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IMPROVING THE TIME PERFORMANCE OF HIGHWAY CONSTRUCTION CONTRACTS

FINAL REPORT

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16. Abstract

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Abstract

The objective of this research was to develop implementation details for: criteria for defining a time-sensitive project; criteria and process for assigning project time classifications to contractors and designers; criteria and process for determining the appropriate SUE level; best practices for avoiding utility relocation delays; and criteria for determining optimum incentive values in A+B and other performance incentive contracts. The goal of this project is to improve contract time performance on highway construction contracts. The authors visited six states to discuss strategies used for time-sensitive projects. As no state identified time-sensitive projects *per se*, the authors applied modern management principles from other construction sectors to the problem of time sensitivity to create new practices rather than best practices. The products of this study will be practical tools to facilitate implementation of contract time performance improvement strategies. The criteria, implementation processes, and best and new practices developed in this research will contribute to the current industry-wide effort to improve time performance. It was concluded that most states have rather weak processes in place for minimizing time performance of designers and construction contractors. A number of specific conclusions are discussed.

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1. INTRODUCTION

Time has become an important yardstick for measuring the performance of construction contractors on highway projects. The road user costs and administrative costs associated with delayed completion can be substantial. The cost recovery is only partially offset by liquidated damages. The motoring public is becoming increasingly agitated and impatient with delayed projects.

BACKGROUND

In 2001 a report was written for the National Cooperative Highway Research Program (NCHRP) on avoiding time delays (Thomas and Ellis 2001). The report contained 40 recommendations. An integrated or holistic approach was taken, as there was no “silver bullet” solution to untimely performance. It seems likely that a state highway agency (SHA) will need to adopt effective strategies for all of the following issues to achieve timely performance.

- Classify projects according to time sensitivity and apply scarce resources accordingly.
- Select designers and contractors based on timely performance.
- Ensure construction input into design.
- Substantially reduce utility conflicts.
- Improve utility relocation performance.
- Provide encouragement for contractors to adopt a longer planning horizon.

The 2001 NCHRP report addressed each of theses issues. The focus of this report is to provide implementation details on selected recommendations from that report.

OBJECTIVES

The objective of this research was to develop implementation details for the following:

- Criteria for defining a time-sensitive project,
- Criteria and process for assigning project time classifications to contractors and designers,
- Criteria and process for determining the appropriate SUE level,
- Best practices for avoiding utility relocation delays, and
- Criteria for determining optimum incentive values in A+B and other performance-incentive contracts.

The goal of this project is to improve contract time performance on highway construction contracts. The products of this study will be practical tools to facilitate implementation of contract time performance improvement strategies. The criteria, implementation processes, and best and new practices developed in this research will contribute to the current industry-wide effort to improve time performance.

METHODOLOGY

The researchers visited six states to discuss strategies used for time-sensitive projects. No state identified time-sensitive projects *per se*. Therefore, the researchers applied modern management principles from other construction sectors to the problem of time sensitivity to create new practices rather than best practices.

MINIMUM COST VS. MINIMUM TIME TRENDS

Many years ago SHAs were primarily interested in acquiring construction services that yielded the maximum value for the money spent; that is, minimum cost was the primary objective. This is not to say that time was never considered, only that cost was the dominant factor. Statutes, regulations, processes, and procedures were put into place to ensure that minimum cost was achieved. These processes have served the SHA well.

However, the modern SHA is under new pressures to finish projects in a timely manner. Some of the pressures arise from:

- Increased urban construction,
- Traffic congestion,
- Citizen complaints,
- Environmental and business concerns, and
- High utility densities.

The list of pressures could be expanded, but that is not the goal here. The point is that modern SHAs are under pressure to complete projects in the shortest time practical. Unfortunately, there are few processes in place to enhance the minimum-time objective.

The report from an earlier NCHRP project was an initial effort to define some of the practices that can be adopted by SHAs to more effectively meet the minimum time challenge (Thomas and Ellis 2001). This report continues that effort by presenting in more detail some of the more easily definable strategies.

2. DISCRETIONARY AUTHORITY OF AWARDING AGENCIES

The process of competitive bidding on public projects is one that is governed by federal, state, and local statutes and regulations that require that the award of a contract be made to the lowest "responsible" bidder. The determination of criteria on what constitutes a "responsible" bidder is generally left to agency or authority regulatory procedures. Any discussion relative to the process requires that certain core principles be highlighted.

In reality, statutory language relative to "lowest responsible bidder" varies from one locale to another, but as a practical matter, the statutes are uniformly enforced as "lowest responsible bidder." Thus, the text in this chapter should be universally applicable.

AGENCY DISCRETION

In determining responsibility of a bidder for a public construction contract, several important principles were considered, as discussed below: As stated in *Housing Authority of Opelousas, La v. Pittman Construction Company*:

> A public works statute gives discretion to an awarding board or body. When the board acts fairly and honestly within the reasonable exercise of a sound discretion, the courts will not interfere with the board's award. Public administration would be hamstrung if courts were free to second-guess reasonable administrative decisions[1].

The Pittman decision involved an assertion by the contractor that a housing authority had abused its discretion in awarding the contract to another firm. In describing similar decisions in Louisiana and other states, the court pointed out that an awarding body can consider skill, integrity, judgment, experience, reputation, previous conduct on other contracts, and other factors in determining responsibility. The court also stated that:

> Courts will not substitute their judgment for the good faith judgment of an administrative agency, but an awarding body's administrative discretion must be exercised in a fair and legal manner and not arbitrarily. The Board has the right to be wrong, dead wrong; but not unfairly, arbitrarily wrong.

In *Conduit and Foundation v. Metropolitan Transportation Authority*[2] the Court of Appeals of New York in 1985 made a number of compelling statements about the authority of a SHA administrator.

Conduit and Foundation submitted the lowest bid for the rehabilitation of part of New York City's subway system in an amount that was within the advertised range of $120 million to $140 million. Following unsuccessful discussions with the three lowest bidders on how to

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[1] *Housing Authority of Opelousas, La v. Pittman Construction Company*, 264 F.2d 695 (1959).
[2] *Conduit and Foundation Corp.v. Metropolitan Transportation Authority*[2] 485 N.E.2d 1005 (1985).

reduce the project cost, the authority rejected all bids and took steps to reduce the project scope and re-advertise the project. Conduit and Foundation sued the Authority for acting unlawfully in rejecting all bids. The basis of their argument was that the discussions with the prospective bidders gave the "appearance of impropriety."

In ruling for the Authority, the Court of Appeals made the following statements:

> . . . the mere "appearance" of impropriety is not sufficient ground to disturb the decision of the Transit Authority absent a showing of actual favoritism, fraud, or similar evil which competitive bidding is intended to prevent.

and

> . . . the discretionary decision ought not to be disturbed by the courts unless irrational, dishonest or otherwise unlawful . . .

As further analysis, Sweet says that:

> An awarding authority or owner conducting a competitive bid should be able to reject a bidder if a good-faith determination has been made that the bidder is not likely to be able to complete the required performance.[3]

However, discretionary authority must be balanced against statutes protecting the public interest, ensuring honest competition and protecting taxpayers from favoritism and high prices in the awarding of public contracts. These provisions

> . . . exist to protect citizen taxpayers from unjust, ill-considered or extortionate contracts, or those showing favoritism . . . To depart from these principles would be to open the door to abuses and practices fraught with danger to the welfare of the citizens and taxpayers of municipalities and political subdivisions of the state[4].

Thus, authorities, municipalities, cities, and states have broad discretionary powers in determining the lowest responsible bidder, and as long as this power is not exercised arbitrarily, decisions will not be set aside.

DETERMINATION OF NON-RESPONSIBILITY

Many factors can be considered in determining responsibility. These generally fall in the four broad categories of financial capability, managerial and technical ability and experience, past performance on projects for the awarding agency, and business practices[5]. It is helpful to

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[3] Sweet J., *Legal Aspects of the Architectural, Engineering, and Construction Process* (4th ed.) West Publishing Co., St. Paul, MN (1984).
[4] 43 Am.Jur., *Public Works and Contracts*, Sec. 45.
[5] Thomas, H. R. and G. R. Smith. *NCHRP Synthesis of Highway Practice*, Synthesis 190, Transportation Research Board, Washington, DC (1994).

summarize some specific instances where disqualification was deemed justified according to various courts.

