conditions
- Misrepresentations
- Defective specifications
- No-damages-for-delay
- Liquidated damages

Additionally, the course should present appropriate contract administration practices.

Rating:

Addresses root cause	★
Will have a significant impact	★★
Can be implemented with relative ease	★★★
Can be implemented in the short term	★★

The contract is a detailed, voluminous description of the rights and responsibilities of the respective parties. The contract is a legally enforceable document. It contains detailed procedures and describes the technical requirements of the work. It is not possible to eliminate all the ambiguities in a contract. The contract will always require interpretation by a knowledgeable engineer or manager.

Over the course of interviews with highway engineers and contractors spanning many years, it has been observed that the understanding of contracts is sometimes lacking. The situation is the same regardless of experience level. Individuals involved in a project often do not understand the meaning of contract language and the circumstances under which certain terms of the contract can be enforced.

Particular clauses of concern are notice requirements, differing site conditions, errors and omissions, and liquidated damages. This lack of understanding also leads to lack of rigor in contract enforcement. For example, one on the construction project visited during this research, it was observed that after six months of work, 115 days of time extension had already been granted even though the project CPM schedule had never been updated.

Confusion on how to interpret contracts is perpetuated by training courses that concentrate on legal aspects rather than how to interpret and enforce the contract. Many courses serve to further the business interest of the instructor. Some courses degrade to that of telling entertaining “war stories.”

It is proposed that the NCHRP and/or FHWA fund the development of a training course designed to explain the meaning of a contract and how to interpret various clauses in the general

conditions of the contract. There should be a significant concentration of effective contract administration practices. The training should be on fundamentals of interpretation and should be independent of the specific contract language of any particular agency. The FHWA guide specifications may serve as the base for such a course. Numerous case studies could be incorporated and the participants should be required to participate in the workshop exercises. The course should be rigorous and should be offered through a university where CEUs are awarded.

Project Closeout Procedures

Recommendation CA-6: Revise Project Closeout Procedures to Limit the Number of Punchlists. The goal should be to have only one punchlist; thereafter, any work done by the contractor should not be charged against his or her Class 1 classification.	
Rating:	
Addresses root cause	*
Will have a significant impact	*
Can be implemented with relative ease	**
Can be implemented in the short term	**

Procedures on closing out a project need to be examined because contractors should not place their Class 1 qualification in jeopardy just because there are punchlist items being completed.

Conversely, there should be embodied in the procedures consequences for not completing punchlist items in a timely manner. Perhaps the project manager and the contractor, depending on the length of the punchlist, could negotiate a suitable timeframe.

CHAPTER 6 RECOMMENDATIONS RELATED TO INJECTING CONSTRUCTION INPUT INTO THE DESIGN

A widely heard complaint from SHA project engineers and contractors is that the contract documents do not contain sufficient construction input to ensure that the design is buildable in an efficient and timely manner. The lack of construction input manifests itself in a number of ways, including design errors and omissions, inefficient traffic sequencing, and poorly coordinated drawings. This situation is acute in many instances because the SHA and design consultants have lost much of their experience base through retirements and employment terminations. Lack of construction input manifests itself in many of the root causes of delay listed in Appendix C. The volume of work in most agencies and the shrinking experience level compound this situation.

Injecting construction input into planning and design is an ongoing process that begins as the project plan is being developed. This is where the greatest opportunity lies to affect the time and cost performance of the project (see Fig. 2 and Recommendation BPP-1). It is for this reason that constructibility reviews are viewed by the researchers as essential. However, as summarized below, SHAs need to make more effective use of the constructibility review process.

Conduct More Effective Constructibility Reviews

Recommendation CI-1: Make More Effective Use of Formal Constructibility Reviews. Constructability reviews should be formalized based on the classification (time sensitivity) of the project. Class 1 projects should have very formalized reviews.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	*
Can be implemented in the short term	*

A constructibility review is a process for assessing and improving highway construction project contract documents to ensure rational bids and to minimize problems during construction. Constructibility is defined as the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives (Anderson et al. 1997a). Most constructibility reviews are milestone-driven and are largely informal processes.

Constructibility reviews have been part of the industrial construction process for years. The Construction Industry Institute (CII), a national research consortium, has sponsored several research projects and published numerous reports pertaining to project constructibility in the

context of industrial and commercial projects. This research and these publications originally focused on identifying constructibility-related applications (Construction Industry Institute 1986; Tatum et al. 1986; O'Connor et al. 1986; O'Connor and Davis 1988).

More recently, CII constructibility research focused on quantifying the benefits of constructibility and on the development of ready-to-implement procedures and tools (O'Connor and Miller 1993; Russell et al. 1992; O'Connor and Miller 1992). The *Construction Implementation Guide* presented 19 tools including a procedural roadmap, glossary of terms, program evaluation matrices, barrier assessment checklists, barrier “breakers,” an implementation policy, suggested organizational structure, and more (O'Connor and Miller 1993).

The success of constructibility reviews in industrial and commercial construction has expanded interest into the highway construction sector (Anderson 1997a, 1997b). A 1997 NCHRP report observed that few SHAs have a formal structured process. Reviews were driven by project milestones and were often conducted late in the design process as part of the design review. Traditionally, minimal constructibility reviews were done in the planning phase.

In 2000, the AASHTO Subcommittee on Construction issued a final draft report, *Constructability Review Best Practices Guide*, which suggests that limited progress has been made in implementing formalized constructibility review processes (AASHTO 2000a). The guide recommends the implementation of a Constructibility Review Process but stops short of recommending a formalized process. A total of 24 states indicated they have a constructibility review program and 12 indicated that they have a written policy. While it cannot be determined from the guide, it would appear that few have a formalized process that calls for reviews early in design development. The cost and time benefits of constructibility reviews are widely reported and recognized. It seems SHAs have a powerful process available that simply needs to be used effectively.

This research identified several issues that will enhance current constructibility reviews. These emerged from a visit to one state where a formalized process is being used. In this particular agency, constructibility reviews were conducted on all projects. While commendable, this meant that critical resources were being thinly applied to all projects. The outcome is that possibly the constructibility reviews are not being effectively applied to most projects. NCHRP Report 390 recommends that project classifications be defined according to project complexity: the more complex the project, the more formalized the process. This is similar to the classification scheme recommended in BPP-2. This concept embodies the idea that more resources are applied to the projects that are most critical. Therefore, it is proposed that formalized reviews be applied to all Class 1 projects and less-intensive efforts be applied to Class 2 and 3 projects as resources permit.

Constructibility reviews are primarily triggered by predetermined project milestones, typically at the 30%, 60%, and 95% stages of design development. However, it was determined from the site visits that the reviews were done on specific calendar dates (associated with the specified milestones). Frequently, in the event that the documents associated with the milestones were not available, the review was conducted anyway. This situation is unfortunate because at later stages, it may be too late to propose a change. It is recommended that the reviews be triggered by the availability of predetermined documents, and if these documents are not

available, the review should be postponed. A CPM schedule covering planning, design, and construction (Recommendation CA-2) would assist in planning the reviews.

The senior project manager (Recommendation CA-1) should be in charge of the constructibility review, with assistance from a facilitator as needed. The team leader should have the authority to direct that certain modifications to the design be made. This recommendation is made because it was learned that sometimes the constructibility review team recommended changes but the affected party refused to implement the change because there was insufficient time. This viewpoint is directly contrary to Recommendation BPP-1.

The constructibility review team should include the expertise necessary to facilitate satisfactory project performance. This includes members of the construction community. As stated by the AASHTO Guide, 100% of the attending members agree that involving the construction industry in these reviews is essential, yet less than 5% are doing so. The guide highly recommends that contractor personnel be used. Again, it would appear that the mechanisms and procedures for eliminating certain problems plaguing the construction process are available but are not being fully utilized.

Use the CM Delivery Process

Recommendation CI-2: **Use a Construction Manager (CM).** The construction manager should be responsible for coordinating the design and construction schedules. The CM should also be a member of the constructibility team.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	*
Can be implemented in the short term	*

Both the NCHRP report on constructibility and the AASHTO guide to recommended practice recommend the use of industry professionals in constructibility reviews (Anderson 1997a; AASHTO 2000a). A central purpose of these reviews is to incorporate construction knowledge into the planning and design process. One way this can be done is through a senior project manager with construction experience (perhaps from outside the agency) that oversees the entire process (Recommendation CA-1). Another way is through constructibility reviews. Still another way is to use a construction manager.

On selected projects, a construction manager (CM) would be selected in a manner similar to that used for design consultants, and this individual's role would begin during the planning phase. The CM would provide construction expertise in the design process and develop a project schedule and project budget. During construction, the CM handles submittals, negotiates changes, reviews progress payments, and performs many other functions normally handled by the SHA.

There are two forms of CM used in the private sector: CM at risk and CM agency. In the CM at risk, the CM hires the contractors and subcontractors. When the design is sufficiently

developed, a lump sum price or Guaranteed Maximum price can be negotiated and the CM can assume the role of construction contractor. The Florida DOT is using this method on a \$350 million bridge project in Miami. The project was let under statutory provisions as an exceptional project that allows one to waive the low-bid system.

The CM agency (contracts let by the SHA) is probably a better alternative than CM at risk. In this way, the SHA maintains overall control of the project and leverage over the contractor's performance. States that use the construction management services of a consultant are already using the CM approach. The limitation is that in current situations, the CM consultant is not brought on board until after the design is complete. It is proposed that the CM consultant be retained much earlier, and its role should be expanded to include coordinating planning, design, and construction.

Include Contractors as Part of Constructibility Review Team

Recommendation CI-3: Include Contractors on the Constructibility Review Team. The contractor may not be brought onto the team until after the planning process has advanced to late in the planning phase.	
Rating:	
Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	*
Can be implemented in the short term	*

Introducing construction input is exceedingly important. There is no better way to do so than including contractors as part of the constructibility review team. Currently, most constructibility reviews are done in-house. It is proposed that the constructibility review team include representatives of the contracting community. This recommendation is included in the AASHTO Subcommittee on Construction "Constructibility Review Best Practices Guide" (AASHTO 2000a).

The issue of contractors being potential bidders needs to be addressed. A contractor may need to be declared ineligible to bid on the project if he or she participates on a review team. Another possibility is to use retired or out-of-state contractors. In this way, states in a particular geographical region could establish cooperative alliances.

Establish a Lessons-Learned Database

Recommendation CI-4: **SHAs Should Maintain a Lessons-Learned Database.** The database could be shared by various SHAs.

Rating:

Addresses root cause	★
Will have a significant impact	★★
Can be implemented with relative ease	★
Can be implemented in the short term	★

One of the best sources for construction input are the field engineers that are close to the work. Without some structured mechanism, there is no reliable way to capture their expertise. Therefore, SHAs should establish and maintain a lessons-learned database.

This is an excellent way to capture the knowledge of the entire SHA. All persons should be encouraged to contribute to the database, including contractors and others. Perhaps persons contributing to the database should be annually recognized with a best-practice certificate. Some screening of the proposed entries would be needed.

Examples of lessons-learned databases can be found in several states. One of the best examples comes from Wisconsin. The database is accessible from a CD ROM. The lessons-learned are correlated to the state specifications that are also on CD ROM. The lessons-learned database can also include figures and photographs. If common protocols existed, these databases could be used and maintained by multiple states.

CHAPTER 7

RECOMMENDATIONS RELATED TO UTILITY LOCATIONS AND RELOCATIONS

The survey prepared for this project identified site utilities as the leading cause of time delays on highway projects (see Appendix B). However, there are multiple dimensions to the utility problem, as described below.

BACKGROUND AND LITERATURE REVIEW

Communications and Relations

In a 1998 survey of FHWA division, region, and headquarters offices (FHWA 1998), the most prominent problems in order of significance were identified as:

1. Utility relocations;
2. Coordination, cooperation, and communication with utilities; and
3. Unforeseen utility conflicts.

The recommendations from the report are included in Appendix D.

In the FHWA report, recommendations were made relative to each of the three problem areas identified above. The recommendations relate generally to communications and relations between the DOT, utility, designer, and contractor. For instance, under relocations, states are encouraged to coordinate, communicate, and cooperate with utilities, provide relevant timely information, and use partnering meetings.

The AASHTO Highway Subcommittee on Right of Way and Utilities has developed best practice guidelines for utilities (AASHTO 2000b). The main broad categories of practice are:

1. Use current available technology to the greatest extent possible.
2. Encourage frequent coordination and communication with local governmental agencies to reduce delivery time, reduce costs, and improve quality in the utility process.
3. Encourage frequent coordination and communication with utility companies to reduce delivery time, reduce costs, and improve quality in the utility process.
4. Improve contract, internal project development and training processes to expedite utility relocation.

Specific recommendations in each of these areas were also developed and are included in Appendix E.

This report does not deal specifically with coordination and communication issues. These are viewed as an essential part of dealing with utility locations and relocations. Readers are strongly encouraged to adopt the recommendations included in the appendices.

Locating Utilities

Much effort has been spent by FHWA over the past decade in promoting and encouraging the use of Subsurface Utility Engineering (SUE). SUE is defined as “an engineering process for accurately identifying the quality of subsurface utility information needed for highway plans, and for acquiring and managing that level of information during the development of a highway project” (FHWA 2000; see also the FHWA website at <http://www.fhwa.dot.gov/infrastructure/progadmin/sueindex.htm>). A more recent and comprehensive definition by the American Society of Civil Engineers in a pending document, “Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data,” is as follows: *A branch of engineering practice that involves managing certain risks associated with: utility mapping at appropriate quality levels, utility coordination, utility relocation design and coordination, utility condition assessment, communication of utility data to concerned parties, utility relocation cost estimates, implementation of utility accommodation policies, and utility design* (ASCE 2001). Four quality levels are recognized. These are:

- Quality Level D Information derived from existing records or oral recollections.
- Quality Level C Information obtained by surveying and plotting visible, above-ground utility features and by using professional judgment in correlating this information to Quality Level D information.
- Quality Level B Information obtained through the application of appropriate surface geophysical methods to determine the existence and approximate horizontal position of subsurface utilities. Quality Level B data should be reproducible by surface geophysics at any point of their depiction. This information is surveyed to applicable tolerances defined by the project and reduced onto plan documents.
- Quality Level A Precise horizontal and vertical location of utilities obtained by the actual exposure (or verification of previously exposed and surveyed utilities) and subsequent measurement of subsurface utilities, usually at a specific point. Minimally intrusive excavation equipment is typically used to minimize the potential for utility damage. A precise horizontal and vertical location as well as other utility attributes are shown on plan documents. Accuracy is typically set at 15 mm vertical, and to applicable horizontal survey and mapping accuracy as defined or expected by the project owner.

As can be seen, the most precise depiction of existing utility information is Quality Level A. More information can be found on the FHWA website at <http://www.fhwa.dot.gov/infrastructure/progadmin/sueindex.htm>. The economic benefits of SUE are reported on the website and in FHWA Publication No. FHWA-IF-00-014 (FHWA 2000). Numerous case studies are cited and benefit/cost ratios in the range of 4.6:1 are common.

Despite the reported savings resulting from Quality Levels A and B utility mapping, SUE services are not widely or routinely used. In a presentation to the Wisconsin DOT, Mr. Jim Anspach lists the 11 most commonly cited reasons why SUE is not widely used. These are listed below in the order of frequency.

1. Why should we pay for better information when the utility owners don't/won't relocate their facilities accurately in time anyway?
2. There aren't any local firms who can do SUE.
3. The utility company owns the facilities. They mark them for construction. That should be good enough. And if it isn't, let's make them mark them during design.
4. There is always a prominent disclaimer on the plans about existing conditions being the responsibility of the contractor.
5. Delays in the design process occur due to the time required to execute SUE contracts and perform the work.
6. The use of SUE provides a benefit to the utility at the DOT's expense.
7. The use of SUE increases the project costs.
8. Utilities occupy the Right of Way at little or no cost. They are required to move at their expense. Conflicts between design and utilities are their problem.
9. The use of SUE is not the way "we have always done it."
10. We are basically a rural state. We don't need a big program.
11. Nobody has shown me that there are cost savings from using SUE.

The potential for cost and time savings from better utility location and relocation practices has been reported by the U.S. General Accounting Office in report GAO/RCED-99-131 (U.S. GAO 1999). In the report, the percentage of federal-aid projects that were delayed by utility relocations is summarized in Table 2.

Table 2. Number of States Reporting Federal-Aid Projects Delayed by Utility Relocations (U.S. General Accounting Office 1999).

Percentage of Projects Delayed	No. of States
0-10 percent	20
11-20 percent	8
21-30 percent	6
Above 30 percent	8

The report also summarized the most frequently cited reasons for delays in relocations. In order of significance, the causes were:

1. Utility lacked resources.
2. Short time frame for state to plan and design project.
3. Utilities gave low priority to relocations.
4. Increased workload on utility relocation crews because of increased highway/bridge construction.
5. Delays in starting utility relocation work: some utilities would not start until a construction contract was advertised or let.
6. Phasing of construction and utility relocation work out of sequence.

The increase in the project schedule was also reported in the GAO report. The survey responses are summarized in figure 6. A total of 40 out of 50 states reported that construction schedules increased somewhat or more. Most states rely on early planning and coordination and

special contracting methods to mitigate delays from utility relocations. In this regard, the AASHTO recommendations are pertinent (see Appendix E). However, from the extent of reported delays, the current planning and coordination practices are either inadequate or ineffectively applied.

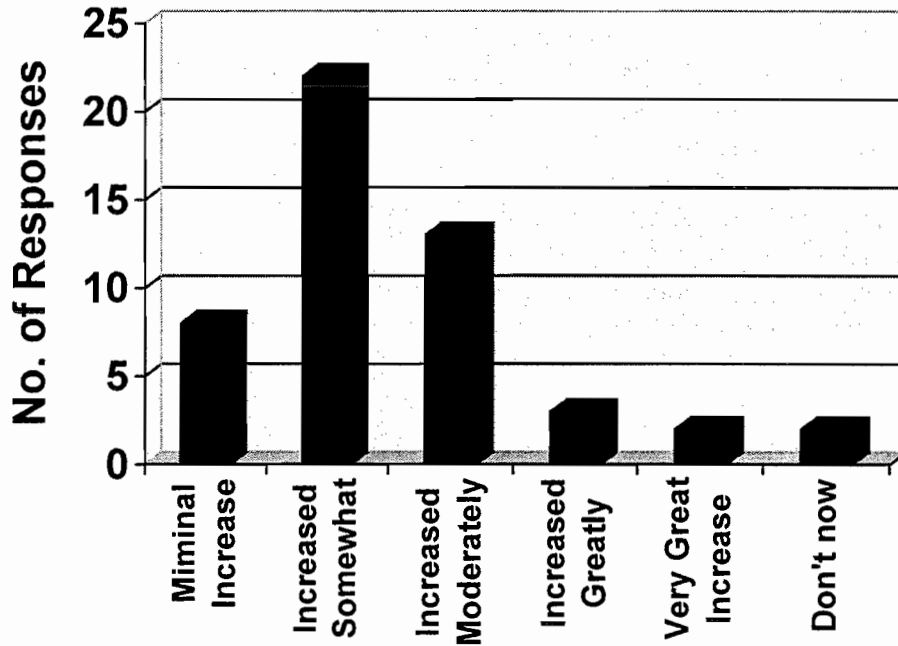


Figure 6. Extent of Project Delay Due to Utilities (U.S. GAO 1999).

This project examined the utility delay situation and identified widespread frustration in three broad categories. These are:

- Unforeseen and incorrectly located utilities,
- Delays in utilities relocating their facilities, and
- Slow responses (primarily from municipalities and local service providers) regarding betterment and improvement decisions.

To understand the situation further, one needs to recognize that there are two categories of utilities: those relocated by the construction contractor, and those relocated by the utility. In the former category are water and sewer lines and drainage facilities. Utilities that are not relocated by the construction contractor are telephone, power, fiber optics and communications, and gas lines. While not entirely mutually exclusive, the facilities relocated by the utility are generally plagued by late relocations by the utility, and the facilities relocated by the contractor are generally plagued by unforeseen conflicting utilities and late responses on betterments and improvements. Clearly, solutions are needed for all three categories of delay.

UNFORESEEN OR INCORRECTLY LOCATED UTILITIES

This section deals mainly with subsurface utilities. These may be ones that the contractor is required to protect or relocate, or they may include ones that are to be relocated by another utility subcontractor. The issue detailed below relates to the location.

Use Subsurface Utility Engineering

Subsurface Utility Engineering was developed as a means to deal with the identification, depiction, and characterization of utilities in a more thorough and professional manner. SUE involves the application of geophysical and other means, new equipment, and data processing technologies to locate subsurface utilities to within several centimeters in the x and y direction. Table 3 lists available subsurface geophysical methods used for SUE (Anspach 1995). "Potholing" allows location of the precise location in the z direction as well as defining the character and condition of the utility.

Table 3. Technologies Used in SUE (Anspach 1995).

Geophysical Method	Comments
Radiofrequency Electromagnetic – ELF, VLF, LF ranges	Inexpensive and highly useful for metallic utilities or utilities that can be accessed and a conductor or transmitter inserted.
Magnetic – Flux Gate	Inexpensive and highly useful for utilities or appurtenances that exhibit a strong magnetic field at the ground surface.
Terrain Conductivity	Moderately inexpensive and useful in non-utility congested areas or areas of high ambient conductivity. Most useful for tank and drum detection.
Impulse Radar (Ground Penetrating Radar)	Moderately expensive and highly interpretative. Useless in areas of high conductivity such as marine clays or small utility targets.
Seismic Reflection and Refraction	Expensive and highly interpretative. Usefulness under field conditions extremely limited due to signal/noise ratio problems.
Thermal Imagery	Moderately expensive and interpretative. Sometimes useful for poorly insulated steam systems or other high heat-flux systems.
Radioscopic Tracing	Moderately inexpensive to highly expensive. Useful for utilities already impregnated with radioactive isotopes.
Microgravitational	Expensive. Limited to identifying utilities of great mass differential from their surrounding environment.

It would appear that the technology exists for the cost-effective location of utilities.

Use Quality Levels A and B

Recommendation U-1: Use SUE On All Class 1 (Time-Sensitive) Projects.

Quality Level A should be used at key locations where there is a concentration of utilities or where critical utilities are located. Quality Level B should be used in other locations.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	**
Can be implemented in the short term	**

The research found that Quality Level A and B were not being used on time sensitive projects. While varied, two reasons stand out as common. The SHA officials at the district or region levels were unaware of the specifics of SUE. Therefore, the view was that it was not particularly accurate (QL B can locate utilities to within several centimeters in the horizontal direction). Also, SUE was viewed as something new and there was a premium on doing things the way they were done in the past. This is the business-as-usual view that is strongest when there are time pressures.

It is proposed that a comprehensive Quality Level B utility search be performed within the entire project limits. Quality Level B data should be depicted early in the preliminary design phase in order to maximize the designers' available time in making judgments on how best to deal with utility systems. Early in the final design, procure and depict Quality Level A data on all utilities in potential conflict with construction that have a cost or time impact on relocation or present a safety hazard during construction. Every attempt should be made to eliminate or lessen potential utility conflicts through design changes before construction. The SUE information should be provided in CAD format so it can be directly incorporated into the contract documents.

These data should be made available to the constructibility review team at its 30% design review. Changes in the grades and profiles can be made at this time to avoid costly relocations if possible. Delays in waiting for utility mapping could be a concern unless planned early. Another concern is that there are a number of companies, due to market expansion and misinformation, claiming to provide SUE services that are not qualified.

Typically, Quality Level B mapping will depict a majority of utilities to within centimeters of their actual horizontal position. Utilities buried at great depth or non-metallic utilities present increasing imaging challenges. Overcoming such challenges with advanced equipment and techniques may not be cost effective. With reliable and comprehensive mapping of virtually all utilities, design can proceed so as to avoid or mitigate disruptions. Design time may increase slightly, and there will be additional cost over traditional Quality Level D and Quality Level C. However, the cost of mapping at QL A and QL B will likely be much less than the delay costs and the associated contract damages. In a 2000 report by FHWA, the average cost of SUE was in the range of 1 to 5 percent of the total construction cost, although the average percentage could be higher in particularly congested situations (FHWA 2000). The average

benefit/cost ratio from 71 projects in North Carolina, Ohio, Texas, and Virginia was 4.62. Typical time savings were 2 to 30 days per project. Importantly, these time savings often kept the relocation off of the critical path. On \$1,138 million of construction, the SUE costs amounted to \$6.12 million (or 2.5%) and the savings were calculated as \$28.282 million.

Cost savings can accrue from many sources. Typical cost savings could be as follows:

Administrative 2%. Projects completed up to 20% faster (VDOT study) allow financing to be paid more quickly. Insurance and bonding costs may be less. Administration of change orders is lessened.

Engineering 0.5%. SUE techniques save time and, therefore, expense by employing direct digital incorporation of utility data from survey into CADD files.

Utility Location 5%. Designers take comprehensive, accurate utility information into consideration during the design of a project. Minor changes of design “footprint” or elevation data on paper eliminate wholesale utility relocations before construction.

Construction 2.25%. Construction bids are lower because of fewer utility conflicts and an increased assurance of correct data. Liability for identification is borne by the SUE firm, not the constructor.

Cost Overruns 5%. Contractor delay claims are reduced (FDOT). Engineering rework is reduced. Utility damages are reduced.

The AASHTO “guidelines and best practices” should be adopted in conjunction with this recommendation (AASHTO 2000b). These are included in Appendix E. The guidelines address issues of coordination and communication with the utility.

A SUE study is viewed by FHWA as a legitimate, reimbursable project expense. In other instances, inventive ways to generate funds to support high-quality utility mapping should alleviate funding issues. This is a particularly attractive avenue in states where utilities reimburse the state for relocations. A benefit-cost analysis based on actual data would aid states in making the decision to use appropriate utility quality levels. Because of the expense involved, it would appear that prudent selection of where QL A data are requested is a key judgment best left to the subsurface utility engineer in consultation with the SHA.

Use 3-D and 4-D CAD

Recommendation U-2: Use 3-D and 4-D CAD Models at Critical Intersections and Locations. This modeling technique will allow designers and the constructibility review team to visualize how the new installations will be installed and if changes in the profile and grade will minimize the relocations.

Rating:

Addresses root cause	★★
Will have a significant impact	★★
Can be implemented with relative ease	★★★
Can be implemented in the short term	★★

Complex intersections pose the greatest challenge for engineers and contractors alike. Here, there can be a high concentration of utilities that are integrated with drainage facilities and new signalization installations. How this work is done is often difficult to visualize until the utilities are exposed during the work. At this time, it is usually too late to make more than minor adjustments without incurring a project delay.

A 3-D CAD representation will make it easier to integrate utility locations into the contract drawings, thereby minimizing the potential for errors and omissions. The representation should be available at the 60% design review. The use of 4-D representations will allow contractors and designers to envision the most efficient sequence of relocation and protection. The CAD files should be made available to the contractor.

If judiciously used, it seems likely that the application of this recommendation would be successful. Such representations have been routinely used in industrial construction for the last 10 years. In the Houston district, TXDOT uses 3-D CAD on all projects. Disney used 4-D CAD on all major construction. The Boston “big-dig” has made limited use of 4-D CAD.

Develop Relocate/Protect Guidelines

Recommendation U-3: Develop Guidelines Citing Specific Criteria Defining When Utilities Should Be Relocated. Protection standards should also be developed.

Rating:

Addresses root cause	*
Will have a significant impact	★★
Can be implemented with relative ease	★★
Can be implemented in the short term	*

One dilemma facing design engineers is when to protect and how and when to relocate utilities. Some of this information is within the purview of the utility companies who maintain protection standards. Each utility will have different standards. However, there are no clear

guidelines regarding how close an existing utility can be to a new installation before the existing utility should be relocated. Just because a facility can be protected or relocated on paper does not mean the work can be done in the field.

If guidelines are supplemented with 3-D and 4-D CAD (Recommendation U-2), more informed decisions can be made with regard to protecting or relocating utilities. Proper and safe ways to protect should be the objective. Quality Level A will help as well (Recommendation U-1). The constructibility review team should review this effort.

Develop Depiction Standards

Recommendation U-4: Develop Standards of Practice on How Utility Information is Conveyed. These standards should differentiate between quality levels, information, symbols, number of pages, number of details per page, etc.	
Rating:	
Addresses root cause	★
Will have a significant impact	★★
Can be implemented with relative ease	★★
Can be implemented in the short term	★

On complex projects and at complicated intersections, the showing of utility locations and the responsible party is challenging, especially with half-size drawings. Each designer conforms to his or her own standards of practice that define how much information goes on each plan sheet. With all this and other information, it is little wonder that utilities are missed or incorrectly located.

If there were good standards of practice, the information would be more readable and understandable by the contractor. He/she could more readily understand the scope of work required. Graphic standards should also depict the responsibility (utility or contractor).

ASCE’s pending “Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data” provide some information related to line code/style, labeling, symbol imbedding, color, line weight, layer/level, and accompanying text (see Fig. 7). However, the discussion is general. More specific criteria should be developed.

LEGEND

COLOR/LINE CODES

----- CW -----	CITY WATER
----- FP -----	FIRE PROTECTION
----- RW -----	RESERVOIR WATER
----- DI -----	DEIONIZED WATER
----- CHW -----	CHILLED WATER
----- GAS -----	GAS
----- PROPANE -----	PROPANE
----- STEAM -----	STEAM
----- CR -----	CONDENSATE RETURN
----- CA -----	COMPRESSED AIR
----- N -----	NITROGEN
----- O -----	OXYGEN
----- CD -----	CARBON DIOXIDE
----- T -----	TELEPHONE
----- E -----	ELECTRIC
----- CS -----	CHEMICAL SEWER
----- UNK -----	UNKNOWN FUNCTION
----- ST -----	STORM
.....	LINE CODE FOR QLC OR QLD INFORMATION

SYMBOLS

○	MANHOLE
●	DROP INLET
□	UTILITY POLE
□	LIGHT POLE
⊗	VALVE
*	FIRE HYDRANT
├─	UTILITY END POINT
○	RISER
◇	HANDHOLE, BOX
⊕	PEDESTAL, TRANSFORMER
●	BOLLARD
■	SIGN
□	HOUSE TRAP
⊙	"QUALITY LEVEL A" DATA POINT

ABBREVIATIONS

F.O.	FIBER OPTIC
EOI	END OF SURFACE GEOPHYSICAL INFORMATION
EORI	END OF RECORD INFORMATION
AATUR	UTILITY ABANDONED ACCORDING TO UTILITY RECORDS
AATFI	UTILITY ABANDONED ACCORDING TO FIELD INSPECTION
EATUR	EMPTY ACCORDING TO UTILITY RECORDS
NAP	NO ASSOCIATED PIPING FOUND FROM STRUCTURE
NAC	NO ASSOCIATED CABLES FOUND FROM STRUCTURE

NOTES

- NOTE 1: "QUALITY LEVEL A" DATA POINTS INDICATED BY SYMBOL ⊙. SEE QLA SUPPLEMENTAL DATA FORM FOR ADDITIONAL UTILITY INFORMATION.
- NOTE 2: ALL "QUALITY LEVEL A" ELEVATIONS ARE FOR THE TOP OF THE UTILITY UNLESS OTHERWISE NOTED.
- NOTE 3: ALL UTILITIES DEPICTED AT "QUALITY LEVEL B" UNLESS INDICATED BY DOTTED LINE CODE (.....) AND LABELED "QLC" OR "QLD".

Figure 7. Legend of Utility Codes and Symbols.

Provide Traceability of PVC Pipe

Recommendation U-5: Reconstitute PCV Pipe So It Can Be Located Using Conventional SUE Technologies. The most commonly cited remedy is to incorporate iron filings in the material.

Rating:

Addresses root cause	**
Will have a significant impact	**
Can be implemented with relative ease	*
Can be implemented in the short term	*

The geophysical methods listed in Table 3 will locate most utilities to within centimeters. One exception is PVC pipe, unless a No. 12 wire trace wire is required. Unfortunately, the trace wire approach does not always yield satisfactory results because the wire is not always included or may be incorrectly installed. Further, after about 10-15 years, the wire may corrode, meaning traceability is lost.