- A contractor who engaged in an illegal scheme with a government official to obtain government contracts [6]
- A contractor who admitted to wrongful bidding practices [7]
- Repeated failure to pay minimum wages [8]
- A contractor's delinquency in completing another construction contract [9]
- Financial weakness [10] and failure to provide the necessary financial information [11]
- Using an unlicensed subcontractor [12]
- On a prior identical project, a contractor intentionally deviated from the contract specifications [13]
- Previous delays, lack of cooperation and poor performance [14]
- A reputation for poor quality work [15, 16]
- Being in arrears on an existing contract or in litigation with the awarding authority on an existing contract for having defaulted on a previous contract[17]
- A subcontractor had a dispute with the prime contractor on an earlier job and had made misstatements on his previous work experience[18]

However, there are also instances where a contractor may not be declared not-responsible. Several examples are:

- Refusing to contract with persons and businesses involved in bribes [19]
- The contractor employed nonunion labor [20]
- The mere change of a contractor's name [21]
- A contractor was involved in litigation with the awarding agency on another project[22]
- Disputes over a previous job[23]
- A provision requiring bidders to provide evidence of previous experience with the design configuration of a proposed floating bridge [24]

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[6] *K & R Engineering Co. v. United States* 616 F.2d 469 (1980).
[7] *Latrobe Road Construct., Inc. v. Pennsylvania Dept. of Transp*. 527 A.2d 214 (1987).
[8] *New Jersey Dept. of Labor and Industry v. Union Paving Constr*. 401 A.2d 698 (1979).
[9] *Shurly Contracting, Inc. v. Fla. Dept. of Transp*. 477 So.2d 24 (1985).
[10] *Becker v. Interstate Properties* 569 F.2d 1203 (1978).
[11] *Broomes v. City of East Chicago, Ill*. 342 N.E.2d 893(1976).
[12] *Stano v. Soldo Construction Co*. 455 A.2d 541, 187 N.J. Super. 524 (1983).
[13] *Suburban Restoration Co. v. Jersey City Housing Authority* 432 A.2d 564 (1981).
[14] *J. N. Futia Co. v. Office of General Services of the State of New York* 332 N.Y.S.2d 261; N.Y. A.D. (1972).
[15] *Warren G. Kleban Eng. V. Caldwell* 361 F. Supp. 805 (1973).
[16] *D. Stamato v. Township of Vernon* 329 A.2d. 65 (1974).
[17] *M. T. Reed Construction Co. v. Jackson Municipal Airport Authority* 227 So.2d 466 (1969).
[18] *Kopelman v. Univ. of Massachusetts Building Authority* 295 N.E.2d 161 (1973).
[19] *Polyvend v. Puckorius* 77 Ill.2d 287,395 N.E.2d 1376 (1979).
[20] *Wittie Electric Company Inc. v. The State of New Jersey* 354 A.2d 659; N.J. Super A.D. (1976).
[21] *Coken Co. Inc. v. Department of Public Works, Commonwealth of Massachusetts* 402 N.E.2d 1110 (1980).
[22] *Housing Authority of Opelousas, La v. Pittman Construction Company* 264 F.2d 695 (1959).
[23] *D. Stamato & Co. v. Township of Vernon* 329 A.2d 65 (1974).
[24] *Manson Construction & Engineering Co. v. State of Washington* 600 P.2d 643 (1979).

RELATIVE SUPERIORITY

In response to the requirement of not acting arbitrarily in the evaluation of responsiveness, states and other agencies have sought to develop objective criteria to judge responsibility. However, agencies need to be careful in the exercise of numerical attributes. A 1972 decision by the Supreme Court of California illustrates this point. It is in this case that the concept of "relative superiority" is discussed.[25]

In planning for the construction of a new $12 million civic center, the Civic Center Authority Commission of the City of Inglewood, CA sought the services of a construction manager. Agro Construction Co. submitted a bid that was $70,000 lower than Swinerton & Walberg Co. Relative to the financial responsibility portion of the qualification documents, a point system was applied. The highest score attainable was 38, but contractors scoring less than 30 were considered unqualified. Swinerton scored 34 and Agro scored 30. Thus, both contractors were deemed qualified.

The contractors were also evaluated on the basis of experience, ability, personnel, workload, and client relations. A numerical scale was again applied. Out of a maximum of 61 points, Swinerton scored 55 points while Agro scored second with 42 points. Both were deemed qualified. The reviewing board recommended the award to Swinerton stating that "based upon the evaluation scores and interviews, the panel believed the city would obtain excellent construction talent, experience, and other qualities important to the successful completion of the project. Swinerton's qualifications were considered to be so superior as to justify its selection. The report did not state that Agro was unqualified. The court stated that:

> . . . the contract for a public construction project must be awarded to the lowest monetary bidder . . . unless it is found that the lowest bidder is not responsible . . . There is no basis for the application of a relative superiority concept under that section, and if petitioners applied such standard in selecting Swinerton rather than Agro as the contractor the award cannot stand.

The City of Manchester, New Hampshire advertised for the construction of a vocational education center. No date or time of completion was specified in the bid documents. Instead, contractors were invited to propose the number of calendar days they needed to complete the project. Gerard Construction Co. submitted the lowest monetary bid of $7.38 million, but the longest completion time of 730 days. The reviewing board recommended the second lowest bidder arguing that it offered better value to the city because completion in 730 days, as Gerard had proposed, would have been beyond the needed completion date. The Supreme Court of New Hampshire rejected this argument stating that:

> . . . insofar as Gerard's qualifications have never been questioned, we agree with the trial court's ruling that subsection II (b) provides no authority for considering completion time in determining the low bid[26].

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[25] *City of Inglewood-Los Angeles County Civic Center Authority v. Argo Construction Co*. 500 P.2d 601 (1972).
[26] *Gerard Construction Company, Inc. v. City of Manchester* 415 A.2d 1137.

APPEAL PROCESS

Contractors that have been determined to be not responsible have the right to rebut the charges. This view was asserted by the United States Court of Appeals in the case of *Pittman v. Housing Authority of Opelousas, La*. In that dispute, Pittman Construction Co. was disqualified from a contract award. The disqualification was based on irregularities in the bid and unfavorable rumors about Pittman that had been reported to members of the board. Pittman was never informed of these allegations, nor was the company invited to meetings where these issues were discussed. The Court made it clear that this practice was unacceptable. It stated:

> In the light of what fair-minded, reasonable laymen would do, we think that before a Board disqualifies the lowest bidder as not responsible, the lowest bidder has the right to be heard and the Board has the duty to listen on the subject of responsibility.

It was further elaborated that it was not expected that "a Board conduct FBI investigations, hold elaborate hearings, adhere to legal rules of evidence, and function as a judicial body."

The California Supreme Court in the City of Inglewood case provided similar findings. There, the Court said the following:

> We hold that prior to awarding a public works contract to other than the lowest bidder, a public body must notify the low monetary bidder of any evidence reflecting upon his responsibility received from others or adduced as a result of independent investigation, afford him an opportunity to rebut such adverse evidence, and permit him to present evidence that he is qualified to perform the contract[27].

IMPLICATIONS TO ADMINISTRATOR

Courts have spoken with certainty that unless there was actual favoritism, fraud, or similar evil, the decision made by an awarding agency within its discretionary powers will not be examined by the Court. The administrator has broad discretion to exercise his/her duties.

IMPLICATIONS TO THIS PROJECT

From the foregoing analysis, it is clear that SHA administrators have broad discretionary powers and that unless their decisions are unlawful, arbitrary, or capricious, the courts will not intercede. Administrators have broad discretionary freedom to exercise their duties and courts will give them latitude in fulfilling their duties.

A designer/contractor certificate program to undertake time-sensitive projects, if allowed by statutes and regulations, can be adopted. Attempts to incorporate time into the selection

[27] *City of Inglewood-Los Angeles County Civic Center Authority v. Argo Construction Co*. 500 P.2d 601 (1972).

process must avoid the “relative superiority” concept. The A+B approach seems to be satisfactory.

It is impossible to outline all the discretionary powers that are available to an administrator. This chapter is included in this report only to show administrators that unless precluded by statute, all the recommendations in this report can be legally implemented so long as they are not unlawful, arbitrary, or capricious. This is especially true with qualifying designers and contractors. Time can be included as a criterion. Contractors who are late in performance and designers who produce faulty plans can be disqualified from time-sensitive projects. SHA administrators can do much that approaches the private-sector environment. They need not fear judicial oversight.

3. TIME CLASSIFICATION

The Phase 1 report recommended that projects be categorized into classes according to time sensitivity, with class 1 being the most sensitive. The rationale behind classification is that time-sensitive projects require more SHA resources, and in the current resource-constrained environment, a SHA cannot afford the resources needed to treat all projects alike.

It is further recognized that each project is unique. Therefore, a methodology was developed that allows each project to be evaluated according to its time sensitivity with the final decision as to classification resting with the SHA.

DEFINITIONS

Three classifications of project are used in this report: class 1, 2, and 3. It is impractical to provide more than a general description since all projects are unique, and a given factor may make one project time sensitive and not have that effect on another. Ultimately, it is up to the SHA administrator to decide if a project is time sensitive or not. This chapter merely provides guidance in making the decision. The key determinate is inconvenience to the public. Size or type of project is not a strong factor.

The most time-sensitive project is a class 1 project. It is one that either must be completed on time or, if late, will cause serious inconvenience or safety concerns to the public. Generally speaking, only about 10% of all projects would be class 1.

A class 2 project is similar to class 1 but there are only one or two factors that would qualify the project as class 1. Some inconvenience can be tolerated or there may be one or two alternate ways to encourage timely performance.

Where inconvenience to the public is not a significant concern, a class 3 designation would be applied.

FACTORS TO CONSIDER

The factors to consider in identifying time-sensitive projects were developed from interviews with the SHAs. The factors generally are in two categories: common factors and unique factors.

Common Factors

Various factors were identified that were common in each state. These primary factors were:

- Average daily traffic (ADT)
- Peak daily traffic
- Business/economic impact

- Political and citizen considerations/special events/environmental
- Type of closure: partial or complete

The only factor requiring explanation is political considerations and special events. Sometimes events like the Super Bowl or the Olympics mean that certain projects must be completed on time. There can be local events as well. These events can make a project much more time sensitive than would ordinarily be the case. Environmental and safety concerns can also make a project time sensitive through citizen/political concerns.

There may be several factors that can be used as substitutes for one or more of the primary factors. Indeed, SHAs are encouraged to tailor the factors to unique SHA practices and project conditions. For instance, road user costs, delay times, and trip times can be used in lieu of ADT or peak daily traffic. Caution needs to be exercised in selecting factors to ensure that all factors are mutually exclusive.

Unique Factors

There are factors that may be considered unique to each state or project. Since no state considers time sensitivity, these factors are speculative. Four such factors were identified as:

- School bus route
- Potential for unforeseen utility conflicts
- Emergency
- Length of detour

SHAs are encouraged to add unique factors as appropriate. The principle of mutual exclusivity needs to be followed.