It is proposed that AASHTO and NCHRP should encourage and support the development of ways to permanently locate PVC pipe. Since there is no good centralized standard, an ANSI standard on traceability should be developed. When a solution is reached to this problem, the SHA should specify this type of pipe in all underground applications.

The pipe manufacturers have been working on this problem for a number of years but have not fully resolved certain strength issues. But, if successfully applied, all PVC pipe could then be located and this would be true as long as the pipe was present. Manufacturers will add additional cost, but the cost would be less than the cost of delays and unforeseen utility claims.

DELAYS IN UTILITIES RELOCATING THEIR FACILITIES

A leading cause of project time delays is that a utility is late in moving its facilities that are located in the SHA right-of-way. In the normal scenario, water lines, drainage facilities, sewer lines, and similar facilities are included within the scope of the contractor's contract. Moving these is the responsibility of the contractor. However, utilities such as power, gas, and communications are not included within the contract scope and therefore, the contractor must coordinate with each utility company to have these moved.

Utilities generally do not respond expeditiously in instances where they need to relocate their facilities. The reasons are varied. Contract schedules change and utilities may arrive to relocate facilities only to find that the new location has not been prepared. Utility companies have become accustomed to this mode of operation. Accordingly, they prefer to wait until the last minute. This situation poses an added problem. Utilities are also constrained by limited resources. Thus, they may not be able to respond quickly. Also, the SHA relocation work does not generate revenue for the utility. Thus, the SHA is low on the priority list behind other revenue-producing ventures. It should be obvious why SHA-contractor-utility communications are important (see Appendices D and E).

The situation regarding utilities relocating their facilities is an acute one. Table 4, reproduced from the GAO study on utility delays, cites 12 reasons identified by the states as causing project delays. These are listed in the order of occurrence.

Table 4. States' Responses Identifying Reasons for Delays in Relocating Utilities (U.S. GAO 1999).

Reason	Number of States
Utility Lacked Resources	34
Short Time Frame for State to Plan and Design	33
Utilities Gave Low Priority to Relocations	28
Increased Workload on Utility Relocation Crews Because Highway/Bridge Construction Had Increased	28
Delays in Starting Utility Relocation Work; Some Utilities Would Not Start Until Construction Contract Was Advertised	28
Phasing of Construction and Utility Relocation Was Out Of Sequence	26
Inaccurate Locating and Marking of Existing Facilities	23
Delays in Obtaining Right-of-Way for Utilities	23
Shortages of Labor and Equipment for Utility Contractor	19
Project Design Changes Required Changes to Utility Relocation Designs	19
Utilities Were Slow in Responding to Contractors' Request to Locate and Mark Underground Utilities	16
Inadequate Coordination or Sequencing Among Utilities Using Common Poles/Ducts	13

As can be seen, the reasons for utility relocations are varied, but are frequently cited in many states. Resolving these issues is not a straightforward or simple task, as some reasons can be attributed to the SHA, some to the contractor, and some to the utility. However, three of the four most commonly cited reasons are because of utility resources and priorities. It would appear that the only way to alleviate this situation is to remove the utility from the relocation process.

Relocate Utilities Using Specialty Contractors

Recommendation U-6: Relocate Utilities Using Specialty Subcontractors. The subcontractors would be selected from a list provided by the utility. The utility would be assured that the subcontractor would perform the relocation to the standards specified by the utility.

Rating:

Addresses root cause	***
Will have a significant impact	***
Can be implemented with relative ease	*
Can be implemented in the short term	**

Current practice is that utilities move their facilities on their own schedule. The SHA must coordinate with the utility and in some cases plead with the utility to cooperate. The SHA has little leverage with the utility, so responsiveness may be slow. Utility relocations may sometimes become controlling activities because of delays. It is therefore recommended that the utility be “taken out of the loop.” This can be done by having an approved list of specialty contractors provided by the utilities. Highway contractors would be required to select from this list and identify the specialty contractor at the time of the bid.

One strong reason why this recommendation will likely be successful is that utilities have limited in-house resources and often resort to specialty contractors to do their relocation work. Thus, the only change would be for whom the specialty contractor worked; in this case, it would be the highway contractor instead of the utility. The specialty subcontractor would still need to coordinate with the utility regarding when changeovers could be made; however, with recommendations BPP-3 (SHA time accountability), CP-7 (contractor time accountability), CP-8 (designer accountability), CP-2 (two-phase contracts), and CI-1 (constructibility reviews), advanced planning would be greatly improved.

With the specialty contractors having a subcontract with the general contractor, all coordination would be between the prime contractor and the specialty contractor, and there could be liquidated damages assigned to the specialty subcontractor. The prime through the specialty subcontractor would be solely responsible for coordinating relocations. The specialty subcontractor would be responsible for coordination with the utility. The specialty subcontractor would move communication, gas, and power utilities according to the prime contractor’s schedule.

In some states, the utility is backcharged by the SHA for the relocation work. If this arrangement posed a problem, funds could be drawn from an escrow account. However, some care must be exercised in determining the lowest bidder. The dilemma arises when the SHA is reimbursed for the relocation. Is the subcontractor’s bid used in determining the lowest bid? A recent decision in New York state indicates that the subcontractor’s bid is not included in the determination (see *Diamond Asphalt Corp. v. Sander*, 700 N.E.2d 1203 1998). Another option is to create an escrow account and pay the subcontractor invoices from that account.

Rewrite Utility-SHA Agreements

Recommendation U-7: Revise Utility-SHA Agreement. The agreement should include liquidated damages.

Rating:

- | | |
|---------------------------------------|---|
| Addresses root cause | ★ |
| Will have a significant impact | ★ |
| Can be implemented with relative ease | ★ |
| Can be implemented in the short term | ★ |

In many states, the SHA-utility agreement has little effectiveness in avoiding delays. An alternative to Recommendation U-6 is to rewrite the SHA-utility agreement to include stiff liquidated damages.

The research identified one model for a new agreement, which is the TRANS 220 agreement now used in Wisconsin. (It is an adaptation from several other states.) TRANS 220 is an administrative rule that applies to selected parts of the state highway system. The regulation provides for extensive and detailed coordination plans. A key provision relative to Recommendation U-7 is found in Trans 220.06 Responsibilities 7 (c) and reads as follows:

(c) If the owner (utility) fails to provide a work plan as provided in § Trans 220.05, or fails to complete the alteration or relocation of its facilities in accordance with the work plan approved by the department as provided in § Trans 220.05, the owner (utility) shall be liable to the contractor for all delay costs and liquidated damages incurred by the contractor which are caused by or which grow out of failure of the owner (utility) to carry out and complete its work in accordance with the approved work plan.

In theory, TRANS 220 would seem to provide sufficient leverage to place the SHA higher on the priority list. However, in reality, it has not alleviated the problem of utility relocations for two reasons. First, it applies only to certain highways and therefore has limited scope. More importantly, TRANS 220 allows the contractor to seek damages from the utility. The SHA is not a party to the dispute and has no influence. Wisconsin contractors seldom seek damages from the utility because the delay costs are much less than the legal costs of seeking liquidated damages. It would also seem difficult to set forth the argument that the delays were solely the responsibility of the utility.

TRANS 220 does seem to be a step in the right direction, but some rethinking would appear to be in order. However, the potential of this recommendation to be successful on a national scale appears low, since legislation would be required, and in many states the utilities may have considerable influence on the legislative process.

SLOW RESPONSES TO BETTERMENTS

Recommendation U-8: SHAs Loan Monies to the Municipality Until Their Funding Request Is Approved.

Rating:

Addresses root cause	★★
Will have a significant impact	★★
Can be implemented with relative ease	★
Can be implemented in the short term	★★

The research found that in some instances, decisions on betterments and improvements were late because the approval of funds from other state agencies was not timely. This situation was most likely to occur with smaller cities, municipalities, and counties. To avoid the delay, it

is recommended that SHAs loan the monies to the municipality and be reimbursed when the monies are allocated. In this way, the work can proceed as planned without delay. There is some risk to the SHA if the municipality funding request were denied, but with proper communication, this situation would appear to be minimal. The keys to minimizing the risk are early submission and good communications.

The SHA could charge a fee for this service. Over time, a reserve of monies could accrue which could be used to offset any losses.

CHAPTER 8 RECOMMENDATIONS RELATED TO CONTRACTOR MANAGEMENT

Clearly, all efforts by the SHA to ensure timely project completion will be fruitless unless the contractor is incorporated into the management team concept. The recommendations in this chapter are designed to improve the team concept, and these should be adopted along with other recommendations made in preceding chapters. Foremost among these is Recommendation CP-7, Develop Contractor Responsibility Procedures that Include Time Accountability, p. 27. CP-7 is fundamental to encouraging the contractor to extend his/her planning horizon beyond two weeks or so. With the help of the SHA and designer, potential bottlenecks and barriers will be removed long before they become problems creating a delay. Contractors will have to finish projects within the original contract time in order to remain eligible to bid on other Class 1 projects (Recommendation BPP-2: Develop a Time Classification Scheme, p. 15).

BACKGROUND

Obviously, contractor planning is an important element in the successful execution of a construction project. Under the present economic environment, contractors are stretched thin with many projects ongoing at the same time. It was often stated during the site visits that contractors were so busy that it was not possible to aggressively pursue project completion on all projects. Even in slower economic times, contractors are challenged to ensure that all resources are available at the right time. This task calls for planning ahead and effective use of reliable, accurate schedules. Unfortunately, contractor schedules often seem to have become a tool for litigation rather than a construction planning tool.

Two issues make contractor planning more difficult. First, many fabricators are completely booked with orders. It is not uncommon for contractors to have a 4-6 month wait for certain bridge components like girders and beam seats, and signalization equipment and poles. Second, there is a shortage in some areas of skilled labor, and this shortage is projected to worsen. The only way a contractor may have to attract enough labor (away from another job) to a project with an aggressive schedule is to offer higher wages. It is understandable why contractors do not wish to do this.

The issues here for the contractor are forward planning, effective scheduling, and marshalling the resources between multiple projects. The issue confronting the SHA is to decide which projects will be designated as Class 1 and which ones will be designated as Class 2 or 3. It may be necessary for states to allow more time for completion on Class 3 projects, permit flexible start dates (Recommendation CP-4: Allow Flexible Start Dates), and other strategies to allow the contractor to allocate resources between multiple projects.

The SHA plays another important role by ensuring that contractors respond appropriately to the way states administer projects. In states where contracts are strictly enforced, contractors are aggressive in project execution. Where contract enforcement is less rigorous, contractors plan accordingly. SHAs should recognize that the contract defines what is fair and equitable to all parties, and strict enforcement is not unfair treatment.

The research found certain deficiencies in contractor planning and scheduling and in DOT enforcement of contracts. The root causes can be summarized as follows:

- Contractor planning:
Planning horizon for some contractors is 1 to 2 weeks.
- Contractor scheduling:
Lack of aggressive enforcement of contract schedule requirements.
CPM schedules are often complex and confusing, and may not reflect the way the job is ultimately built.
- Ineffective enforcement of the contract:
Lack of incentives to adhere to the original contract time.
Lack of understanding of contract language.

CONTRACTOR PLANNING

A number of recommendations have been made throughout this report that relate to contractor planning and encourage the contractor to plan ahead. These include:

- Recommendation BPP-2: Develop a Time Classification Scheme
- Recommendation CP-4: Allow Flexible Start Dates
- Recommendation CP-5: Make Use of Right-of-Way or Lane Rentals
- Recommendation CP-6: Assign Liquidated Damages to Intermediate Project Milestones
- Recommendation CP-7: Develop Contractor Responsibility Procedure that Includes Time Accountability

CP-5 and CP-6 provide punitive measures should the contractor be late in completing the project. However, CP-4 and CP-7 provide opportunities for the contractor to plan ahead and positive, non-monetary incentives to do so. Other opportunities for better contractor planning are discussed below.

A + B Bidding or Establishment of Completion Dates

Recommendation CM-1: Use A + B Bidding or Establish a Fixed Completion Date. This recommendation allows the contractor to determine how long it should take to build the project or how to fit the work into a tight schedule.

Rating:

Addresses root cause	★★
Will have a significant impact	★★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

Historically, SHAs define in the contract documents the amount of time (in working days or calendar days) a contractor has to complete the project. In almost all instances, time extensions are allowed for poor weather conditions and changes impacting the critical path. The SHA bases its allocation of time on historical data, experience, and the particular need for the project.

This allocation of time by the SHA can stifle innovation in several ways. The contractor is usually told how to sequence the work and how long it should take. There is little or no incentive to finish the job sooner. The SHA may add a liberal amount of weather days to the time allotment, which gives the contractor considerable time to complete the project. Understanding the factors contributing to contract time determinations remains important, since SHAs need to provide the appropriate amount of time. In NCHRP Synthesis 215, the factors shown in Table 5 were deemed to be significant (NCHRP 1995).

Table 5. Factors Affecting Time Determinations (NCHRP 1995).

Factor	Percentage of Respondents
Weather and Seasonal Effects	98
Location of Project	88
Traffic Impacts	86
Relocation of Construction Utilities	79
Type of Project	76
Letting Time	76
Special Items	74
Night/Weekend Work	71
Dominant Activities	65
Environmental	62
Material Delivery Time	60
Mobilization and Assembly Time	60
Conflicting Construction Operation	60
Permits	48
Waiting and Delay Time	43
Budget and Contract Payment Control	24
Others	19
Legal Aspects	12

As seen, there are a number of factors affecting the time allotment, and it would seem that the SHA would not be as up-to-date as the contractor on the time requirements or alternative methods and sequencing that would be the most time efficient. Therefore, it seems appropriate on Class 1 projects to use A + B bidding to allow the contractor to determine the amount of time required. For states where A + B bidding is not permitted, an alternative is to establish a fixed completion date, but this alternative does not appear as attractive as A + B bidding.

SHAs are strongly encouraged to use A + B bidding on time-sensitive projects. Additional time during the bidding phase may be needed for contractors to determine the best time duration for a project. A + B bidding has been used for a number of years by many states and has resulted in much better project time management. In some states, legislation may be required; however, there seems to be no legal barrier or conflict with the low-bid procurement system.

This recommendation should be considered along with Recommendation CP-3: Use a Realistic “B” Parameter in A + B Bidding. If the “B” parameter is too small, then there is no real incentive to reduce the time, as the “B” parameter conveys that time is not really that important.

If too large, there may be opportunities for abuse of the system. Since Class 2 projects have somewhat less time significance than Class 1 projects, it seems consistent with the A + B concept that different values of “B” would be developed for Class 1 and Class 2 projects.

Right-of-Way (ROW) Rentals

The use of right-of-way (ROW) rentals was discussed in the chapter on contractor procurement (Recommendation CP-5: Make Use of Right-of-Way or Lane Rentals). This recommendation is similar to lane rentals that discourage the contractor from closing too many sections of roadway at once. This concept extends to the entire right-of-way and will encourage the contractor to get the work done on a section-by-section basis and turn the work over to the SHA. ROW rentals may be limited to certain sections like those involving business access.

Liquidated Damages and Milestone Dates

In lieu of right-of-way rentals, SHAs may be more comfortable in using liquidated damages on intermediate milestones (Recommendation CP-6: Assign Liquidated Damages to Intermediate Project Milestones). This recommendation will also encourage the contractor to get the work done quickly.

Provide a Planning Phase

Recommendation CP-1: Award A Single, Two-Phase Contract and Recommendation CP-2: Require that Contractors Have Key Planning Documents Approved Prior to Commencing the Work both dealt with the problem of rushing to show progress at the expense of detailed planning. The implementation of these two recommendations plus Recommendation CM-1: Use A + B Bidding or Establish a Fixed Completion Date will provide much-needed incentives to plan the work both before the bid submission and after the award.

TIME-REDUCTION INCENTIVES

Time-Reduction Proposals

With diminishing resources, contractors are often more knowledgeable about new materials and methods than are designers and SHA officials. Therefore, it is recommended that SHAs adopt Recommendation CP-9: Encourage and Accept Time-Reduction Proposals. SHAs and the FHWA should consider time-reduction proposals in the same way as they consider cost-reduction or value-engineering proposals.

Time-reduction incentives should be submitted during the Phase 1 period of the contract (Recommendation CP-1 and CP-2). Specific guidelines should be developed by the SHAs for establishing monetary savings.

One downside to time reduction incentives is that the contractor does not have the opportunity to incorporate innovative thinking into the bid. After the award, there is no guarantee that the SHA will accept the time reduction proposal. This dilemma will be alleviated if Recommendation CM-1: Use A + B Bidding or Establish a Fixed Completion Date is adopted.

Organize a Project Review Team

When projects are executed at a fast pace, everything must be orchestrated and highly coordinated. Contractors lose much of the flexibility to accommodate ordinary variations and disruptive events. The experience of the research team indicates that the first aspect that disappears during a fast-paced project is the contractor's ability to perform day-to-day planning. The result is that when outsiders visit the job site, the problems associated with coordination, material management, and sequencing of work are readily obvious. An effective use of the expertise of the DRB is to allow the board to suggest to the contractor better ways to execute the work to make the job go more smoothly and timely (Recommendation BPP-5: The Experience and Expertise of the DRB Members Should be More Fully Utilized). One way this could be done is to augment the DRB with several experts specializing in workforce management and labor efficiency. These experts could be advisors to the DRB or serve as non-voting members.

CONTRACTOR SCHEDULING

Contractor scheduling practices were sometimes found to be unusual or deficient in that contractors often did not follow their own schedule or did not do routine schedule updates. Sometimes the initial schedule was wrong. An outside consultant who had little or no connection with the project sometimes prepared the initial schedule. Additionally, the research also found that SHAs did not always insist on schedule updates. The result was that the most current project schedule was often outdated or wrong or the contractor was not following his or her own schedule. The SHA-contractor contract often did not provide adequate enforcement measures to ensure that the contractor followed recognized and accepted scheduling practices.

Hire a CM to Review Schedules

Recommendation CM-2: Hire or Retain a CM or Use the DRB to Review Project Schedules.

Rating:

Addresses root cause	**
Will have a significant impact	**
Can be implemented with relative ease	**
Can be implemented in the short term	**

Rather than provide for punitive measures relative to schedule adherence, a more effective way to achieve timely completion is to improve scheduling practices. It is therefore recommended that SHAs hire or retain a CM or use the DRB to review project schedules.

With reduced resources, it is often difficult for the SHA to critique a detailed schedule. Therefore, flaws in the schedule may go undetected. However, a CM is accustomed to critiquing detailed project schedules, particularly complex, time-sensitive projects. The CM can also review schedule updates. The CM could be retained on an annual job-order basis.

Strengthen Contract Language Relative to Schedule Updates

Recommendation CM-3: Provide Contract Language Requiring Schedule Updates at Regular Monthly Intervals.

Rating:

Addresses root cause	**
Will have a significant impact	**
Can be implemented with relative ease	**
Can be implemented in the short term	**

SHAs should include contract requirements for regular schedule updates rather than updates as required. The SHA or its agent should review the schedule carefully. Where completion dates extend beyond the contract completion date, there should be contract provisions allowing the SHA to take liquidated damages out of the monthly pay request before the project is completed. This recommendation should ensure that the contractor follows his or her own schedule.

Develop Standards of Practice

Recommendation CM-4: Develop Guidelines or Standards of Practice on How to Critique a Project Schedule. These guidelines should also include the critique of SHA planning and design schedules and how these are integrated.

Rating:

Addresses root cause	*
Will have a significant impact	*
Can be implemented with relative ease	**
Can be implemented in the short term	**

The review of detailed schedules can be a tedious and taxing exercise. At present, there are no standards or guidelines for how to critique a schedule or to recognize flaws. It is therefore recommended that NCHRP initiate a research project to develop guidelines or standards of practice on how to review a schedule.

Use Alternate Scheduling Methods

Recommendation CM-5: Make Use of Alternate Scheduling Methods. Bar charts and linear schedules are particularly attractive for smaller and medium-complexity projects.

Rating:

Addresses root cause	★
Will have a significant impact	★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

A Critical Path Method (CPM) schedule has become the de facto standard for scheduling complex projects. It is widely used on commercial and industrial projects. A CPM schedule shows the relationship and dependencies between various project activities. Unfortunately, CPM has been recognized as not being particularly well suited for linear projects such as pipelines and highways. Additionally, the expense and complexity of a CPM schedule makes it unattractive for all but the largest and complex projects. Finally, because the focus is on detailed representations, it is sometimes difficult to envision the larger picture when CPM schedules are used.

Recommendation CM-6: NCHRP Should Develop Guidelines on the Use of Linear Schedules and Promote Their Use.

Rating:

Addresses root cause	★
Will have a significant impact	★
Can be implemented with relative ease	★★
Can be implemented in the short term	★★

Fortunately, there are other scheduling methods available including bar charts and linear schedules. It seems that the schedule selected should be the type that is most appropriate for the size and character of project. Mixing of schedule types on some projects is also appropriate.

The most common criticism of linear schedules is that they are mainly graphical representations and that they fail to provide the analytical rigor as does the CPM schedule. However, recent advances in linear schedules now provide the analytical exactness that was heretofore lacking. It is now possible to calculate the controlling activity and to perform other analytical analyses (Harmelink 1998). An added advantage of these schedules is that they are more easily understood in judicial and arbitration forums. It seems appropriate that on selected projects, bar charts or linear schedules could be used to monitor the total project and that a CPM schedule could give the detailed insight for certain elements of the project, like bridges.

CONTRACT INTERPRETATION

The research found significant misunderstanding about the meaning of contracts and how to interpret contract language. This deficiency led to Recommendation CA-5: Develop a Training Course on Contract Interpretation and Administration. To varying degrees, this shortcoming was evident at all levels of SHAs. It would be fair to say that the same situation is true for contractor organizations. Therefore, the training course associated with CA-5 should be offered to contractors as well. Perhaps this course should be jointly sponsored by FHWA, NCHRP, AASHTO, ARTBA, and AGC.

MAINTENANCE (SEQUENCING) OF TRAFFIC

Recommendation CM-7: Contractors Required to Develop Their Own Maintenance (Sequencing) of Traffic Plans. This approach will provide for the lowest cost and shortest time schedule of operations.

Rating:

Addresses root cause	**
Will have a significant impact	**
Can be implemented with relative ease	*
Can be implemented in the short term	**

Delays caused by maintenance of traffic plans were not ranked very high by the survey that was initiated via this project (see Appendix B). However, this was ranked high as a factor affecting time determinations (see Table 5). It was also uncovered as an issue in several court decisions involving time delays. Therefore, it seems worthy of some attention.

The current approach is for the designer or SHA to retain a traffic engineer to prepare the maintenance of traffic (MOT) plans. These plans are incorporated into the bid documents that form the basis for the contractor's bid. The plan establishes a particular sequence of work. After award, the contractor may submit a revised MOT plan. If the revised plan is accepted by the SHA, it is incorporated into the contract documents.

This approach has several drawbacks. First, the designer establishes the MOT sequence, and this may or may not reflect the most time- or cost-efficient way for the project to be executed. Second, the shortage of experienced personnel affecting most SHAs also affects the designer and traffic engineer. Therefore, the MOT plan may reflect limited construction knowledge. Third, the process may be time consuming because the revised plan is developed after the contract is awarded, which means that the SHA may not always receive the best time and cost benefits from the revised sequence. Lastly, contractors can potentially go through the expense of developing a revised plan only to have it rejected by the SHA.

A better way to approach MOT plans is to adopt an approach that would be similar to that used in the design-build procurement method. It is proposed that prior to bid (and during the constructibility review process), the constructibility team should develop performance criteria for maintenance (sequencing) of traffic. This would include aspects such as lane-closure restrictions, methods of business access, etc. These requirements would be incorporated into the

bid documents. During the bidding period, contractors would develop the best construction and MOT sequence that would yield the lowest cost and shortest time. After contract award, the contractor would retain a traffic engineer to develop detailed plans that met the performance requirements and SHA safety standards. The plans would be sealed by a registered traffic engineer approved by the SHA to ensure compliance with SHA standards, and incorporated into the contract documents. The detailed plan could be developed during Phase 1 of the contract (Recommendation CP-1: Award A Single, Two-Phase Contract).

CHAPTER 9 IMPLEMENTATION

Nationally, State Highway Agencies are alike in the sense that they share a common mission and scope of organizational responsibilities. However, there are many important differences from state to state, such as organizational structure, size, procedures and specifications, controlling state statutes, and state policies influenced by local politics. Because of these differences the root causes of delays will also vary. Given these differences, implementation will require a unique plan for each state. Therefore, the implementation plan that is discussed below is general, leaving the task of developing detailed implementation plans to each respective SHA.

PREREQUISITES TO IMPLEMENTATION

There are three prerequisite steps to implementation. It appears that efforts at implementation will be futile unless these steps are addressed.

1. Accept Fundamental Principles

The first step in implementation is to accept the fundamental principles of project management listed in Chapter 2. The list may be expanded or reduced, but there must be guiding principles for the implementation strategy. No change should be implemented for the sake of change. These principles are repeated here for reference purposes:

Cost-Time-Influence—More time spent in design identifying problems will reduce construction time and avoid delays.

Priority—Timely completion of projects must be a priority.

Accountability—All members of the project team must be accountable for their performance.

Rewards—Reward systems must reward superior performance.

Knowledge—Superior knowledge and skill must be available at all steps in the project development and delivery.

Efficiency—Organizational structure and processes must support delay avoidance and mitigation.

Innovative Thinking —Innovative thinking is an important axiom to risk aversion.

2. Establish Top Level Support

For many of the recommendations contained in this report, successful implementation will require fundamental changes in the way organizations do business. There is limited chance of success in implementing these changes without top management support and leadership. The Secretary or Commissioner must believe that late project completion is a solvable issue. He or she must communicate this belief to all members of the organization and to the external stakeholders his or her commitment to reducing construction delays and to the changes necessary to accomplish this objective. Additionally, managers at every level in the SHA need to communicate their support of the program to their own people. This visible management support is essential for success.

The important stakeholder groups include designers, contractors, utility companies, municipalities, and legislative and citizen groups. In each instance, the stakeholders must be convinced that the problem is solvable. When presented along with the fundamental principles in Chapter 2, the framework for meeting resistance will have been established.

3. Establish a System of Measurement

Improvement requires measurement. Things that are not measured generally do not improve. Therefore, it is important to have in place a system that records and classifies all categories of extensions or delays to the original project time. The system should be simple and easy to use. A pilot measurement program should be made to establish the datum from which improvements will be measured.

To illustrate the problem arising when there is no datum from which to gauge success, consider the following example. One SHA recently developed an administrative regulation providing that contractors could recover delay damages directly from utilities for delays caused by the utility failing to timely perform relocations. However, the SHA is unaware if the new regulation has reduced utility delays because there is no measurement system in place.

Review and analysis of these data will provide valuable information for managers concerning the most frequent causes of delays and the results of the delay avoidance strategies. The Florida Department of Transportation has developed an information system for measuring and classifying all extensions of time on its projects. Periodic reviews of the information provide FDOT managers with insight into which management initiatives have been successful and which areas should be given more attention.

The measurement system should be relatively simple. For instance, the simple statistic of the percentage of Class 1, 2, and 3 projects that finish within the original contract time would provide a good yardstick for measuring improvements. Other statistics can be envisioned. Also, some form of yardstick for assessing each implementation strategy would be useful. In this way, unsuccessful strategies could be modified or discarded.

The measurement system should not be used for alternative purposes. For instance, a system for assigning delay causes should not be used to seek damages for errors and omissions. It should not be used as a punitive measure against contractors or designers.

IMPLEMENTATION STEPS

The general steps for implementation include the four steps discussed below.

1. Select Improvement Strategies

A Task Group of senior officials should be appointed to perform an organizational self assessment to identify the root causes for delay on construction projects. Primary strategies and supporting strategies to counter the identified root causes should be selected for consideration. The group should consist of experienced professionals from the various functional areas within the organization. The group should be free thinkers that are not bound by the old ways of doing business. It is important to consider representation from the operational project level of the

organization, as central office perceptions sometimes differ from reality. Industry leaders from contractor organizations and design consulting organizations should be added to the Task Group.

The Group should have access to the data from the pilot measurement program. Using these data and other information, the Group should select the strategies that will most likely be successful for the organization. The root causes in Chapter 3 were many and varied. Therefore, it is necessary that a broad, comprehensive approach be taken, which means that multiple strategies will need to be adopted. Selecting a few “easy to do” strategies is not likely to produce significant improvement.

The comprehensive plan and individual strategies should be reported to the Secretary or Commissioner. His or her concurrence should be obtained.

2. Develop Detailed Implementation Procedures

A separate task committee should be formed for each strategy. Committee members should be selected because of their experience and involvement with the issues related to the strategy being developed. The committee should identify what must be done differently in the organization to implement the strategy. These changes may involve all forms of established procedures such as business practices, specifications, procedure manuals, organizational structure, and employee management. Advice from the in-house legal counsel may be advised for some strategies. Once the elements that need to be changed have been identified, the committee should then develop a detailed plan for initiating the changes. The detailed plan should include action items defined by: who? what? when? and how?

3. Proceed with Implementation

Once the implementation details are finalized, implementation should begin. Depending upon the specific situation, some organizations may choose to undertake a demonstration project prior to full implementation. A demonstration project is advised because it is a good way to convince all that timely completion can be achieved. A demo project also facilitates refinement and improvement of the process prior to organization-wide implementation, and demonstrates that the strategies will work.

Each delay-avoidance strategy should be assigned a manager who will take the lead in overseeing implementation. Recognizing that organizations have a natural resistance to change, it is important that the reasons and objectives of the change be clearly communicated to everyone affected by the change. Also, depending upon the nature of the strategy, personnel training may be required to facilitate implementation of the new procedures.

4. Evaluate the Outcome and Make Adjustments

Outcome assessment is an important follow-up activity. The results should be evaluated after the new strategy has been implemented and in place for a reasonable amount of time. Delay data should be used to monitor the causes of delays and to determine the effects of the new change in procedures. It is also important at this time to seek input from organizational members and others outside the SHA who have been involved with or affected by the changed process. People actually working on the construction projects may make a valuable contribution toward

improving the process. The strategy should be revised or adjusted based upon the review of the data and the information received from project personnel.

The implementation process may be summarized as follows:

Prerequisites	Implementation Steps
<ol style="list-style-type: none">1. Accept Fundamental Principles.2. Establish Top Level Support.3. Establish a System of Measurement.	<ol style="list-style-type: none">1. Select the Strategies to be Implemented.2. Develop Detailed Implementation Plan.3. Proceed with Implementation.4. Evaluate Results.

USE THE LESSONS LEARNED BY OTHERS

Who Has Tried This?

It makes good sense to check with organizations who have tried something new prior to implementing it yourself. Actually, many of the strategies recommended in this study are being used today. In general, SHAs are very good at sharing information with one another. It would be very useful to know what lessons other SHAs may have learned during their implementation. However, given the number and scope of possible strategies, it would appear to be difficult for any state to know who is doing what.

Need for an Implementation Clearinghouse

What is needed is a single source of information about what delay-avoidance strategies are being used by which state. This would be a valuable resource for all SHAs considering the implementation of any of the recommended strategies. At a minimum all that would be required is a current database of those strategies that have been implemented by one or more states, and contact information for those states. Additionally, it would be useful to have statistics on delays by root cause for each reporting SHA. An organization considering implementation or in the process of developing its implementation details could contact others who have had experience with the same issues and perhaps avoid repeating mistakes.

The logistics of setting up and maintaining such a clearinghouse are not demanding. One organization needs to act as the depository and source of information, and the individual states must keep the clearinghouse updated on their efforts. One possibility might be for one of the many Technology Transfer Centers across the country to assume the responsibility for a reasonable period. Another option would be for one of the AASHTO member states or FHWA to volunteer to act as the information source.

There are a number of ways that this service could be offered. The value of this type of information resource is clear, and it is the recommendation of this research team that an Implementation Information Clearing House be established to facilitate the implementation of the recommendations of this study.

CHAPTER 10

SUMMARY AND CONCLUSIONS

The purpose of this research was to identify the apparent and root causes of time delays during the construction phase of highway construction projects. The research was accomplished by conducting a literature review and a mailed survey to design and construction professionals. This was followed by on-site visits to six states. From these visits, root causes of delay were identified and categorized. Recommendations were presented to avoid construction delay.