METHODOLOGY

A methodology was developed that reserves the final classification for SHA personnel. A four-step process is proposed.

Step 1. Select Factors – Mutually exclusive factors are selected and introduced into a format such as shown in Table 1.

Step 2. Rate Each Factor – Each factor is rated according to the procedures, practices, and conditions in each SHA, district or region, and locale. Thus, each project is evaluated uniquely.

Step 3. Create A Visual Record – A visual image is created by connecting each rating node with a line, as illustrated in Table 2.

Step 4. Determine Time Sensitivity Classification – The decision as to the project classification is left to the SHA. The evaluator can assign weights to each factor as the situation dictates. For instance, if all factors suggest a Class 1 project, but the resources are not available, then the resources factor may be overriding.

Table 1. Factors for determining time sensitivity.

Criteria	Class 3	Class 2	Class 1
PRIMARY FACTORS			
ADT	○ Low	○ Med	○ High
Peak Daily Traffic	○ Low	○ Med	○ High
Business/Economic Impacts	○ Low	○ Limited	○ High
Political/Citizens Concerns	○ Low	○ Limited	○ High
Resources Available	○ No	○ Limited	○ Yes
Type of Closure		○ Partial	○ Complete
SECONDARY FACTORS			
School Bus Route	○ No		○ Yes
Potential for Unforeseen Utility Conflicts	○ Low	○ Med	○ High
Emergency	○ No		○ Yes
Length of Detour/User Costs/Trip Times	○ Short/Low/Brief Delays	○ Intermediate	○ Long/High/Lengthy Delays

CASE STUDY EXAMPLE

A case study project is used to illustrate a time sensitivity analysis methodology. The factors used in the analysis should be tailored to each agency's needs. More factors can be added, and factors in Table 1 can be deleted.

Case Study Description

The case study project is of a bridge replacement on West Branch Road in rural, central Pennsylvania. The abutments were stone and were badly deteriorated, so the scope of work required new abutments and bridge deck. The potential for utility conflicts was low because there were few utilities and the SHA was reasonably confident in their location. There were no communication utilities, only stormwater, water, and sewer. Relocation of these utilities was part of the contractor's scope of work.

The contract called for new abutments, and a new, cast-in-place concrete bridge deck. The creek was considered environmentally sensitive so the contract allowed the contractor to work on only one abutment at a time. The SHA-provided design was a cast-in-place deck. A precast bridge deck was not permitted as an alternate design solution.

Table 2. Illustration of classification procedure for case study project.

Criteria	Class 3	Class 2	Class 1
PRIMARY FACTORS			
ADT	Low	Med	High
Peak Daily Traffic	Low	Med	High
Business/Economic Impacts	Low	Limited	High
Political/Citizens Concerns	Low	Limited	High
Resources Available	No	Limited	Yes
Type of Closure		Partial	Complete
SECONDARY FACTORS			
School Bus Route	No		Yes
Potential for Unforeseen Utility Conflicts	Low	Med	High
Emergency	No		Yes
Length of Detour/User Costs/Trip Times	Short/Low/Brief Delays	Intermediate	Long/High/Lengthy Delays

The bid price of this project was approximately $770,000, so this was not a large project. The contract gave the contractor 215 calendar days to complete the project. The actual contract duration was 142 calendar days. The contract was executed during the summer months. The contractor used a complete road closure.

On the north side of the closure was the Village of Lemont, Pa. It is a quiet, residential community. However, a number of small businesses located along West Branch Road were affected by the closure. Access to the local post office was a major citizen concern because the closure denied access to all residents on the south side of the project. The length of the detour was about 16 miles. West Branch Road is a popular north-south “short cut.” The ADT is not heavy by many urban standards, but for the area, it is a heavily traveled road.

Time Sensitivity Analysis

Step 1. Select Factors – The time sensitivity analysis uses the factors in Table 1.

Step 2. Rate Each Factor – The factors in Table 1 were rated as follows:

ADT: The ADT on this project was not very high by urban standards, but for the locale it was a heavily traveled road. Therefore, the ADT was rated as medium.

Peak Daily Traffic: The traffic peak was highest in the morning and evening rush hours, but there was steady traffic throughout the day. Therefore, the peak daily traffic for the locale was rated as medium.

Business/Economic Impacts: Although the businesses affected by the closure were few in number, the impact to each business of a 7-month closure was significant. These were small, locally owned businesses, not large, national retail outlets. The business impact was rated as high.

Political/Citizen Concerns/Environmental: Because of the prospects of a 7-month closure and the associated business impacts and inconvenience, citizen concerns were high. Access to the post office was a concern because of the 16-mile detour. The impact to the environmentally sensitive creek was also a cause for citizen concern. Thus the citizen concern factor was rated as high, although the number of citizens directly affected was comparatively small.

Resources Available: For a project to be designated as Class 1, SHA resources are needed for constructability reviews, SUE investigations, and other activities. Because the project was small and relatively simple and there were no significant utility issues, the additional resources needed were few. It was determined that the SHA resources were available.

Type of Closure: The type of closure was complete.

School Bus Route: West Branch Road was a school bus route.

Potential for Unforeseen Utility Conflicts: The potential for surprises was low because of the number and type of utilities. The contractor was responsible for all utility relocations. The only utilities requiring relocation were water, sewer, and stormwater.

Emergency: This was not an emergency project.

Length of Detour: The "official" detour route was 16 miles in length, although shorter routes to the Village of Lemont were available. Nevertheless, in the context of the local area, the detour is considered long.

Step 3. Create a Visual Record – Where there are a number of factors, a visual image is important. Humans respond to visual records more readily than to a compilation of numbers or assessments. A visual record is created by connecting each evaluation node with a straight line, as is illustrated in Table 2 for the case study project.

Step 4. Decide Classification – The more the visual image is skewed to the right, the more likely the project should be considered a Class 1 project. For the case study project, there is strong justification as a Class 1 project, despite its size and low impacts when compared to more urban areas. The final decision is left to the SHA.

IMPLICATIONS

The implications of being designated a Class 1 project for the SHA are many. The project is one of a small number of projects (maybe as few as 10%) where minimum time as a project objective is a high concern. The implications of a class 1 designation are that more SHA resources will need to be devoted to time-sensitive projects to qualify only those contractors who can finish the project on time, conduct SUE investigations (if deemed necessary), perform constructability reviews, rely on contractor ingenuity instead of telling the contractor what to do, be ingenious in drafting the contract, provide more up-front planning and design time, and possibly other activities.

4. CONTRACTOR TIME QUALIFICATION

The phase I report recommended classifying projects according to their time sensitivity. Three project time classifications were suggested, as shown in Table 3.

Table 3. Suggested project time classifications.

Class 1	A Class 1 project is one where timely completion is the overriding objective.
Class 2	A Class 2 project is important relative to time issues, but not as important as a Class 1 project.
Class 3	A Class 3 project is an ordinary project where it is not justified to expend the resources available to Class 1 or 2 projects.

The concept of project time classification was further expanded to include the recommendation that contractors be specifically qualified for time-sensitive projects. This chapter presents recommendations for appropriately qualifying contractors with regard to time performance.

CURRENT PRACTICE

Qualification

The majority of SHAs utilize a contractor qualification system. The FHWA found in a survey of SHAs that only eight states reported not using a contractor qualification system (FHWA 2002). The FHWA survey also determined that 20 of the states that had a qualification process for contractors also used performance criteria to adjust qualification ratings. Currently most SHAs qualify contractors and many use contractor performance as a factor in the qualification process.

Contractor Performance Rating

The FHWA requires that all contractors' performance be evaluated in accordance with FAR 36.201. Contractors are evaluated on a satisfactory or better scale; this evaluation aids in the agency's process for mitigating serious or chronic unsatisfactory performance.

The authors obtained information from SHAs on their current practices with regard to evaluating contractor performance. Contractor evaluation forms and procedures were obtained for 22 SHAs. The results of the findings are shown in Table 4. Only 16 of 22 SHAs use time as a qualification criterion. The forms were used to grade contractors on either a numerical or a qualitative scale, such as excellent to poor. The Project or Construction Engineer from the SHA typically makes the evaluation upon completion of the project. Contractors are generally evaluated based on the following categories:

- Workmanship and Performance
- Coordination and Cooperation
- Timeliness
- Supervision
- Schedule
- Safety
- Traffic Control in the Work Zone
- Labor and EEO Requirements
- Equipment
- Public Relations
- Environmental Compliance
- A&E Relationship
- DBE Compliance

Table 4. Contractor evaluation forms criteria.

Evaluation Criteria	Number of States Using Criteria out of 22 States Responding	Percentage of Total States Responding
Workmanship/Performance	22	100.00%
Cooperation/Coordination	21	95.50%
Timeliness	16	72.70%
Supervision	15	68.20%
Schedule	15	68.20%
Safety	14	63.60%
Traffic Control in Work Zone	14	63.60%
Labor/EEO	13	59.10%
Equipment	12	54.50%
Public Relations	12	54.50%
Environmental Compliance	11	50.00%
A&E Relationship	7	31.80%
DBE Compliance	4	18.20%

Time performance is a priority item in most SHA contractor evaluations. Timeliness is considered a valuable evaluation category for contractors by nearly 75% of the responding SHAs. Critical dates for submittals and project milestones must be exceeded to achieve the highest marks. Nearly 68% of the contractors were evaluated on the submission of completed schedules and whether they performed regular updates to the schedules. The quality of submitted schedules with attention to detail was considered, in addition to schedule compliance by contractors and subs. Perfect scores were given for projects that finished ahead of schedule. The case study project in Chapter 3 would have been given a perfect score, even though a liberal amount of time was allowed.