APPARENT CAUSES OF DELAY

The literature review was conducted of journals, periodicals, published reports, and other sources. Of importance were previous studies of construction delays, particularly highway projects. The literature review was followed by a mailed survey to almost 1,000 design and construction professionals. The response rate was about 15 percent.

The literature review and survey confirmed previous studies that the leading causes of delay to highway construction projects were:

- Utilities,
- Delays in environmental planning and permitting issues,
- Differing site conditions,
- Errors and omissions, and
- Extra work.

These broad categories are defined as apparent causes of delay.

ROOT CAUSES OF DELAY

When apparent causes are defined in sufficient detail so that corrective action can be taken, they are termed root causes. The literature review determined that the root causes of delay had not been identified.

Site visits were made to Florida, California, Georgia, South Carolina, New York, and Wisconsin. Prior to the visits, highway construction contractor claims from each state were examined in detail. When the visits were made, every effort was made to interview SHA officials familiar with the claim. The factual aspects of the claim provided specific issues to discuss. The follow up on these issues led to the identification of the root causes of delay. These root causes were categorized into the following broad categories:

- Business practices and procedures,
- Utilities,
- Differing site or concealed conditions,
- Contractor planning,
- Maintenance of traffic, and
- Errors and omissions.

As these categories evolved and the root causes of delay became apparent, the researchers conducted numerous informal brainstorming sessions to identify possible remedies to untimely construction. Two of the important knowledge bases for the research team were their personal knowledge of fundamental principles of project management and the peculiarities of the industrial construction sector. Industrial construction was a particularly relevant source of knowledge because of the similarities with highway construction. Among these similarities are that projects tend to be complex; the work is usually done in an operating environment; planning and design are often compressed; and there is often little tolerance for time delays.

Following the brainstorming sessions, recommendations were developed and presented in the following categories:

- Business practices and procedures,
- Contract procurement,
- Contract administration,
- Construction input into planning and design,
- Utilities, and
- Contractor management.

The recommendations are not revolutionary or radical. Rather, many have been tried by SHAs with varying degrees of success. The reason for much of the lack of success in application appears to be that the recommendation was tried in a vacuum or that certain fundamental principles were not followed in its application.

CONCLUSIONS

The preeminent conclusion of this study should be encouraging to SHAs: *the untimely completion of highway construction projects is a solvable problem*. The management processes are known and the technological methods are readily available to be used by SHAs. Various SHAs have tried most of the recommendations in this report over the last 10 years. The reason for lack of success is probably because a strategy has been tried unilaterally, not as part of a comprehensive plan to reduce untimeliness. SHAs still enjoy business as usual. In a few instances, legislation may be needed to permit the use of a strategy; however, where required other alternative strategies not requiring legislation are proposed.

The root causes of delay are many and varied, and there is no “silver bullet” to address this problem. Timely completion will be achieved with multiple strategies targeted to each of the significant causes of delay. The SHAs must be prepared to develop comprehensive, multiple solutions.

RECOMMENDATIONS

The following baseline recommendations have emerged as a result of this research.

1. *There is a need for national leadership on the issue of timely completion of highway construction projects*. Several reasons that make clear the need for this leadership are evident. SHAs are close to the action and do not always have the opportunity to see the bigger picture. Therefore, some may not foresee the delays in construction as problematic. Data are needed to convince the SHAs and others that delays in project completion are very costly. SHAs are not

always aware that the processes and technologies are available to solve this problem. National leadership can bring this knowledge to the attention of the states. Lastly, the SHAs, with the assistance of national leadership, would be helpful to convince state legislators of the need to conduct business differently. Legislative efforts would be better received. One way to initiate the national leadership is with a national workshop sponsored by FHWA, AASHTO, AGC, and ARTBA.

2. One of the important steps in the national implementation strategy is to convince all stakeholders that the recommendations in this report will result in the timely completion of highway construction projects. To further this process, the FHWA should initiate several demonstration projects involving different project types, i.e., realignments, bridge replacements, etc. These projects would be typical of the time-sensitive projects completed in the particular state. The demonstration projects should be handled the same as other, similar projects except for the application of various recommendations in this report.

Throughout the report, recommendations were made regarding future research projects. These recommendations are summarized below.

- ▶ AASHTO should work with pipe manufacturers to develop a way to locate underground PVC pipe using existing geophysical technologies.
- ▶ AASHTO and NCHRP should work together to develop rational methodologies for determining the “B” parameter in A + B bidding. The “B” parameter should vary depending on the classification of the project (i.e., Class 1, etc.).
- ▶ AASHTO should develop a manual of recommended practice relative to the time evaluation of design consultants. This activity could also be done as an NCHRP Synthesis report. Perhaps some research would be required to modify the best current practice to be consistent with the recommendations of this report. Similar studies might be done with respect to contractors. Related to the issue of team accountability are SHA employee evaluations.
- ▶ Guidelines should be developed for when and how to relocate and protect underground utilities. Guidelines should also be developed on how to depict underground utilities in the contract documents.
- ▶ A common protocol should be developed for lessons-learned databases.
- ▶ Standards of practice should be developed by AASHTO on how to review a project schedule. The standards should cover the different schedule types and encourage tailoring the type of schedule to the particular project situation. In conjunction with this recommendation, AASHTO should promote the use of other types of schedules, especially those that are more readily understood in judicial tribunals.
- ▶ A training course on contracts and contract interpretation should be developed by the NCHRP. The course should cover how to interpret the various clauses in the general conditions of the contract. Effective contract administration should also be included. The course should be a hands-on course with workshop exercises utilizing contract language taken from actual highway construction projects. CEUs should be offered.

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**APPENDIX A:
LITERATURE REVIEW**

APPENDIX A LITERATURE REVIEW

The literature review involved the examination of technical reports, periodicals, published articles, and other unpublished reports and studies. The review was limited to time delays to construction projects during the construction phase. The yardstick against which delays were measured was the original time allotted in the contract or the initial specified completion date. Time extensions, excusable delays, and liquidated damages are not relevant to this discussion.

OVERVIEW

Much has been written about the causes of delay during construction. A 1985 FHWA report identified differing site conditions and design errors and omissions as leading causes (Thomas et al. 1985a). The same report indicated that time delays were more likely to occur in the first 10 percent of the construction phase. A project that was late at the 10 percent complete milestone had an 85 percent likelihood of finishing late (Thomas et al. 1985b).

A 1998 audit report of the Oregon DOT by the Legislative Audit Committee of the Oregon Audits Division reported that over half of the projects reviewed were completed later than the initial specified completion date (Oregon DOT 1998). The audit also revealed that 47 percent of the cost overruns were attributed to design errors and omissions, contract specification problems, estimating errors, and extra work not originally identified in the design phase (www.sos.state.or.us/audits/summary/1998/1998-24FR.htm). Time delays were also examined. The committee found that of 236 projects completed during the 1995-1997 biennium, 55 percent were completed after the original specified completion date. Larger (and more visible) projects were more prone to being delayed. Of 24 projects exceeding \$5 million, only 6 were completed on or before the initial specified completion date.

The GAO published a report summarizing the impact of utility delays on highway projects (U.S. GAO 1999). In this study, 42 responses were noted to the question of the percentage of federal-aid projects experiencing utility relocation delays in the last two years. The results were as follows:

<u>Distribution</u>	<u>Number</u>
0-10%	20
11-20%	8
21-30%	8
Above 30%	8

The median percentage of projects experiencing utility delays was 13.5%. Clearly, from the studies cited above, problems with delays in highway construction are a serious problem to state highway administrators.

CAUSES OF LATE COMPLETION

Late Completion and Claims on DOT Projects

Some of the more frequently cited causes of construction delays are summarized in Table A-1. In this table, each cause is identified as being primarily within the control of the contractor or SHA.

Table A-1. Apparent Causes of Delay.

Major Causes of Delay	DOT Control	Contractor Control
Poor contractor management		X
Weather delays		
Design errors and omissions	X	
Specification problems	X	
Unforeseeable site conditions		
Unknown utility locations	X	
Untimely relocation of utilities	X	
Erroneous estimation of contract time	X	
Inefficient traffic control plans	X	
Foreseeable scope increases	X	
Permit delays	X	

In reviewing Table A-1, it is apparent that most of the causes of delay are within the control of the SHA and involve planning prior to the construction phase.

A 1985 FHWA report examined the apparent causes of highway construction claims (Thomas et al. 1985a). The percentages based on 325 contractor claims are shown in Fig. A-1.

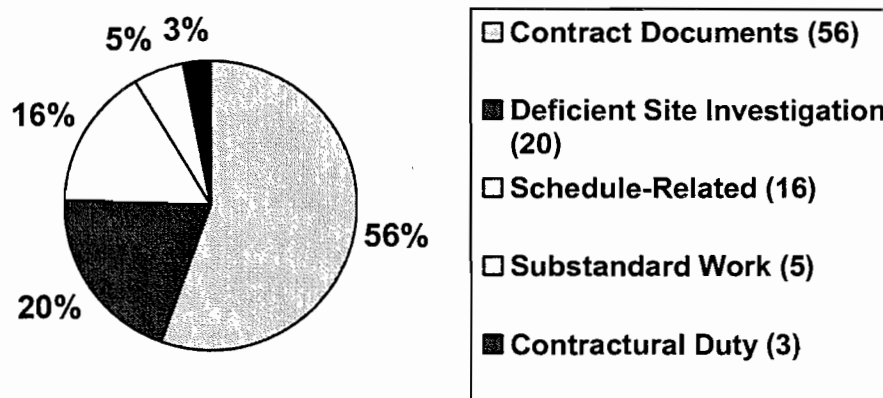


Figure A-1. Summary of Apparent Causes of Claims.

As seen, three claims out of four originated from the contract documents and deficient site investigations.

One problem that may occur on many projects is that the time of performance provided for in the contract may be based on insufficient or erroneous information. Understanding the factors contributing to contract time determinations remains important. Agencies need to provide the appropriate amount of contract time. In NCHRP Synthesis 215, the factors shown in Table A-2 are deemed to be significant (NCHRP 1995).

Table A-2. Factors affecting time determination (NCHRP 1995).

Factor	Percentage of Respondents (%)
Weather and seasonal effects	98
Location of project	88
Traffic impacts	86
Relocation of construction utility	79
Type of project	76
Letting time	76
Special items	74
Night/weekend work	71
Dominant activities	65
Environmental	62
Material delivery time	60
Mobilization and assembly time	60
Conflicting construction operation	60
Permits	48
Waiting and delay time	43
Budget and contract payment control	24
Others	19
Legal aspects	12

As seen, traffic impacts and utility relocations are ranked very high. A number of other pre-construction activities are also listed. The number of factors listed in Table A-2 suggests that SHAs may not always provide the appropriate amount of time, and too much time is a distinct possibility.

The General Accounting Office researched utility location and relocation as a cause of construction delays in a study titled, "Impacts of Utility Relocations on Highway and Bridge Projects" (U.S. GAO 1999). The percentage of delays reported due to utility relocation varied from state to state, with 22 states reporting that more than 10 percent of their construction delays were due to utility location and relocation. The most frequently cited cause of the delay was the short time frame available to plan and design projects. A study of the report indicates that although utility relocations are an apparent cause of construction delay, the root causes still need to be defined.

The Office of Program Policy Analysis and Government Accountability (OPPAGA) for the Florida Legislature reviewed the problem of cost overruns and delays on Florida Department of Transportation projects in Report No. 95-30, *Florida Department of Transportation's Performance in Controlling Cost Overruns and Delays when Building Roads and Bridges* (Florida Legislature 1996). OPPAGA found that failure to complete projects on time was a chronic problem for the Florida Department of Transportation (FLDOT). Florida transportation projects were found to take, on average, 2½ months longer to construct than planned. Delays were attributable to five main apparent causes:

1. Errors and omissions in project design plans,
2. Inadequate coordination with the local governments and utility companies,
3. Problems identifying the scope of work that needed to be done,
4. Changes made to project specifications after design plans were completed, and
5. Damages to construction sites due to extreme weather.

In response to the OPPAGA report, FLDOT established a system for classifying and tracking every project delay. Each project modification is classified into one of 48 cause categories. Analyses of the frequency distributions are used to prioritize management efforts.

While not specifically cited in the literature, several court cases have arisen over allegedly defective maintenance of traffic (MOT) plans. The assertions were that the project could not be sequenced as prescribed in the MOT plan and allow the contractor to complete the project within the allotted calendar days.

Late Completion and Claims on Non-DOT Projects

While claims represent a fraction of the number of projects undertaken by an agency or organization, they are a good source of problem identification because they are often well documented. Much has been written about the causes of contract claims. Working with 60 U.S. Air Force construction claims resolved by the Board of Contract Appeals, Merrill (1982) found that approximately half were related to defective plans and specifications. Most of the balance focused on differing site conditions and project schedules. These findings are consistent with the findings expressed in Fig. A-1.

Diekmann (1985) studied 440 change orders in 22 U.S. Army Corps of Engineers projects on light mechanical and industrial facilities. Approximately 50% of the change orders originated from defective designs and a secondary contributor to these change orders was related to schedules and differing site conditions.

Similarly, in a study of Environmental Protection Agency projects conducted by Hester (1980), the principal sources of change orders were differing site conditions and designer-related difficulties. Although not explicitly identified as the sources of changes, project schedules played an important role in the change orders as well.

In a 1984 study of 224 publicly funded water and wastewater-treatment projects throughout the United States, the technical product specifications and the associated review processes were shown to be involved in a major portion of all serious project disputes (Galloway and Nielsen 1984). It was shown that the earlier a dispute was addressed and resolved, the less

serious an impact it had upon the project. Inferential evidence showed that when resolved quickly, time delays were less serious.

Late Completion and Claims on Private Sector Projects

Much qualitative information has been written about the effects of delays on contractor performance. Two themes emerge consistently in private-sector writings: changes and schedule acceleration. Both topics are much too lengthy for an in-depth discussion. It is sufficient to say that both situations can have a significant effect on labor productivity. Time extensions resulting from loss of labor efficiency are different from delays in that a work stoppage is not necessary. Yet, reduced efficiency can also result in the contractor failing to complete the project on schedule.

Contractor management and fabricator relations have been shown to have a degrading effect on the construction schedule. A closely related issue is the timeliness of the approval of contractor submittals. Thomas and Sanvido (2000) showed that poor material management and ineffective communications with fabricators can lead to schedule slippage of 50 to 129 percent on selected construction activities. Delays in the contractor submittal process have been shown to have a causal effect on schedule acceleration.

METHODS OF AVOIDING/MITIGATING DELAYS

Transportation Sector

Beginning with the TRB Task Force A2T51 on Innovative Contracting Practices, a number of innovative contracting practices were identified. Many of the practices identified have been used under the auspices of FHWA's Special Experimental Project No. 14 (TRB 1991). Three of the innovative practices are no longer considered experimental; these are A+B bidding, lane rental, and warranties. While the practices identified can significantly contribute to cost savings and quality improvements, improvements can be made relative to the time of performance. Table A-3 lists some of the more commonly cited practices and the primary cause to which each practice relates.

Table A-3. Selected Innovative Contracting Practices Related to Time.

Innovative Contracting Methods and Procedures	Primary Delay Cause Where the Impact Can Be Minimized
Incentive/disincentive	Contractor management
No excuses bonuses	Contractor management
Design-build	Multiple causes
A+B bidding	Contractor management Contract time determination
Lane Rental	Contractor management
Constructibility reviews	Design errors and omissions Maintenance of Traffic (MOT) plans

A number of methods for mitigating delays are related to utility locations and relocations. The literature suggests that SHAs have difficulty getting utility companies to relocate utilities. Some options that have been applied include the use of monetary incentives, penalties, and court action. Another problem with utility locations is erroneous locations provided by the utility company.

The critical path method (CPM) of scheduling is often cited as a tool that can be used to identify constraints and reduce the likelihood of delays. However, one often-cited limitation of CPM is that it is not well suited to linear projects. Linear scheduling has been proposed as a viable alternative to CPM schedules. Recent advances in the quantitative aspects of the linear scheduling method (LSM) have made it possible to calculate controlling activities and to computerize the process (Harmelink 1998).

Opportunities Not Reported in the Literature

A number of ideas and concepts that have not been widely reported in the literature can potentially reduce highway construction times. These are briefly described below.

Use of Precast Elements and Prefabrication. It is possible to build a precast bridge from the footings up. Such construction techniques would shorten field construction time but more up-front engineering would be needed.

Automated Quality Control. Automated quality-control techniques could reduce inspection needs and minimize the need for waiting for inspections and test results. Systems based on sensor technologies also can flag a quality problem in time for corrective action to be taken. Such systems have been developed for asphalt compaction and pile driving. Permanent quality-control records can be produced.

Lump Sum Contracting. Traditional unit-price contracting requires considerable administration by the DOT agency. Opportunities exist to mirror the private sector and make more use of lump sum contracting for many contract line items. This would reduce the need for administrative time and cost.

Payment on the Basis of Work Packages. It is observed on many highway projects that at any given time the work may be concentrated in several areas of the site, while no work is in progress in the other parts of the project. Efforts need to be taken to encourage completion of various segments and portions of the project. The use of work packages could provide the necessary incentive to speed construction.

“Early Planning” Line Items. One reason for starting a project early is to commit monies before the end of a fiscal year. This leads to less-than-satisfactory plans and inconsistent planning, which result in extra costs and time. Early planning line items (like MOT plans, project schedules, location and movement of utilities) could be used to establish that the funds were committed while ensuring that sufficient planning takes place prior to construction.

Modified Fast-Track. The phrase fast-track in private-sector construction applies to a shortening of the overall time for design and construction. However, in highway construction, the phrase seems more applicable to shortening the construction time. This will minimize

inconveniences to the traveling public. Thus, modified fast-track should be an approach to suboptimizing design and construction separately. In reality, fast-tracking construction is more analogous to outage construction in an industrial or manufacturing project. Successful concepts applied therein should be applied to highway construction.

Nighttime Construction. Nighttime construction in certain instances can reduce the inconveniences to the public.

SURVEY RESULTS

The initial phase of this project involved the distribution of a questionnaire to various industry professionals knowledgeable about delays in construction. The response rate was 15 percent.

As would be expected, the responses varied according to the category of respondent. Table A-4 shows the ranking of causes according to the three major categories.

Table A-4. Ranking of Survey Results According to Respondent.

Cause of Delay	SHA Ranking	Contractor Ranking	Designer Ranking
Utility Relocations Delayed	1	1	1
Differing Site Conditions (Utility Conflicts)	2	3	2
Errors in the Plans or Specifications	3	2	13
Weather	4	4	6
Permitting Issues	5	7	4
Delays in Right of Way Acquisition	6	11	9
Delays in Environmental Planning	7	8	3
Insufficient Work Effort by Contractor	8	18	5
Owner Requested Changes	11	5	10
Differing Site Conditions (Other Causes)	9	6	7

The results in Table A-4 are interesting. There is general agreement regarding utilities. Beyond utilities, the responses are very much dependent on the category of respondents, with each category being reluctant to accept the blame. For instance, regarding design errors, the designers rank this problem low whereas contractors and SHA representatives rank it quite high. Insufficient work by the contractor is ranked very low by the contractors and owner-requested changes are not seen as too significant by the SHA or the designer. Overall, it would appear that the responses are very dependent on the responder's perception and therefore are of limited value in arriving at root causes.

SYNOPSIS

From the literature review, there is ample indication that many delays and claims originate from errors, omissions, and misunderstandings of the contract documents. Further, deficient site investigations, which also include utility locations and relocations, are a continuing problem. Maintenance of traffic plans are also a concern. In the private sector, changes and change orders are a frequently cited problem. It is also obvious from the literature review that

the reasons cited are apparent causes of delay and claims. Little if any investigation has been made to identify the root causes of delay and claims.

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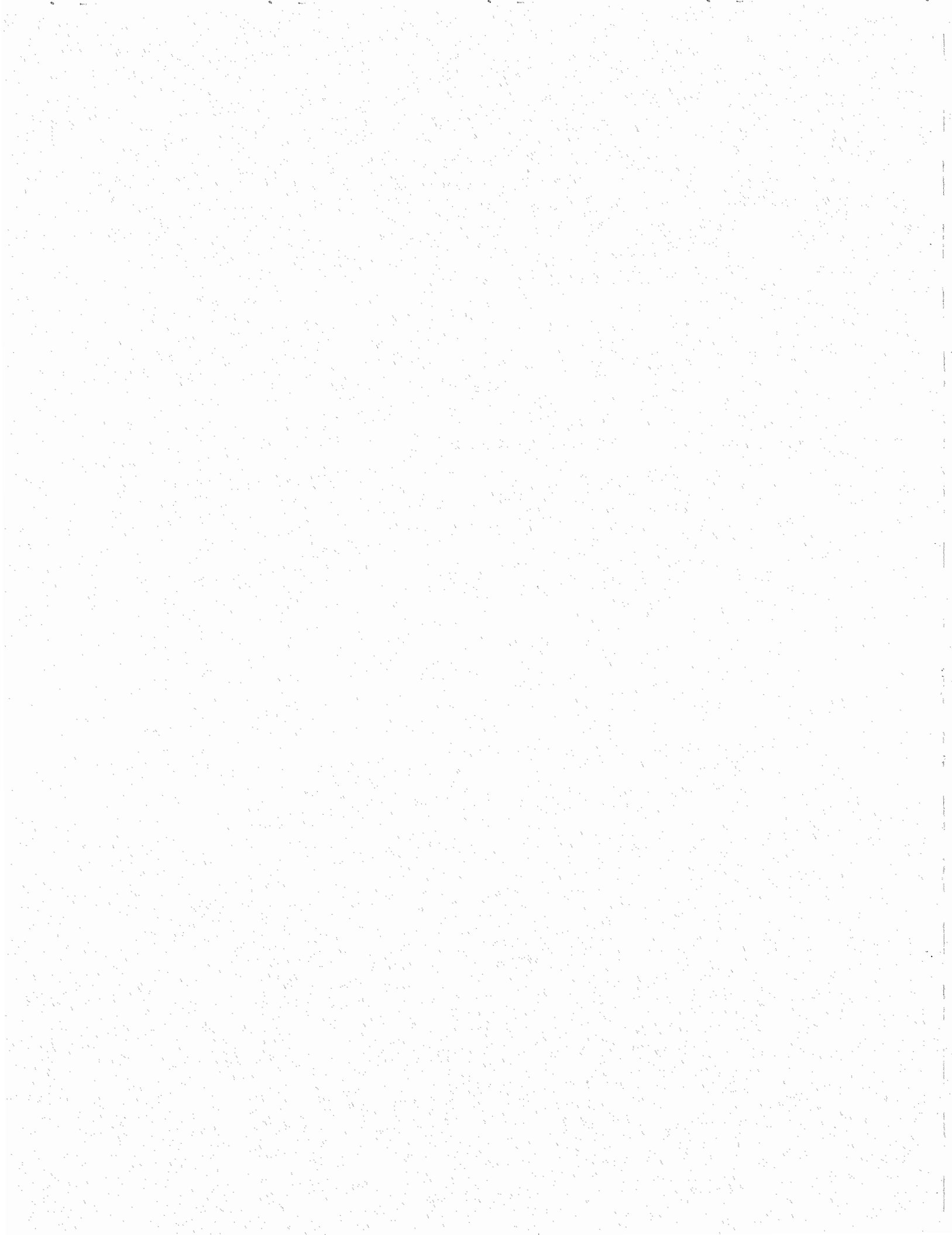
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**APPENDIX B:
INDUSTRY SURVEY**



APPENDIX B INDUSTRY SURVEY

Task 2 of the project work plan provides for the preparation and distribution of survey document. The purpose of the survey is to obtain input from working professionals of State Highway Agencies (SHA), transportation construction contractors, transportation designers and other user groups, concerning the most frequent causes of delays and their delay avoidance measures. A survey document was developed and approved by the NCHRP prior to distribution. A copy of the final survey document is attached to this report. The Pennsylvania State University mailed the survey. Surveys were to be returned to Dr. Ellis at the University of Florida. More than 950 surveys were mailed. A total of 133 surveys have been received. Table 1 presents a summary of the responses by all respondents to Question 1 in the survey, which addresses the frequency of occurrence for various delay causes. Note that the causes have been listed in descending order by a weighted frequency score.

Responses were given a weighted ranking taking into account the three frequency categories. "Frequently" was assigned a weight of 5. "Sometimes" was assigned a weight of 2. "Rarely" was assigned a weight of 0. A ranking score was calculated by multiplying the frequency choices by the appropriate weighting factor and adding the total points.

The top five causes as ranked by all respondents were:

All Respondents

1. Utility Relocations Delayed
2. Differing Site Conditions (Utility Conflicts)
3. Delays in Environmental Planning
4. Permitting Issues
5. Insufficient Work Effort by Contractor

Table 2 presents a summary of the responses by SHA respondents to Question 1 in the survey, which addresses the frequency of occurrence for various delay causes. The top five causes as ranked by SHA respondents were:

State Highway Agency

1. Utility Relocations Delayed
2. Differing Site Conditions (Utility Conflicts)
3. Errors in Plans and Specifications
4. Weather
5. Permitting Issues

Table 3 presents a summary of the responses by Construction Contractor respondents to Question 1 in the survey, which addresses the frequency of occurrence for various delay causes. The top five causes as ranked by Contractor respondents were:

Construction Contractors

1. Utility Relocations Delayed
2. Errors in Plans and Specifications
3. Differing Site Conditions (Utility Conflicts)
4. Weather
5. Owner Requested Changes

Table 4 presents a summary of the responses by Designer respondents to Question 1 in the survey, which addresses the frequency of occurrence for various delay causes. The top five causes as ranked by Designer respondents were:

Designers

1. Utility Relocations Delayed
2. Differing Site Conditions (Utility Conflicts)
3. Delays in Environmental Planning
4. Permitting Issues
5. Insufficient Work Effort by Contractor

Note that two causes were ranked number one and number two by all groups:

1. Utility Relocations Delayed
2. Differing Site Conditions (Utility Conflicts)

Questions 2 through 21 requested input from the respondents with regard to successful measures that they were employing to avoid delays. These responses have been organized by specific delay cause. These solutions have provided useful benchmarking information from which to develop candidate solutions to the root causes of delay problems. Follow up contacts with a number of respondents to gain more detailed information have been initiated.

Table 1 Ranking of Delay Causes by Estimated Frequency of Occurrence by All Respondents

Rank	Question No.	Question	Number of Frequently	F Score	Number of Sometimes	S Score	Number of Rarely	R Score	Total Ranking Score
1	1.8	Utility Relocations Delayed	80	400	46	92	5	0	492
2	1.9	Differing Site Conditions (Utility Conflicts)	63	315	50	100	19	0	415
3	1.2	Delays in Environmental Planning	45	225	60	120	24	0	345
4	1.3	Permitting Issues	27	135	81	162	21	0	297
5	1.13	Insufficient Work Effort by Contractor	35	175	59	118	38	0	293
6	1.15	Weather	22	110	74	148	33	0	258
7	1.10	Differing Site Conditions (Other Causes)	29	145	54	108	43	0	253
8	1.12	Poor Coordination of Work by Contractor	25	125	62	124	39	0	249
9	1.4	Delays in Right of Way Acquisition	20	100	69	138	39	0	238
10	1.16	Owner Requested Changes	20	100	67	134	43	0	234
11	1.18	Labor Shortages	22	110	58	116	46	0	226
12	1.1	Funding Issues	20	100	57	114	52	0	214
13	1.6	Errors in the Plans or Specifications	14	70	56	112	58	0	182
14	1.14	Delays in Receiving Materials	5	25	66	132	58	0	157
15	1.17	Conflict with other Construction Projects	7	35	45	90	77	0	125
16	1.7	Pay Items do Not Match Scope of Work	5	25	42	84	83	0	109
17	1.11	Late Start on Work by Contractor	7	35	32	64	89	0	99
18	1.5	Delays in Design	1	5	36	72	90	0	77
19	1.19	Equipment Shortages	0	0	23	46	107	0	46
20	1.20	Other	1	5	2	4	22	0	9

Table 2 Ranking of Delay Causes by Estimated Frequency of Occurrence by State Highway Agency

Rank	Question No.	Question	Number of Frequently	F Score	Number of Sometimes	S Score	Number of Rarely	R Score	Total Ranking Score
1	1.8	Utility Relocations Delayed	27	135	26	52	1	0	187
2	1.9	Differing Site Conditions (Utility Conflicts)	17	85	27	54	10	0	139
3	1.6	Errors in the Plans or Specifications	10	50	26	52	17	0	102
4	1.15	Weather	8	40	29	58	16	0	98
5	1.3	Permitting Issues	12	60	19	38	23	0	98
6	1.4	Delays in Right of Way Acquisition	7	35	27	54	19	0	89
7	1.2	Delays in Environmental Planning	8	40	24	48	21	0	88
8	1.13	Insufficient Work Effort by Contractor	4	20	34	68	16	0	88
9	1.1	Differing Site Conditions (Other Causes)	3	15	33	66	18	0	81
10	1.12	Poor Coordination of Work by Contractor	1	5	38	76	14	0	81
11	1.16	Owner Requested Changes	4	20	28	56	22	0	76
12	1.5	Delays in Design	3	15	27	54	22	0	69
13	1.11	Late Start on Work by Contractor	2	10	28	56	24	0	66
14	1.14	Delays in Receiving Materials	0	0	28	56	26	0	56
15	1.1	Funding Issues	3	15	16	32	34	0	47
16	1.17	Conflict with other Construction Projects	3	15	13	26	39	0	41
17	1.7	Pay Items do Not Match Scope of Work	3	15	9	18	41	0	33
18	1.18	Labor Shortages	1	5	10	20	42	0	25
19	1.19	Equipment Shortages	0	0	6	12	47	0	12
20	1.20	Other	0	0	1	2	21	0	2

Table 3 Ranking of Delay Causes by Estimated Frequency of Occurrence by Construction Contractors

Rank	Question No.	Question	Number of Frequently	F Score	Number of Sometimes	S Score	Number of Rarely	R Score	Total Ranking Score
1	1.8	Utility Relocations Delayed	49	245	19	38	4	0	283
2	1.6	Errors in the Plans or Specifications	44	220	20	40	9	0	260
3	1.9	Differing Site Conditions (Utility Conflicts)	33	165	32	64	6	0	229
4	1.15	Weather	18	90	48	96	5	0	186
5	1.16	Owner Requested Changes	21	105	39	78	13	0	183
6	1.10	Differing Site Conditions (Other Causes)	14	70	44	88	13	0	158
7	1.3	Permitting Issues	20	100	27	54	21	0	154
8	1.2	Delays in Environmental Planning	20	100	25	50	22	0	150
9	1.5	Delays in Design	15	75	36	72	18	0	147
10	1.7	Pay Items do Not Match Scope of Work	18	90	28	56	26	0	146
11	1.4	Delays in Right of Way Acquisition	17	85	29	58	21	0	143
12	1.18	Labor Shortages	16	80	29	58	27	0	138
13	1.1	Funding Issues	12	60	25	50	32	0	110
14	1.14	Delays in Receiving Materials	5	25	35	70	30	0	95
15	1.17	Conflict with other Construction Projects	4	20	27	54	40	0	74
16	1.12	Poor Coordination of Work by Contractor	2	10	27	54	41	0	64
17	1.11	Late Start on Work by Contractor	4	20	21	42	45	0	62
18	1.13	Insufficient Work Effort by Contractor	0	0	25	50	44	0	50
19	1.19	Equipment Shortages	0	0	17	34	55	0	34
20	1.20	Other	1	5	1	2	1	0	7

Table 4 Ranking of Delay Causes by Estimated Frequency of Occurrence by Designers