All of the SHAs consider workmanship of the final product and the performance of the materials a high priority. Coordination of the key on-site players, such as the project manager and the superintendent, as well as the cooperation of these individuals with the transportation department engineer, was given high priority by all but one of the SHAs. Coordination with material suppliers and utilities was also factored into this category. Supervision of the prime contractor's employees for self-performed work and the subcontractor's work was also considered important. Seventy percent of the departments that responded considered supervision to be a worthy evaluation criterion.

Nearly 60% of the departments examined whether the contractor supplied adequate labor force to the project. Adequate labor was defined to be knowledgeable of the proper procedures and require minimal supervision. In addition, the contractors were required to comply with Equal Employment Opportunity (EEO) when hiring workers. Sufficient equipment for timely completion of work was rated by 55% of the departments. Contractors were rated based on the condition and upkeep of the equipment, amount of equipment on the project, and number of critical path delays due to equipment failure.

The results of the current practice review indicate that contractor time performance evaluation is standard practice in most states. Timeliness is a key element of performance evaluations.

DEVELOPMENT OF CONTRACTOR TIME QUALIFICATION

Discussion of Relevant Issues

Objectives

Clearly, the objective is to maximize the probability of completing time-sensitive projects on time. On-time completion is defined as completing the project within the original contract duration plus approved additions of time. Contract provisions for addressing excusable delays vary and are often modified for time-sensitive project types. The SHA's choice of contract provisions may affect overall contract duration; however, this is a matter that is distinct from the question of contractor qualification.

Factors Affecting Time Completion

In general, factors that delay completion of a project can be grouped into three categories:

- Issues that can be controlled by the Contractor, but not by the Owner
- Issues that can be controlled by the Owner, but not by the Contractor
- Issues that cannot be controlled by the Contractor or the Owner

Contractors directly manage execution of the project work. They have sole responsibility for the work means and methods. Contractors plan, schedule and allocate resources to the project effort. Within the area of project execution, contractors have responsibility and control.

However, many of the project-specific factors are directly controlled by the owner. Investigation and design of utility relocations is a good example. Utility related delays are one of the most frequent problems encountered in highway construction, and there is little the Contractor can do to avoid these delays. Additionally, there are delays that neither party can control, such as natural disasters. For example, the Florida Department of Transportation has granted additional time for hurricane-related delays even in their "No excuse" contracts.

The strategy of contractor time qualification is aimed at the first category of issues that can be controlled by the Contractor. A contractor's past time performance record is a reliable indicator of that contractor's probable time performance on future projects. The contractors that have consistently completed projects on time have demonstrated the capability and commitment to complete on time. Furthermore, implementing a contractor time qualification system will provide additional motivation for timely performance.

Qualification Program Requirements

A successful contractor qualification system should include the following features:

- Objectively measures contractor past time performance,
- Fairly evaluates both new and experienced contractors,
- Uses realistic criteria permitting a sufficient number of contractors to participate and compete, and
- Is easy to implement and administer.

Selection of Appropriate Time Performance Measure

Alternative 1: Number of Projects Completed Not On Time

This approach would set the qualification criteria as a maximum number of late projects within the performance period. For example, contractors qualifying for Class 1 project work might be required to have had no late projects in the last three years.

The weakness of this method is that it does not differentiate between a contractor that has performed only a few projects and a contractor that has performed many projects. A contractor that had performed 30 projects with one late project would not qualify, and a contractor that had performed only two projects on time would qualify. More experienced contractors would be penalized.

Alternative 2: Number of Net Late Performance Days

Another option is to use the net number of late performance days as the criterion. In this case the net late performance days is the total late project days less the total early completion days. In this approach the contractor is given credit for early completion efforts. Therefore, a late performance on one project could be offset by an early completion on another project.

The problem with this method is that using only days does not differentiate between projects with relatively long and short contract durations. Another issue is that early completion days are typically more numerous than late completion days. A review of project performance statistics by the authors indicates that the average amount of late days on delinquent projects is much less than the average amount of early completion days on non-delinquent projects. Consequently an early completion on one project could offset the late days on several projects.

Alternative 3: Percentage of Projects Completed On Time

In this approach the percentage of projects completed on time within the evaluation period is used as the qualifying criterion. Using the percentage tends to normalize the difference between contractors performing different numbers of projects and differences in project durations.

Evaluation Period

The evaluation period for qualification must be long enough to provide a fair representation of the contractor's performance. On the other hand, too long a period may not represent the contractor's current performance capability. Another consideration is the typical duration of projects. It is not uncommon for significant projects to have durations in the 2 to 3 year range.

Recommended Qualification Measurements

The authors recommend using "Percentage of Projects Completed On Time" as the appropriate metric for evaluating time performance. The recommended evaluation period is between 3 and 5 years, depending upon the SHA data availability. As an option, a minimum number of projects may also be required.

More specifically, Table 5 presents the recommended time performance criteria for the different project time classifications.

Table 5. Recommended contractor time performance qualification criteria.

Project Time Classification	Qualifying Criteria	
	Minimum Projects Completed in Last 5 Years	**Percentage of Projects Completed On-Time Must Be Equal To or Greater Than**
Class 1 High Time Priority	3	90.0%
Class 2 Moderate Time Priority	3	80.0%
Class 3 Normal Time Priority	No Time Qualification Required Normal Qualification Requirements Apply	NA

CASE STUDY EXAMPLE

Application of the suggested time-qualification process is illustrated by using time. The objective is to apply the contractor qualification criteria to a SHA work program to determine how the criteria would affect the pool of qualified contractors. The sample data consist of the time performance statistics for all contractors and construction projects completed within the last five years for a SHA. The records include 203 contractors and 713 completed projects. The overall program performance was that 564 or 79.1% of the projects were completed on time. Figure 1 shows the distribution of contractor performance in terms of projects completed on time. Only contractors completing three or more projects in the last 5 years are shown.

Table 6 provides an analysis of the contractor time qualifications based upon the recommended Time Qualification Criteria. Given the 5-year time performance records, 25 (16.7%) of the 150 contractors would qualify for bidding on Class 1 projects and 36 (24%) of the contractors would qualify for bidding on Class 2 projects. It is interesting to note that 67.3% of the contractors, a significant number, were eliminated from qualification because they had performed less than three projects in the 5-year period. However, in spite of the reduction in available contractors, the minimum number of projects criterion is considered by the authors to be necessary to evaluate contractor time performance.

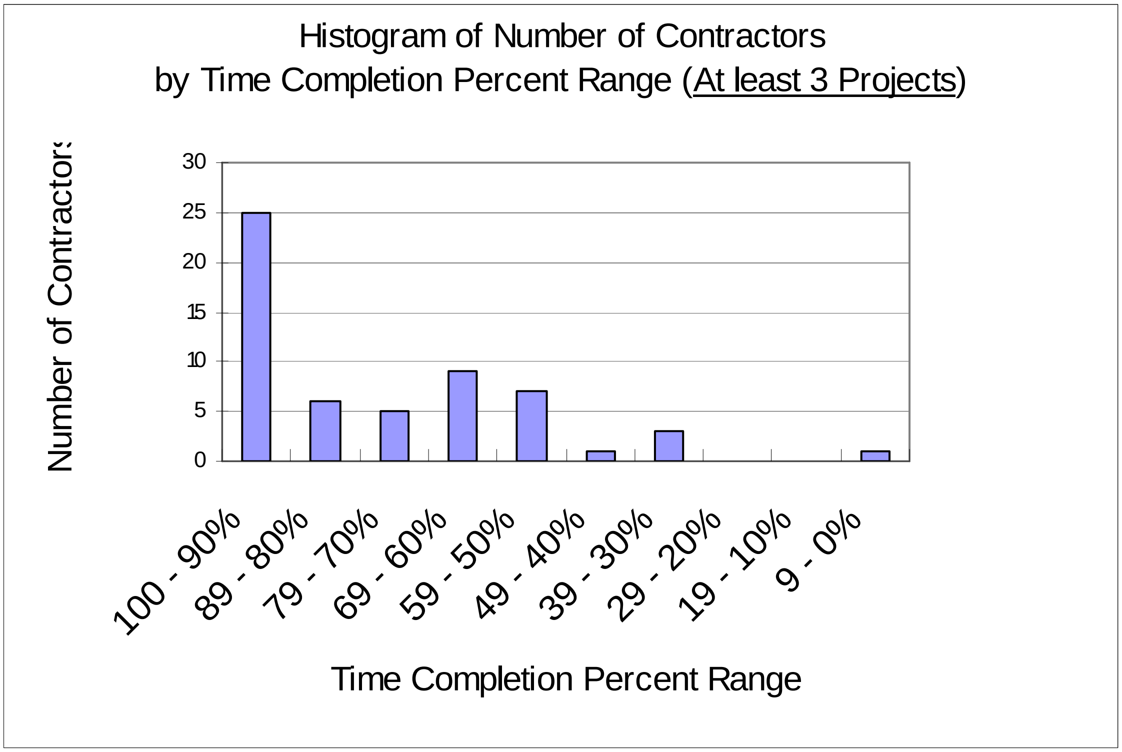

Figure 1. Distribution of contractors by number of on-time projects.

Table 6. Contractor qualification results.

Qualification Category	**Number of Qualifying Contractors**	**Qualifying Contractors Percentage of Total Contractors**
Class 1 Projects *Percent of On-Time Projects 90% or Greater*	25	16.7%
Class 2 Projects *Percent of On-Time Projects 80% or Greater*	36	24.0%
Non-Qualifying Contractors with More than 3 Projects	12	8.0%
Contractors with Less than 3 Projects	101	67.3%
Note that all 150 contractors would qualify for the Class 3 Non-Time Priority Projects 5-year performance qualifying period 150 contractors 713 projects		

CONCLUSIONS

Although not the only factor, contractor performance is undoubtedly a key factor in obtaining on-time project completions. Logically, in order to establish categories of projects with high time priorities and to devote extraordinary efforts to those projects, it is essential to also engage the best contractors on those projects. A review of the issue of agency authority indicates that SHAs do have the authority to implement reasonable qualification requirements. Furthermore, a review of current practice indicates that most SHAs now have contractor qualification procedures and many use time performance as a factor.

Contractor past performance records with regard to on-time completion are the best indicator of future performance. The authors have developed in this chapter a recommended contractor time qualification process. When applied to a SHA work program including 5 years of performance data, the suggested qualification criteria appear to provide a reasonable number of qualified contractors to compete for the Class 1 and Class 2 Time Priority projects. Each SHA may want to review its own project performance data when deciding upon its qualification criteria.

5. DESIGN CONSULTANT TIME QUALIFICATION

A survey of both SHAs and highway construction contractors conducted by the authors indicated that errors in plans and specifications by the designer was rated in the top five leading causes of construction delay. Clearly, the quality of the design has a significant effect on project construction performance. Today it is common to outsource highway construction design services. In Phase I of this research the authors recommended that designers also be specifically qualified for work on time-priority projects. This chapter presents a recommended procedure for appropriately qualifying designers with regard to construction time performance.

CURRENT PRACTICE

Qualification

Qualification of design consultants is standard practice for all SHAs. Designer qualification criteria typically require the submission of a qualification application. In general, the following qualification information is reviewed:

- Resources (Personnel, Number and Qualifications) (Number of CADD Stations)
- Experience (Number and Types of Design Projects)
- Cost (Consultant Fees per Year)
- Internal Control Systems (Published Quality Control Plan)

Although it is reasonable to believe that evaluations of past work would affect design selection for future projects, past performance does not appear in the typical qualification process.

Performance Evaluation

Design consultant evaluation forms and procedures were obtained for 20 SHAs. A summary of the results is presented in Table 7. The forms were used to grade the designers on either a numerical or a qualitative scale, such as excellent to poor. The Project Engineer or Construction Engineer from the SHA generally performs the evaluation upon completion of the project. Design consultants are generally evaluated based on the following categories:

- Quality, Accuracy and Completeness
- Cooperation and Coordination
- Timeliness
- Schedule
- Adherence to Standards, Specifications, and Policies
- Supervision
- Budget
- Competence of Technical Personnel
- Public Relations

- Constructability of the Design
- Attitude
- DBE

Three of the above criteria relate directly to time performance. "Timeliness" is this context refers to the consultant's ability to produce the design deliverables on time. Although this is a relevant factor when considering total project delivery time, it does not relate to construction time. The "Quality, Accuracy and Completeness" criterion is directly related to one of the leading causes of construction delays: errors and omissions in plans and specifications. Additionally, the "Constructability of the Design" may also have an effect on construction time performance.

It is also important to note that evaluation of design consultants is typically performed when design services are complete, which is in advance of construction. Therefore, in many situations the designer evaluation would not take into account design problems arising during construction. However, some SHAs also include a post-design constructability evaluation to be performed by the project construction engineer.

Table 7. Design consultant evaluation forms criteria.

Evaluation Criteria	Number of States Using Criterion Out of 20 States Responding	Percentage of Total States Responding
Quality/Accuracy/Completeness	20	100%
Cooperation/Coordination	19	95%
Timeliness	17	85%
Schedule	14	70%
Adherence to Standards, Specs, and Policies	14	70%
Supervision	13	65%
Budget	12	60%
Competence of Technical Personnel	11	55%
Public Relations	10	50%
Constructability	7	35%
Attitude	3	15%
Disadvantaged Business Enterprises	2	10%

Classifying Contract Changes

Some SHAs assign a causation code to each contract modification. This system of classifying changes provides accountability and provides a useful analysis of the causes of time and cost growth. The Florida Department of Transportation applies a code to each contract change. First the change is classified with regard to who is responsible. Table 8 presents the FDOT responsibility codes.

Table 8. FDOT contract change responsibility codes.

Code	Responsible Party
0 - Unavoidable	No remedial action required
1 - Avoidable	Production consultant
2 - Avoidable	Production FDOT
3 - Avoidable	Consultant CEI
4 - Avoidable	FDOT CEI
5 - Avoidable	Third party

With regard to qualifying consultants, code number 1—"Avoidable - Production Consultant"—would be the category of interest. Florida further classifies changes into 76 codes as to their apparent causes. Table 9 presents most of the cause codes that possibly apply to the Design Consultant.

DEVELOPMENT OF DESIGN CONSULTANT TIME QUALICATION

Discussion of Relevant Issues

Objectives

The overall objective is to maximize the probability of completing time-priority highway construction projects on time. More specifically, the purpose of designer time qualification is to minimize the chance of a project delay caused by an error or omission in the project plans and specifications.

Qualification Program Requirements

The requirements for a designer time qualification program are the same as presented for contractor time qualification in Chapter 4:

- Objectively measures designer past construction time performance,
- Fairly evaluates both new and experienced designers,
- Uses realistic criteria that permit a sufficient number of designers to participate and compete, and
- Is easy to implement and administer.

Selection of Appropriate Time-Performance Measure

As previously discussed, consultant performance during design delivery is not relevant to the issue of construction delays. Therefore, only the designer's impact on construction timeliness should be considered.

Table 9. FDOT contract change cause codes.

001 Subsurface material or feature not shown in plan
003 Harmonize project with adjacent projects or right of way
004 Design Standards, Specification or Policy change after contract letting
005 Utility adjustment delays w/ no Jt. Proj. Agmt. (should be premium Avoidable 3rd party)
007 Work added to or deleted from 3rd party agreements
008 Contract Changes at Right of Way Office's request (litigation, court orders, negotiations etc)
009 Permit related issues
010 Weather Related new work, repairs, overruns or contract changes due to weather
012 Deterioration of, or damage to, project after design (not weather related)
013 Test features not included prior to letting
015 Contract Changes to Utility Joint Project Agreement Work (should be no cost to FDOT)
016 Article 8-7.3.2(2) of Standard Specifications including Materials Acquisition
018 Impacts from special events or excessive traffic (ex. Delays & MOT for super bowl)
019 Conflicts between contractors, from overlapping project limits, pay items, schedules etc.
020 Increase in Steel Material Prices
101 Necessary pay item(s) not included in contract
103 Incorrect or insufficient subsoil information (included in plans but not accurate - not code 001)
104 Incorrect pay items for earthwork, embankment & excavation jobs on one contract.
105 Discrepancies between plan notes, plan details, pay items, standard indexes and specifications
106 Utility work w/ no JPA: conflict, wrong size, wrong location, proposed or existing
107 MOT: Modification of Maintenance of Traffic for pedestrians, boats, cars, bikes, etc.
108 Plans do not describe scope of work (use a more specific reason in lieu of this when possible)
112 Phasing or plan components not constructible as shown in plans
113 Modification to pavement design required
115 Required drainage modifications
116 Inadequate Right of Way to construct project as shown on plans
117 Access management issues
118 Improper or inadequate signing, signalization or pavement marking design or features
119 Revisions required related to major structural component changes
120 Hazardous materials encountered requiring contract changes
122 Bike, pedestrian, ADA or other public transit reqmt. not properly addressed: not MOT related
123 Landscaping issues not adequately addressed
126 Computation errors in pay item work amounts
128 Inaccurate or inadequate survey information used in plans preparation
130 Indecision or delayed response by or on behalf of FDOT causing contract delay
131 Architectural feature related issue (generally for building modifications)
208 No specification provided for item of work

Certainly the constructability of a design has a direct effect on how difficult a project is to construct. Nevertheless, contractors of both easy and difficult projects have committed to completing on schedule. A designer's constructability evaluation is not necessarily an indicator of the designer's time performance with regard to construction timeliness. A more reliable measure of designer time performance is whether or not additional time was granted to the contractor for problems with the plans and specifications.

The authors recommend using the Average Project Time Growth Percentage Caused by the Designer as the appropriate metric for evaluating construction time performance. The recommended evaluation period is between 3 and 5 years, depending upon the SHA data availability. As an option, a minimum number of projects may also be required. This will require the SHA to maintain records of contract changes and to objectively classify the changes.

More specifically, Table 10 presents the recommended time performance criteria for the different project time classifications.

Table 10. Recommended designer time performance qualification criteria.

Project Time Classification	Qualifying Criteria	
	Minimum Projects Completed in Last 5 Years	**Average Percentage of Projects Time Growth Caused by Designer**
Class 1 High Time Priority	3	No Time Growth
Class 2 Moderate Time Priority	3	< 1.0%
Class 3 Normal Time Priority	No Time Qualification Required Normal Qualification Requirements Apply	NA

CASE STUDY EXAMPLE

Application of the suggested time qualification process is illustrated using time performance records. The objective is to apply the designer qualification criteria to a SHA work program to determine how the criteria would affect the pool of qualified designers. The sample data consist of the time performance statistics for design projects completed over a 3-year period for a SHA. The records (see Table 11) include 70 design consultants and 107 completed projects. In terms of overall program performance, 93% of the projects were completed (at least three projects in 3 years) without a design-related delay.

Table 11. Designer qualification results.

Qualification Category	Number of Qualifying Designers	Qualifying Designers Percentage of Total Contractors
Class 1 Projects *Percent of Design-Related Delays 0%*	63	90.0%
Class 2 Projects *Percent of Design-Related Delays < 1.0%*	5	7.1%
Non-Qualifying Designers with More than 3 Projects	2	2.9%
Note that all 70 designers would qualify for the Class 3 Non-Time Priority Projects 3-year performance qualifying period 70 design consultants 107 projects		

CONCLUSIONS

Clearly the quality of the project design influences project construction time performance. The major time focus for SHAs with regard to designers is performance during design delivery. However, some SHAs are also evaluating contract changes and resulting time growth on projects. Changes that are the designer's responsibility are so noted. The authors recommend that time growth due to design errors be used as the factor for qualifying designers for time-priority projects. When surveyed, project participants rated design errors as a leading cause of construction delays. However, a review of project performance statistics indicates that design errors account for a relatively small portion of construction time growth. Only 7 out of 107 projects had time growth due to design error.

6. SUBSURFACE UTILITY ENGINEERING BACKGROUND

INTRODUCTION

The utility management system (UMS) including subsurface utility engineering (SUE) is a relatively new interdisciplinary approach to managing the risks that unknown underground utilities create on highway projects involving excavation. Some of these risks are a direct result of inaccurate, incomplete, or imprecise information on the location or existence of existing utilities. Other risks come from not using or considering existing data, or not using such data at the most opportune time. Subsurface utility engineering utilizes new and existing technologies to collect and manage utility data, and uses or communicates these data, at the right times, in order to decrease project risks. SUE is now accepted and promoted by engineering organizations and federal and state agencies as a means of reducing overall project costs and liabilities.

Three national organizations that promote the profession of subsurface utility engineering are the American Society of Civil Engineers (ASCE), the American Association of State Highway and Transportation Officials (AASHTO), and the Federal Highway Administration (FHWA). The definition and understanding of SUE has become ever broader over the last several decades. ASCE's current definition is "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." This definition is now commonly accepted and infers a broad responsibility to the design professional and project owner. AASHTO, ASCE, and FHWA all have recently published standards and guidelines that directly relate to SUE. These standards and guidelines form a basis for defining standards of care, and by extension, allocations of risk between project owners, engineers, constructors, and other parties involved in transportation projects.

BACKGROUND AND LITERATURE REVIEW

This section provides a more detailed discussion of the SUE concept. First, traditional practices for locating underground utilities are reviewed to identify current problems, and then SUE is presented, including quality levels.

Traditional Practices for Locating Underground Utilities

The one-call system is a damage prevention program regulated by state law. There is at least one one-call center in every state and in the District of Columbia. The one-call system is operated by funds of members consisting of public utilities and other underground facility owners/operators. The one-call system begins with a call from a contractor, designer, or other person who prepares a project that requires an excavation. The call should be made at least two or three working days before starting the excavation. After receiving a request call, the one-call center identifies potential utility conflicts and notifies facility owners/operators around the proposed site. When the facility owners/operators receive the notification from the one-call center, locating crews of the facility are sent to the site to mark the location of their underground utilities on the ground surface with above-ground APWA (American Public Works Association) color-coded markings (Jeong et al. 2003). After all utilities are marked on the ground surface, the excavation can be started. The one-call system just deals with the information on buried utilities that the members of the system provide. In other words, the information on existing utilities of many non-members is not available through the one-call system.

Subsurface Utility Engineering

SUE is an engineering process used to identify and map underground utilities and structures as well as assign a quality level to data. SUE has emerged in the past two decades as a means to better characterize the quality of subsurface utility information and to manage the risks associated with construction activities that may affect existing subsurface utilities. It combines traditional civil engineering practices of utility data collection and depiction with new technologies and new concepts for defining utility information quality. The main components of SUE are:

1. Designation – the use of geophysical investigating methods such as electromagnetic pipe detectors to determine the horizontal position of subsurface facilities.

2. Locating – also known as potholing. Locating or potholing utilizes non-destructive digging equipment to expose the underground facility at critical points along its path to determine the horizontal and vertical position of the facility.

3. Data Management – the collection, documentation, reduction, and depiction of information and data in a suitable format.

Quality Levels of SUE

To understand the concept of SUE, it is necessary to define the quality levels of underground information that is available to the designers, contractors, and owners (Anspach 1994). Quality levels are divided into four levels with different combinations of traditional record, site survey, geophysical technology, and air-vacuum technology (Jeong et al. 2003). The accuracy and reliability of underground information by survey increase from quality level D to quality level A. The cost for surveying also increases from quality level D to quality level A. Figure 2 describes various quality levels of SUE.

A brief description of the four quality levels of SUE data is provided below. Refer to CI/ASCE 38-02 for more information on the tasks involved in each quality level (ASCE 2002).

- **Quality Level A** provides the highest level of accuracy. It involves locating or potholing utilities as well as activities in quality levels B, C, and D. The located facility information is surveyed and mapped and the data provide precise plan and profile information. No matter how well the surface geophysics is applied and interpreted, precise information on elevation, size, material type, condition, configurations and so forth of the utility cannot be verified without exposure. So the quality level A data are those data that are gathered, surveyed, and depicted through excavation or exposure of the utility.

- **Quality Level B** involves designating the horizontal position of subsurface utilities through surface detection methods and collecting the information through a survey method. This includes quality level C and D tasks. It involves the use of surface geophysics to identify, interpret, and field-mark underground utilities, combined with a survey of the field markings, and subsequent reduction onto plans or into the digital database.

- **Quality Level C** involves surveying visible subsurface utility structures such as manholes, hand-holes, utility valves and meters, fire hydrants, pedestals and utility markers, and then correlating the information with existing utility records to create composite drawings. It includes quality level D activities.

- **Quality Level D** provides the most basic level of information. It involves collecting data from existing utility records, or conversations, or visual indications. Records may include as-built drawings, distribution and services maps, existing geographic information system databases, construction plans, etc. It is the lowest quality level and great care should be taken when using it for any purpose.

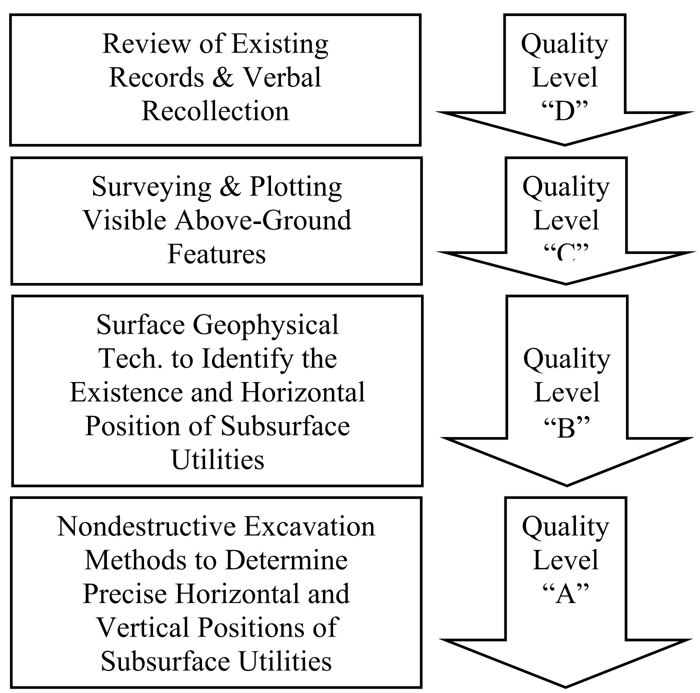

Figure 2. Quality levels of SUE.

Locating Methods for Underground Utilities

This section describes various geophysical techniques and non-destructive methods for the horizontal and vertical location of underground utilities and several factors affecting geophysical techniques. The limitations of geophysical techniques in the industrial field also are presented.

Geophysical Techniques

Geophysical techniques are non-invasive technologies that may be used to image subsurface conditions in the earth through measuring, analyzing, and interpreting physical properties. Every geophysical technique depends upon the ability to identify contrasts in subsurface materials that include various properties: dielectric constants, abilities to transmit acoustic energy, and other abilities (Fenning and Hansan 1993). These techniques have been applied for locating buried utilities. However, no single geophysical technique can work well in all of the various possible site conditions and with the different properties of underground utilities. The use of multiple techniques may yield the best possible target information.

Various Geophysical Techniques for Quality Levels A and B. There are different geophysical techniques available for quality level B, which is called designation, to acquire data regarding the two-dimensional location of underground utilities. It is important for designers or engineers to be familiar with various geophysical methods for successful designations of underground utilities.

Pipe and Cable Locator: A pipe and cable locator system includes transmission coils that release different electromagnetic frequencies (Jeong and Abraham 2004a). The electromagnetic energy generates the magnetic fields around the buried electrically conductive material, which are captured by the receiver coil on the surface. The captured magnetic fields are used to produce a visual or audible indication of the horizontal location of the utility.

Ground Penetrating Radar (GPR): GPR is an electromagnetic method that detects interfaces between subsurface materials with differing dielectric constants (Anderson et al. 2003). Microwave pulses are transmitted into the ground from an antenna and any reflections that are returned are measured at the receiver. The results of a GPR survey are affected by the frequency of microwave (10 to 1,000 MHz), dielectric constants, and conductivity of the soil.

Terrain Conductivity: A terrain conductivity survey measures currents created by differences in the average conductivity from the ground surface to the effective penetration depth (ASCE 2002). Utilities may exhibit conductivities that are different from the average soil conductivity.

Resistivity Survey: The resistivity survey works by introducing DC current into the ground with two or more electrodes and measuring the resulting voltage difference at other electrodes. Average resistivity is then calculated.

Magnetic Survey: Magnetometers can be used to detect buried ferrous metal objects such as pipelines and tanks, or bedrock features with contrasting magnetite content. In the magnetic survey, variations in the Earth’s total magnetic field are measured because of anomalous underlain magnetic materials. Typically, on a pipeline route, the anomalous magnetic material can be ferrous materials such as buried metal pipes and drums.

Metal Detector: The metal detector starts by transmitting an AC magnetic field, which induces currents in nearby metallic objects. The currents produce a magnetic moment in the metallic objects. The metallic objects reflect magnetic fields that are different from the current reflected from the surrounding soil (Jeong and Abraham 2004b).

Acoustic Survey: An acoustic survey generally works by using utilities' noises that can be applied by various transducers when connected to an opening on a service or main line. A highly sensitive acoustic receiver can listen for background sounds of water flowing (at joints, leaks, etc.).

Thermal Survey: Some utilities' products, such as steam systems, high-voltage power lines, and sanitary sewers, may produce a measurable heat flux. The thermal survey device can detect and measure the heat flux (ASCE 2002).

Gravity Survey: Gravity surveys can be used to locate objects or voids that exhibit substantial density variations from their surroundings. The gravity survey measures variations in the Earth's gravitational field, and these variations are correlated with the variations in thickness and density of subsurface materials (Hoover et al. 1996).

Seismic Survey: A seismic survey utilizes ground vibrations that travel through soil and rock. The seismic waves travel at different velocities in different materials. The time-distance relationships of the seismic survey are used for detecting underground utilities (Hoover et al. 1996). Seismic waves are usually created by explosives and hammers.

Non-Destructive Method for Quality Level A. The vacuum excavation system is the predominant leader of non-destructive methods for three-dimensional location data of quality level A, which is called location. The process of this system utilizes vacuum in combination with high-pressure water or air to expose underground utilities through small holes. Three-dimensional data, utility properties, and soil properties can be obtained with the vacuum excavation system.

Factors Affecting the Selection of Geophysical Techniques. Every geophysical technique has its own limitations due to many factors affecting the selection of appropriate techniques. The factors are as follows:

Type of Utility: There are many utilities with various services: gas line, sewer line, water main, electric cable, and communication cable. However, certain techniques are available for the detection of specific types of utilities.

Material of Utility: Various materials have been used for underground utilities: iron, steel, plastic, concrete, clay, etc. However, one technique cannot detect every material for the utilities because of its own limitation. For example, the magnetic survey is not applicable to plastic pipes.

Depth of Utility: The depth of underground utilities is very diverse. While there is a sanitary sewer with a depth of 7 ft, a communication cable is buried with a depth of 18 inches. Hence the limitation of penetration depth of each technique is an important factor for the selection of techniques. For example, the metal detector is not usually applicable for the detection of utilities buried deeper than 2 ft.

Soil Type: The input signal penetrations of geophysical techniques depend on the properties and water contents of soil. There are five typical soils: clay, sand, silt, loam, and peat. High soil conductivity in clays or highly saturated sand causes rapid dissemination of GPR signal and penetration of the signal is reduced to less than a few feet.

Ground Surface Condition: Ground surface condition means a cover on the ground affecting geophysical techniques. Many underground utilities are buried under surface pavements with asphalt or concrete. These ground conditions cause disturbance to specific techniques. For instances, concrete pavement may disturb an electromagnetic wave to be introduced into the ground.

Access Point of Utility: Access point of utility means the presence of surface access points connected to the underground utility in the vicinity. The access points are important for using several techniques such as acoustic survey.

Internal Condition of Utility: Internal condition can affect the use of certain techniques. For example, the acoustic survey is better applicable when the pipe is filled with water because the acoustic survey is based on the pressure to transport the sound wave.

Utility Density and Zoning Condition of Construction Site: Utility density and zoning condition of the construction site ultimately mean how many utilities or buried objects are present around the target utility. They should be considered for selecting geophysical techniques, since many techniques can be affected by interferences from nearby buried objects. The location surveys for the site with high utility density are required to use more accurate and sophisticated techniques, which can be more expensive. The location surveys in commercial or residential areas are also needed to utilize more accurate techniques than in green fields because more congested utilities are usually buried under commercial or residential areas.

Cost-Benefit of SUE

Professional engineers for public and private projects expect numerous benefits on their own projects with SUE. These benefits are important to the DOTs, utility owners, and project contractors. Through accurate underground information SUE reduces delays, unexpected damages of existing utilities, mislocations of utilities, change orders and claims, negative factors for productivity, and social and environmental damages. The benefits are combined with subsequent savings in time and cost for restoring and insurances, utility relocations, redesigns and claims, more efficient construction, traffic delay cost and other social and environmental costs. All benefits result in reduction in time and cost for whole projects. Figure 3 shows significant benefits that can be derived from using SUE.

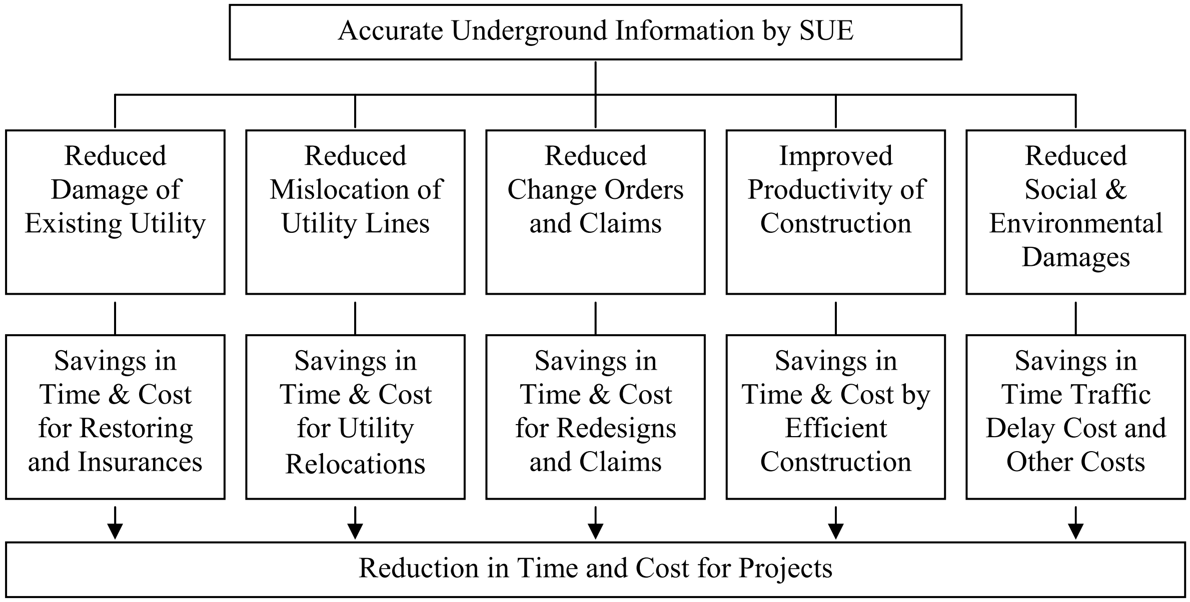

Figure 3. Significant benefits of SUE.

Stevens (1993) presented cost savings in various forms for the taxpayer, the ratepayer, and the owners on projects utilizing SUE, as shown in Table 12. Administrative cost savings would be 2% of overall project costs because projects that are completed up to 20% faster enable financing to be paid more quickly. Costs for insurance, bonding, and change orders also may be less. Engineering cost savings yield 0.5% because SUE techniques may save time by using digital transfer of survey data into CADD. Construction costs realize savings of 2.25% because construction bids may be lowered by fewer utility conflicts with accurate underground information. Liability of identification of utilities is also transferred from contractors to the SUE companies. Overrun costs realize savings of 5%. The overrun savings may be derived from reduced delay claims, reduced engineering reworks, and reduced utility damages. Utility relocation cost savings yield 5% of overall project costs. Designers using accurate underground information may eliminate many underground utility relocations before construction. The results of this research showed that, in comparison with projects not utilizing SUE, the total cost savings of SUE projects may range from 10% to 15% on a typical project.

Table 12**.** Cost savings rate on projects utilizing SUE.

Cost	**Expenditure on Typical Projects**	**Saving Rates**	**Savings on Overall Projects**
Administrative Cost	20%	10%	2%
Engineering Cost	10%	5%	0.5%
Construction Cost	45%	5%	2.25%
Overrun Cost	15%	33%	5%
Utility Relocation Cost	10%	50%	5%
Total	100%	-	14.75%

Anspach (1994) summarized SUE savings derived by various parties. For instance, FHWA reported that applying SUE nationwide would have cost savings exceeding $100 million per year for highway work alone. A state utility engineer of Virginia DOT stated that $700,000 worth of utility conflicts was eliminated with less than $100,000 for SUE in a project of Richmond.

Lew (2000) developed 21 categories to quantify the savings in terms of time, cost, and risk management aspects after interviewing and surveying with the DOTs, utility owners, SUE consultants, and contractors. Table 13 shows categories of SUE cost savings. He analyzed 71 projects and showed that a total of $4.62 in savings for every $1 spent on SUE was quantified in SUE projects. The $4.62 savings has been usually cited to mention the cost-benefit of SUE. The results of his report led to the conclusion that SUE is a viable technology that reduces project costs related to the risks associated with existing underground utilities.

FHWA (2000) cited many numbers to describe the cost savings attributed to the use of SUE. A study by Virginia DOT indicated a cost savings of $7 for every $1 spent on SUE. The Society of American Value Engineers (SAVE) showed a 10:1 return rate and Maryland DOT showed an 18:1 savings. However, these studies were underestimated because they used a limited number of projects to produce results. Jeong et al. (2003) modified the result of Lew (2000) after reanalyzing with the same data, including 71 projects. In their paper, the ratio of the cost of SUE to the total construction cost ranged from 0.02 to 10.76%, and the average ratio was 1.39%. The average $12.23 in savings for every $1 spent on SUE was quantified in SUE projects. They also carried out cost savings analyses of each individual category. A reduced number of utility relocations were analyzed as the most outstanding cost savings, with 37.1% in SUE cost savings. Reduced claims and change orders (19.3%), reduced accidents and injuries (11.6%), and reduced project delays (9.6%) were ranked as significant contributors to cost savings. Other cost savings that comprise 22.3% included reduced right-of-way acquisition costs (3.5%), induced savings in risk management and insurance (3.3%), and other categories (15.5%).

AASHTO'S GUIDELINES AND BEST PRACTICES FOR HANDLING UTILITIES

The AASHTO subcommittee on Right-of-Way and Utilities prepared a report on Utilities Guidelines and Best Practices (AASHTO 2000) that outlines its four guidelines and best practices for handling utilities.

A summary of the AASHTO recommendations follows:

1. Use current available technology to the greatest extent possible.
    - A. Use Subsurface Utility Engineering for projects where underground utilities are present and high-quality levels of information are needed for design purposes.
    - B. Require utility company certificate of record drawings and encourage development of a CADD database system and electronic transfer system.

Table 13. Categories of SUE cost savings (Lew 2000).

Number	Description
1	Reduction in unforeseen utility conflicts and relocations
2	Reduction in project delays due to utility relocations
3	Reduction in claims and change orders
4	Reduction in delays due to utility cuts
5	Reduction in project contingency fees
6	Lower project bids
7	Reduction in costs caused by conflict redesign
8	Reduction in the cost of project design
9	Reduction in travel delays to the motoring public during construction
10	Improvement in contractor productivity and quality
11	Reduction in utility companies' costs to repair damaged facilities
12	Minimization of utility customers' loss of service
13	Minimization of damage to existing pavements
14	Minimization of traffic disruption, increasing DOT public credibility
15	Improvement in working relationship between DOT and utilities
16	Increased efficiency of activities by elimination of duplicate surveys
17	Facilitation of electronic mapping accuracy
18	Minimization of the chance of environmental damage
19	Inducement of savings in risk management and insurance
20	Introduction of the concept of a comprehensive SUE process
21	Reduction in right-of-way acquisition costs

2. Encourage frequent coordination and communication with local government agencies to reduce delivery time, reduce costs, and improve quality in the utilities process; work with local government jurisdictions to establish pavement cutting criteria and backfill requirements.

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

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.
D. Organize periodic (monthly, quarterly, annual) meetings with utility owners within the municipality, county, or geographic or highway planning region.
E. Solicit similar information on utility owners' capital construction programs, particularly where a utility's planned expansion or reconstruction may encroach on or coincide with a planned highway project.
F. Consider using the long-range planning meeting as a convenient forum to discuss other highway/utility issues, such as accommodation policies, reimbursement, etc.
G. Provide utility companies with a notice of proposed highway improvements and preliminary plans as early in the development of the highway project as possible.
H. Involve utility companies in the design phase of highway projects where major relocations are anticipated.
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.
K. Invite utility companies to pre-construction 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.

4. Improve contract, internal project development and training processes to expedite utility relocation.
A. Use standardized utility agreements.
B. Initiate separate contracts for advance roadway work on selected projects prior to utility relocation.
C. Set forth responsibilities for appropriate action to reduce delays to contractors.
D. Provide utility special provision language in the construction contract.
E. Avoid late plan changes.
F. Have highway contractors relocate utility and municipal facilities, when possible.
G. Acquire sufficient right-of-way for utilities purposes.
H. Provide training to department of transportation utility staff and utility companies' staff.

ASCE STANDARD GUIDELINES FOR THE COLLECTION AND DEPICTION OF EXISTING SUE DATA

The American Society of Civil Engineers has developed a National Consensus Standard titled *ASCE C-I 38-02, Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data*.

In general, the standard contains provisions such that:

- The project owner will be responsible for taking appropriate actions to consider and deal with utility risks. On many small projects, where few subsurface utilities are present, and/or where information about subsurface utilities is believed to be generally accurate and comprehensive, this will only involve making a conscious decision to proceed with the project using readily available information. On larger projects, where information about subsurface utilities is not believed to be generally accurate and comprehensive, this may involve employing the services of an engineer to provide expert advice and to use available technologies to provide better information.
- The engineer will advise the project owner of utility risks and recommend an appropriate quality level of utility data for a given project area at the appropriate time within the project planning and design process. Such advice will take into account such items as type of project, expected utilities, available rights-of-way, project timetables, and so forth.
- The project owner will specify to the engineer the desired quality level of utility data.
- The engineer will furnish the desired utility quality level to the owner in accordance with the standard of care.
- The engineer will be responsible for negligent errors and/or omissions in the utility data for the certified utility quality level.

FHWA GUIDELINES FOR REDUCING UTILITY-RELATED CONSTRUCTION DELAY

The Office of Asset Management (HIAM), in cooperation with the Office of Program Administration (HIPA) and with the AASHTO Highway Subcommittees on Construction and on Right-of-Way and Utilities, has developed a video for state DOT and utilities' engineers encouraging them to make a commitment to Coordinate, Cooperate, and Communicate (CCC) early and often. The video *CCC: Making the Effort Works!* is based on the research and the recommendations contained in *AASHTO Guidelines and Best Practices*. It is designed to inform transportation agencies and utility companies of actions they can take toward avoiding construction delays and reducing or eliminating unnecessary project costs, and to motivate them to work in partnership with each other toward this common goal. A summary of FHWA recommendations follows:

1. State and county personnel can help the utility relocation process by adapting the following measures:

   - Practicing CCC early and often throughout the project.
   - Providing long-range construction schedules to utility companies.
   - Formalizing communication and coordination efforts.
   - Avoiding conflicts by designing around known utilities.
   - Encouraging and facilitating cooperative working relationships.
   - Holding regular meetings with utility companies in the planning and design phases.
   - Encouraging utility companies to make and keep commitments on work plans.
   - Sharing best practices.

2. Use current available technology to the greatest extent possible. Examples include:

   - Subsurface Utility Engineering.
   - World Wide Web and the Internet.
   - Electronic transfer of plans.
   - Trenchless technology.
   - Information sharing through various training and outreach programs.

3. Improve contract, internal project development and training processes by:

   - Staking and acquiring sufficient right-of-way.
   - Paying the costs of engineering the utility relocations.
   - Informing bidders of concurrent utility relocation work in special provisions.
   - Accepting responsibility for costs and delays due to late plan changes.
   - Letting separate contracts for selective advance work when feasible.
   - Making contractors responsible for selective relocation work.
   - Supporting and encouraging joint use programs.
   - Sponsoring and conducting ongoing training programs for all DOT divisions and managers, consultants and utility personnel.

- Proactively marketing best practices.

The FHWA recommendations emphasize the fact that proper use of information obtained from using SUE; new locating and characterizing technologies; and early and frequent coordination, communication and cooperation (CCC) can result in a timelier and more efficient relocation process.

7. UTILITY MANAGEMENT SYSTEM

Pennsylvania (PennDOT), Virginia (VDOT), Texas (TxDOT), Georgia (GDOT), Wisconsin (WisDOT), Florida (FDOT), and California (Caltrans) were selected to be part of this study. DOT project managers and engineers, utility owners, constructors, designers, and subsurface utility engineers were interviewed.

CRITERIA AND PROCESS FOR DETERMINING APPROPRIATE SUE LEVELS

Data collected during the SUE process must be combined with base map or background information to create a composite drawing. The composite drawing is then used to determine the best design based on avoiding and minimizing conflicts with existing facilities. The research found that only a few states use SUE as a matter of standard practice. Where used, SUE is often done after the design is complete.

It is in the DOT's best interest to evaluate each project and set the quality level deemed appropriate for its conditions. One way of accomplishing this task is to have the engineer or designer review the construction area, available utility records, and project requirements. Many factors can play a role in determining the quality level required for a project. These include project location, existing utility congestion, right-of-way width, and the size or extent of the project. Also, it could be appropriate that certain areas or sections of a project may require a higher quality level than another.

1. **Pennsylvania:** Pennsylvania uses SUE on some projects and the DOT initially reviews the SUE levels C and D information. If there are significant discrepancies, the DOT will consider initially a level B survey. On projects with more critical buried assets, a level A study may be requested.

2. **Virginia:** In Virginia, whenever SUE is used, it is always level B. On projects with more critical buried assets and on recommendation from a design engineer, a level A study may be requested.

3. **Wisconsin:** In Wisconsin, there are no criteria for deciding when to use SUE. WisDOT uses SUE on some projects. Whenever SUE is used, it is always level B.

4. **California:** In California a two-tiered system is used. Projects or parts thereof are classified as low or high risk. The SUE quality levels assigned to low- and high-risk projects are levels A and D. CALTRANS can require the utility company to locate a utility to a high degree of accuracy.

5. **Georgia:** Georgia has a well-structured process for reviewing projects during the 50% design phase to access potential utility conflicts and to assign SUE levels. GDOT has also developed a SUE Utility Impact Rating System to decide SUE levels.

6. **Florida:** In Florida, when there are suspected conflicts with FDOT facilities (i.e., drainage, signal lines, lighting, wiring, or loss of cover), a SUE provider is called to locate those facilities according to the quality level desired. Each district is responsible for developing its SUE contracts.

7. **Texas:** In Texas, the DOT initially reviews the SUE levels C and D information. If there are significant discrepancies, the DOT will consider initially a level B survey. On projects with more critical buried assets, a level A study may be requested.

BEST PRACTICES FOR AVOIDING UTILITY RELOCATION DELAYS

Utility-related problems are a leading cause of delays that occur during the construction phase of highway projects, according to a recent National Cooperative