Rank	Question No.	Question	Number of Frequently	F Score	Number of Sometimes	S Score	Number of Rarely	R Score	Total Ranking Score
1	1.8	Utility Relocations Delayed	4	20	1	2	0	0	22
2	1.9	Differing Site Conditions (Utility Conflicts)	2	10	3	6	0	0	16
3	1.2	Delays in Environmental Planning	2	10	2	4	1	0	14
4	1.3	Permitting Issues	1	5	4	8	0	0	13
5	1.13	Insufficient Work Effort by Contractor	2	10	1	2	2	0	12
6	1.15	Weather	1	5	3	6	1	0	11
7	1.10	Differing Site Conditions (Other Causes)	1	5	3	6	1	0	11
8	1.12	Poor Coordination of Work by Contractor	1	5	3	6	1	0	11
9	1.4	Delays in Right of Way Acquisition	2	10	0	0	3	0	10
10	1.16	Owner Requested Changes	1	5	1	2	3	0	7
11	1.18	Labor Shortages	1	5	1	2	3	0	7
12	1.1	Funding Issues	1	5	1	2	3	0	7
13	1.6	Errors in the Plans or Specifications	0	0	3	6	2	0	6
14	1.14	Delays in Receiving Materials	0	0	3	6	2	0	6
15	1.17	Conflict with other Construction Projects	0	0	2	4	3	0	4
16	1.7	Pay Items do Not Match Scope of Work	0	0	2	4	3	0	4
17	1.11	Late Start on Work by Contractor	0	0	2	4	3	0	4
18	1.5	Delays in Design	0	0	1	2	4	0	2
19	1.19	Equipment Shortages	0	0	0	0	5	0	0
20	1.20	Other	0	0	0	0	0	0	0

**APPENDIX C:
ROOT CAUSES OF DELAY**

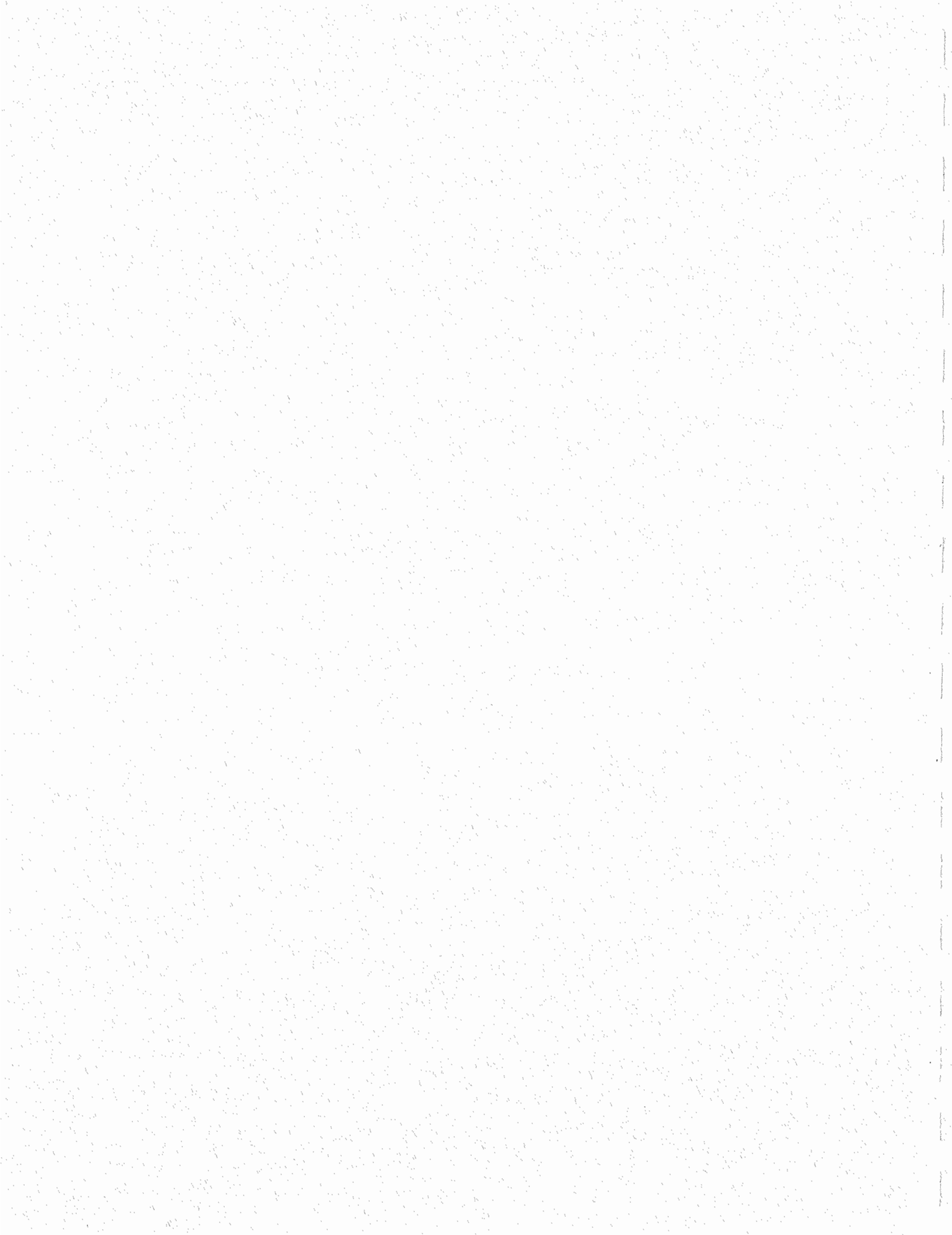


Table C-1. Root Causes of Delay.

1. Business Practices and Procedures (Chapter 4)

- Business as usual.
- Most projects are treated alike.
- For political and funding reasons, projects often need to be awarded based on an accelerated schedule.
- Various team members have different objectives.
- Budgets restrict the expenditure of project funds across functional boundaries.

2. Contractor Procurement and Contract Administration (Chapters 5 and 6)

- There is a lack of team accountability for timely project completion.
- Decision makers weigh cost benefits more heavily than time benefits.
- DOT persons and consultants called to the job site to deal with a problem sometimes do not have keen sensitivity to timeliness of decisions.
- Construction expertise is not incorporated into the design.
Because of time constraints, the attitude of designers is to let construction fix the problem.

3. Utilities Locations and Relocations (Chapter 7)

Unforeseen and Incorrectly Located Utilities

- Many smaller utilities have no as-builts.
- Often, the as-builts are incorrect.
- To save monies, utilities are often located only for the x and y position using as-built drawings.
- The utility information provided on drawings is not always clear, especially for complex intersections (no. of pages and symbols).
- The standard of practice for designers is not always clear as to how to communicate information and protection standards.

Slow Responses Regarding Betterments and Improvements

- Utilities may be late in deciding on utility upgrades because funding approval is untimely.

Delays in Utilities Relocating Their Facilities

- The DOT is not high on the priority list so the utilities may be moved late.
- DOTs are seemingly powerless to get utility companies to respond.

4. Differing or Unforeseen Site Conditions (Chapters 5 and 6)

Information provided is inaccurate

- Conditions are known but are not incorporated into design because of time or funding constraints.
- Viewpoint that the test borings are developed for design, not for construction.

Conditions change after the design is complete

- Project walkdowns not done, ineffective, or too late.
- Conditions are unknown but DOT response time to problems may be slow.
- There is little accountability for time.

Conditions are unknown but are easily discoverable or corrected

- Constructibility reviews are often ineffective or untimely.
- Viewpoint that the investigation is only for design purposes limits how much knowledge is obtained and furnished.

5. Contractor Management (Chapter 8)

Contractor planning

- Planning horizon for many contractors is 1-2 weeks.
- Procurement and contract administration practices do not always encourage detailed contractor planning.

Contractor scheduling

- Lack of aggressive enforcement of contract schedule requirements.
- Critical path method (CPM) schedules are often complex, confusing, and may not reflect the way the job is built.

Ineffective enforcement of the contract

- Lack of incentives to adhere to the original contract time.
- The understanding of the contract is sometimes limited.
- Deferring time extensions and bargaining time extensions for money and claim releases.

6. Maintenance of Traffic (Chapter 8)

- MOT plan does not always incorporate the most efficient and timely manner of construction.
- The least intrusive plan (and longest schedule) is often selected instead of a more intrusive (but shorter duration) plan.

7. Errors and Omissions (Chapter 5)

- The accountability for designers is to complete the design, not for timely project completion.
- The financial incentive to carefully review the plans is not there because the designer usually gets paid extra to correct for unforeseen conditions.
- Prebid review is insufficient.

**APPENDIX D:
FHWA RECOMMENDATIONS FOR UTILITY RELOCATIONS
(Federal Highway Administration 1998)**

RELOCATIONS TO ACCOMMODATE HIGHWAY CONSTRUCTION

RECOMMENDATIONS FOR DIVISION, REGION, AND HEADQUARTERS OFFICES

Relocations to Accommodate Highway Construction		
Division Offices	Region Offices	Headquarters
<ol style="list-style-type: none"> 1. Encourage the State and the utilities to coordinate, cooperate, and communicate more with each other. 2. Encourage the State and the utilities to provide relevant information to each other in a timely manner. 3. Encourage partnering, meetings, and similar activities between the State and the utilities. 4. Become more involved in utility relocation activities of the State and utilities. 5. Encourage the State to establish policies and procedures to assure the utilities are involved early in the development of projects and that utility facilities are relocated prior to construction. 6. Encourage the State to use subsurface utility engineering to reduce the number of utility facilities that need to be relocated, and to investigate other new and innovative relocation approaches. 	<ol style="list-style-type: none"> 1. Provide training, sponsor regional meetings, and participate in national meetings. 2. Encourage, assist, and become more involved in utility relocation activities of the Divisions, States, and utilities. 3. Obtain/share information on state-of-the-art relocation practices, experiences in other States, and other utility-related items. 4. Provide financial and technical assistance to the Divisions on relocation matters. 5. Look for/promote new and innovative methods for relocating utility facilities. 	<ol style="list-style-type: none"> 1. Provide training, promote regional meetings, and sponsor national conferences. 2. Obtain/share information on state-of-the-art relocation practices, experiences in other States, model legislation, and other utility-related items. 3. Provide financial and technical assistance to field offices on relocation matters. 4. Research the problem and promote the development of laws, regulations, policies, and/or guidance requiring all utility facilities to be relocated, to the extent possible, in a timely manner prior to the beginning of construction. 5. Look for/promote new and innovative methods for relocating utility facilities.

**COORDINATION, COOPERATION, AND COMMUNICATION
WITH UTILITY OWNERS**

**RECOMMENDATIONS FOR
DIVISION, REGION, AND HEADQUARTERS OFFICES**

Coordination, Cooperation, Communication with Utility Owners		
Division Offices	Region Offices	Headquarters
<ol style="list-style-type: none"> 1. Encourage the State and the utilities to coordinate, cooperate, and communicate more with each other. 2. Encourage the State and the utilities to provide relevant information to each other in a timely manner. 3. Encourage partnering, meetings, and similar activities between the State and the utilities. 4. Become more involved in utility-related activities of the State and the utilities. 5. Encourage the State to establish policies and procedures to assure the utilities are involved early in the development of projects and that utility facilities are relocated prior to construction. 6. Instill the need for the State, the utilities, and the contractors to better understand each others' problems and to assume responsibility for working with each other to avoid/reduce these problems. 	<ol style="list-style-type: none"> 1. Encourage the Divisions to promote better State/utility coordination, cooperation, and communication 2. Provide training, sponsor regional meetings, and participate in national conferences. 3. Encourage, assist, and become more involved in utility-related activities of the Divisions, States, and utilities. 4. Obtain/share information on state-of-the-art practices, experiences in other States, and other utility-related items. 5. Provide financial and technical assistance to the Divisions on utility-related matters. 6. Help develop policies setting forth utility-related expectations and consequences for non-compliance. 	<ol style="list-style-type: none"> 1. Encourage field offices to promote better State/utility coordination, cooperation, and communication 2. Provide training, promote regional meetings, and sponsor national conferences. 3. Obtain/share information on state-of-the-art practices, experiences in other States, and other utility-related matters. 4. Provide financial and technical assistance to field offices on utility-related matters. 5. Research utility-related problems and promote the development of laws, regulations, policies, and/or guidance setting forth expectations and consequences for non-compliance.

**UNEXPECTED CONFLICTS WITH
UNDERGROUND UTILITY FACILITIES DURING CONSTRUCTION**

**RECOMMENDATIONS FOR
DIVISION, REGION, AND HEADQUARTERS OFFICES**

Unexpected Conflicts With Underground Utility Facilities During Construction		
Division Offices	Region Offices	Headquarters
<ol style="list-style-type: none"> 1. Determine the magnitude of the problem, explore possible solutions with the State, and encourage the State to take positive actions to avoid/reduce utility conflict problems. 2. Encourage partnering, meetings, and similar activities between the State and the utilities. 3. Obtain/share information about subsurface utility engineering, and promote its use with State personnel (e.g., upper management, designers, utilities coordinators, construction supervisors). 4. Establish a policy holding the State and/or the utilities responsible and liable for delays resulting from unanticipated conflicts with underground utilities, particularly in cases where good practices were ignored. 	<ol style="list-style-type: none"> 1. Encourage, assist, and become more involved in activities of the Divisions, States, and utilities to avoid/reduce problems resulting from unexpected conflicts with underground utility facilities.. 2. Obtain/share information on subsurface utility engineering and other related technologies for detecting/depicting underground utility facilities. 3. Encourage the Divisions to promote the use of subsurface utility engineering. 	<ol style="list-style-type: none"> 1. Obtain/share information on subsurface utility engineering and other related technologies for detecting/depicting underground utility facilities. 2. Provide financial and technical assistance to field offices. 3. Encourage the field offices to promote the use of subsurface utility engineering.

**APPENDIX E:
UTILITIES GUIDELINES AND BEST PRACTICES
(AASHTO 2000b)**

Guideline

Encourage frequent coordination and communication with utility companies to reduce delivery time, reduce costs, and improve quality in the utilities process.

Best Practices

- A. Provide utility companies with long-range highway construction schedules.
- B. Host meetings with utility companies to discuss future highway projects.
- C. Recognize the importance of long-range highway/utility coordination. The better utilities are able to foresee potential impacts on highway projects to their systems, the more responsive they will be to the transportation agencies need and the better they can account for such impacts in their capital construction programs. Conversely, transportation agencies will improve the quality of project scoping, budgeting, and design efforts if they can obtain early information on utility construction programs and potential conflicts.
- D. Organize periodic (monthly, quarterly, annual) meetings with utility owners within a municipality, county, or geographic or highway planning region. Such meetings may include all utilities within a corridor or locale; or utilities of a particular type; or be one-on-one with individual utilities. Furnish information on the Department of Transportation long-range highway schedule, such as annual budgets, five or ten-year plans, projected advertisement dates, or whatever else may be available to provide early notice. Be prepared to discuss right of way corridor or other major projects and their potential impacts on existing utilities. Identify probable major conflicts and insure this information is communicated to the project designer and reflected in the project scope.
- E. Solicit similar information on utility owners' capital construction programs, particularly where a utility's planned expansion or reconstruction may encroach on and coincide with a planned highway project. Look for opportunities to coordinate such overlapping projects so costs and public impact may be minimized. Through schedule changes, try to avoid situations such as where a new buried utility line disrupts a newly reconstructed highway.
- F. Consider using the long range-planning meeting as a convenient forum to discuss other highway/utility issues, such as accommodation policies, reimbursement, etc. What begins as a series of informal planning meetings could eventually evolve into a local, regional, or statewide "utility coordination committee."

Examples:

- The Florida Department of Transportation provides a five-year work program to utility companies on a semi-annual basis and is exploring ways to make more use of the worldwide web to keep the industry current.

- In Nevada, monthly meetings with local utility companies and local entities are held in the Las Vegas area in order to enable participants to address upcoming project needs and identify better ways to improve future projects when dealing with utility relocations. This provides an opportunity for the Nevada Department of Transportation to better coordinate efforts with county officials and utilities to prevent project delays and costly mitigation.
- The Montana Department of Transportation provides 5-year long-range project schedules to all utility companies. These schedules are segregated by geographical area.

G. Provide utility companies with a notice of proposed highway improvements and preliminary plans as early in the development of highway projects as possible.

- 1) This will allow them to budget for relocations and have sufficient manpower available to do the work.
- 2) Assure utility companies understand that the dates the work may actually take place are subject to change, that the preliminary plans are subject to many changes, and no relocation work should begin until firm letting dates have been established, plans have been substantially completed, and the Department of Transportation provides notification that work can begin.
- 3) Examples:
 - In Wisconsin, all utility facilities the Department of Transportation is reasonably able to recognize are included in such a notice. Within a reasonable time, usually about 60 days, utility companies are expected to respond to the notice and provide a description of facilities in the vicinity of the improvements, including specific reasons or needs for those facilities to remain in place or be relocated. After each utility responds to the notice, the Department of Transportation mails the utility at least one set of preliminary project plans. These plans should show all existing utility facilities known to the Department of Transportation in areas where they will conflict with the improvements. This process is followed by the Wisconsin Department of Transportation in accordance with a State law enacted to prescribe minimum utility coordination requirements in order to prevent utility relocations from delaying highway projects. [Sec. 84.063, Wis. Stats. Utility Facility Relocations and related Administrative Rule Trans 220].
 - In Missouri, the Department of Transportation furnishes micro station plan files with utility companies to reduce the drafting work by the utility companies. This process expedites development of utility relocation plans on a project.
 - In Florida, the Department of Transportation provides utility companies advance notice of proposed highway improvements and furnishes preliminary route plans.

The Department of Transportation also submits 30, 60, and 90% plans to utility companies as part of the design process. At least one Florida Department of Transportation district sends the utilities a monthly mail-out listing all projects in the production and letting cycle. This typically gives the utilities about 18 months advance notice of planned projects. Twice yearly, the Department of Transportation's five-year work program is sent to all utility companies in the state. The Florida Utility Coordination Committee meets quarterly at different locations around the State. Currently, the Department of Transportation maintains a utility web page containing the Department of Transportation's five-year work program, names, addresses, and contact numbers of district utility engineers, advice on obtaining permits, and permit forms and agreements.

- Georgia and South Carolina also host regular meetings with utility companies to advise them of pending projects and to review and submit preliminary plans to utility companies.

H. Involve utility companies in the design phase of highway projects where major relocations are anticipated.

1. Meet often with utility owners and highway designers, throughout the development of projects, to coordinate ongoing activities.
2. Conduct on-site meetings or plan-in-hands with utility companies to determine utility conflicts and appropriate resolutions.
3. Conduct detailed meetings monthly on major projects, as a minimum, in order for all parties to keep abreast of the project status and changes.
4. Cost effective advance planning is essential to utility companies since they must now compete under deregulation. The Department of Transportation's help and cooperation is needed more than ever. It is not good business, and may have negative political consequences, if Department of Transportation's attempt to dictate to utility companies.
5. Department of Transportation project engineers should meet individually with representatives from every utility company in order to minimize the possibility the Department of Transportation will reject utilities' relocation plans and require them to redesign the relocation. Early involvement can decrease the cost and impact of projects by identifying conflicts that can be avoided.
6. Involve utility companies in the right-of-way design phase to assure utility companies have room between the construction limits and the new right-of-way in which to relocate facilities.

- The Pennsylvania Department of Transportation holds on-site meetings with utility companies in all 11 of their engineering districts. This produces valuable information for and from involved utilities and has not appeared to affect the time frame of projects.
 - The Virginia Department of Transportation contacts utility owners during the design phases of projects where major relocations are anticipated. This allows planners to understand relocation needs and to identify major right-of-way corridor requirements for anticipated relocations. This has worked particularly well for major power transmission and petroleum pipeline relocations. The Virginia Department of Transportation has only had limited success involving utilities on projects where few relocations are anticipated because utility owners seem to prefer to wait until after the design has been essentially completed to discuss relocations. The Virginia Department of Transportation strives to avoid or minimize as many relocations as possible through application of their subsurface utility engineering program.
 - Some states such as Iowa design right of way limits at least eight meters beyond the construction limits to allow utility companies room to relocate facilities.
- I. Conduct on-site utility meetings or utility plan-in-hands with utility companies to determine utility conflicts and resolution.
 - J. Participate in local one-call notification programs to the maximum extent practicable per state law.
 1. Utilize one-call centers at an appropriate level of participation to protect underground facilities.
 - State transportation departments own or manage many underground utilities, sometimes vast, statewide networks for traffic signalization, lighting, ITS, and other purposes. Some transportation departments are specifically exempted by State law from having to participate in local one-call activities. This is possibly because participation may appear to be cost prohibitive due to the expected large volume of calls by excavators for marks and subsequent marking activities. Even so, to the extent allowable, transportation departments may become members of local one-call centers and participate in one-call activities to protect their own utilities from excavation activities.
 - Many utilities are damaged by transportation department's forces engaged in excavation activities. Highway related activities have been estimated to result in up to 20 percent of all damage to underground utilities. Transportation department forces should always "call before they dig." There may be times and situations when it is not practicable to do so. But, in general, taking the time to call for locates before beginning excavation activities will reduce much damage to

utilities, including State-owned utilities. And, there is no charge to the Transportation Departments for this service.

2. Require contractors to fully participate in local one-call notification programs whether required by State law or not. (Departments of Transportation in several States are specifically excluded from one-call requirements, but contractors are not).

- This would include contacting the local one-call center prior to digging, waiting for the site to be marked before beginning to excavate, protecting the markings after they are placed, and hand digging within two feet on either side of marked lines.
- Oversight should be provided to assure compliance. Penalties should be assessed for non-compliance.
- Contractors should be held responsible for damage caused by non-compliance.

3. Examples:

- A regional communication company with underground fiber optics lines in nine states determined that 18 to 22 percent of all damages to its facilities in 1997 to 1999 were caused by state and local highway activities.
- The North Carolina Department of Transportation is participating in a test program in six counties to determine an appropriate level of participation by the Department of Transportation in the North Carolina One-Call Center.
- Montana Department of Transportation is securing proposals for a locating services company to locate state owned facilities for all one-call requests.

K. Invite utility companies to preconstruction meetings and encourage or require utility companies, contractors, and project staff to hold regular meetings, as deemed appropriate, during the construction phase of a project.

1. Encourage or require all utility owners, who must coordinate their relocation work with the highway construction, to attend the project pre-construction conference. The purpose of their participation is to:

- Establish contact with the Department of Transportation project manager and with the contractor's organization.
- Confirm the utility's physical relocation plans.
- Verify the utility's relocation schedule and notification/coordination requirements as may be further described in the project specifications.

- Resolve other coordination details, such as signing/traffic control, site preparation by highway contractor, etc.
2. Give utility owner representatives sufficient advance written meeting notice to facilitate their attendance. Confirm their planned attendance by follow-up telephone call. Designate a specific time during the preconstruction meeting to address utility issues. Honor that meeting schedule and allow the utility representatives to be present only as needed during the reserved time period. Depending on the number and complexity of the utility conflicts, reserve separate times for individual utility owners.
 3. At the discretion of the Department of Transportation's utility engineer or utility liaison, hold a separate pre-construction meeting with utility representatives and/or utility subcontractors. This sometimes provides a more comfortable setting for utilities to address their coordination needs. If potentially serious concerns are identified, the Department of Transportation representative can then provide liaison between the utility and the highway contractor. A separate meeting with utility representatives may also avoid tying up the time of other Department of Transportation and contractor representatives who may have little direct involvement with the utility issues.
 4. Examples:
 - Wyoming recommends utilities that are affected by project construction to attend the preconstruction conference. The Wyoming Department of Transportation assigns levels of utility involvement with a project so that utility companies and contractors are familiar with the extent of each utility company/contractor coordination work that is necessary. Wyoming also invites utility companies affected by a project to attend partnering meetings.
 - The Virginia Department of Transportation encourages or requires regular meetings between the contractor, utility owners, and others on major projects.

Guideline

Improve contract, internal project development and training processes to expedite utility relocation.

Best Practices

- A. Use standardized utility agreements.
 1. The use of standard utility agreements eliminates the need for approvals on each and every contract, saves time for the Department of Transportation and the utility company and reduces the time to have agreements consummated.

2. Examples:

- The Pennsylvania Department of Transportation uses standard agreements on approximately 95% of their projects. Utility and Department of Transportation attorneys in Pennsylvania are receptive to standard agreements. They know what is in them and usually sign without question.
- In Missouri, the Department of Transportation pays the utility company, upon request, the estimated cost of relocation before the utility company begins the work. Relocation of utilities is expedited since budget concerns are eliminated which previously created a strain on the ability of a utility company to perform the relocation work.
- Other Departments of Transportation such as Montana use standard agreements for the majority of utility relocation work

B. Initiate separate contracts for advance roadway work on selected projects prior to utility relocation.

1. Advance roadway work may consist of, but is not confined to, the following activities: clearing and grubbing, slope staking, monumentation, demolition of buildings, advance grading.
2. On selected projects, the letting of advance roadway work as separate contracts in advance of the grading may enable utilities to be relocated prior to letting the roadway contract. This will help reduce delays to the contractor waiting for utilities to be relocated out of the way.
3. There may be situations where utility relocation work could begin, but must await advance roadway work, and, for whatever reason, letting of the primary contract including that work has been delayed. In such cases, separate contracts for the advance roadway work would afford an opportunity to relocate utilities out of the way in advance of the primary highway contract. The Department of Transportation should consider reimbursing the utility company, with project funds, for this work if the utility performs the work or contracts it.

4. Examples:

- The Iowa Department of Transportation has recognized relocation delays awaiting clearing and grubbing to be a problem at times and has recommended separate clearing and grubbing contracts on selected projects as a solution.
- The Florida Department of Transportation has let separate clearing and grubbing contracts. Last year, as an innovative idea, the Department of Transportation proposed legislation that passed, effective July 1999 which allows the Department

of Transportation to pay utility companies to do selected clearing and grubbing if they would agree to do the relocation work in advance of the highway construction. The FHWA has agreed to participate in this work on a project-by-project basis if the legislation passes. This is expected to help reduce delays and shorten the contract time for highway projects.

- The Virginia Department of Transportation has let on-call contracts for the demolition of buildings and miscellaneous structures prior to the advertisement of the highway project, but has not found it to be advantageous to oversee separate clearing and grubbing work. Most of the utility companies in Virginia who perform on a force account basis have contractors available on a continuing-contract basis. The use of that method does not seem to cause any delays or inefficiencies. The Virginia Department of Transportation encourages the practice of having contractors available to demolish vacant structures that are in the way of utility relocation, but doesn't believe this practice should be extended to clearing and grubbing.

C. Set forth responsibilities for appropriate action to reduce delays to contractors.

1. There needs to be a clear understanding of each party's responsibilities and rights, preferably supported by case law or statute.
2. The Department of Transportation is responsible to ensure the utility owner has adequate lead-time and notice and to control or make allowance for late highway design changes.
3. There should be a notice, or preferably a written agreement describing the work required, the schedule for performance, and penalties for noncompliance.
4. There must be mutual agreement for, and allowances made for all changes made in the field during construction.

D. Provide utility special provision language in the construction contract.

1. Special provisions are needed to define the responsibilities of the Department of Transportation's highway construction contractor with respect to cooperation with the utility owner.
 - Special provisions provide a formal statement of the timing schedule and work windows between contractor, utility owner, and Department of Transportation. This levels the playing field and ensures all of the players are aware of their responsibilities.
 - Standard special provisions help establish statewide uniformity.

- Helps to ensure that there will not be conflicts between utility companies for same work site location and time.
- Provide notice to the Department of Transportation's contractor of agency's requirements for protection in place and workarounds.

E. Avoid late plan changes.

1. Late plan changes tend to complicate and often delay utility relocations for construction projects. Projects have been delayed because utility relocations are affected by late plan changes. In some cases utility companies have been required to relocate previously relocated facilities because of late plan changes, resulting in increased costs to both utility companies and Departments of Transportation.
2. Late plan changes must be avoided to help compensate for increased numbers of utilities being placed on highway right-of-way, increased funding for highway projects, increased utility relocation requirements, and reduced utility company and Department of Transportation engineering staff.
3. Plan changes due to right-of-way acquisition have a similar impact on utility relocations.

F. Have highway contractors relocate utility and municipal facilities, when possible.

1. Although it is generally acceptable for the utility owner to relocate its facilities with its own forces (see 23 CFR 635.205(b)), other construction methods are available, including but not limited to having the work performed on the owner's behalf by the highway contractor (see 23 CFR 645.115). In consultation with the utility, select the appropriate method based on cost effectiveness considerations, including whether the work can be done at a reasonable cost and "at a time convenient to and in proper coordination with the associated highway construction" (23 CFR 645.115(a)).
2. Incorporating the utility relocation work into the highway contract has the following potential advantages:
 - Improved ability to control the work and to coordinate sequential or concurrent operations (with a corresponding reduced risk of delay or disruption).
 - Greater utilization of contractor's equipment and manpower.
 - Less duplication of effort on items such as traffic control.
 - Lower bid prices by consolidating items such as excavation under a single contract.

3. In determining if the highway contractor should relocate utilities, consider:
 - Whether the utility work must be performed prior to or concurrent with highway work.
 - Whether the highway contractor can be reasonably expected to perform the utility work; or if the work can be readily subcontracted. In some cases a pre-approved list of contractors acceptable to the utility company is an option.
 - Whether the utility work substantially alters the planned scope of the highway project.
 - Whether utility owner and/or labor union policies allow others to perform the work, and if so, under what conditions, e.g., the use of pre-approved subcontractors, use of proprietary materials, etc.
 - Potential efficiencies to be gained by consolidating the utility and highway work.
 - Whether the necessary funding can be put into place.
4. If the Department of Transportation and utility agree to incorporate the work into the highway construction contract, make appropriate written arrangements for work performance, standards, payment, inspection, liability etc. If the utility is responsible for relocation costs, make provision for the utility to either fund the work in advance, or reimburse the highway agency (or contractor) upon completion. In the event bid prices for the utility work are excessively high, make contingency plans for the work to be withdrawn from the contract and performed by other suitable means, or for the responsible party to make up the shortfall. As needed, incorporate utility-furnished or approved plans and specifications into the highway project bid package. Make adequate provisions for the owner to inspect and accept the work.
5. In practice, utility work that is more readily performed by highway contractors, or their subcontractors, may include such items as storm and sanitary sewers, water lines, gas line service laterals, manhole and valve cover adjustments, and sleeves or ducts for later use by utilities. Power, communications, and high pressure commodities pipeline companies may be reluctant to delegate work on their facilities, due to safety, union, proprietary, or other concerns (however, they may allow the use of pre-approved subcontractors). Highway contractors may likewise be reluctant to assume responsibility for work that is well outside their normal qualifications or experience.

G. Acquire sufficient Right of Way for utilities purposes.

1. When a Department of Transportation requires utilities to be relocated to accommodate highway construction and intends to permit utilities to be accommodated on the right-of-way of a proposed new highway project, such use should be considered in determining the extent and adequacy of the right-of-way

needed for the project. Failure of the Department of Transportation to acquire sufficient right-of-way to accommodate utilities may affect the safe and efficient operations of the highway.

2. When a Department of Transportation dedicates or permits a portion of highway right-of-way for use by utilities in accordance with established criteria pursuant to State law, regulation, or policy, such right-of-way may be considered eligible for Federal-aid reimbursement as an integral part of the project right-of-way.

H. Provide training to Department of Transportation utility staff and utility companies staff.

1. Department of Transportation utility staff should have continuous and ongoing training in department operations and requirements that may come into play during the utility relocation process. Some examples are changes in design standards, environmental requirements to require the utility companies to comply with federal and state environmental regulations and laws and federal codes and state statutes that deal with utility relocation and reimbursement.
2. Department of Transportation utility staff should be trained and familiar with utility company design, estimating, billing, placement, and bidding requirements so as to avoid confusion during the utility relocation process.
3. Department of Transportation staff should provide training for utility company staff in utility relocation procedures required by the department. In addition, department staff can provide training on how to read plans and cross sections to enable utility company staff to design facilities to avoid conflict with the project construction.
4. An excellent resource to share with utility companies is the Highway Utility Guide and the Program Guide, Utility Adjustments and Accommodation prepared by the Federal Highway Administration.
 - a) Examples:
 - Pennsylvania Department of Transportation is preparing a video to be distributed to utility companies on how to read department plans.
 - Other Departments of Transportation host periodic meetings with utility staff to better acquaint them on department requirements, such as utility permitting.

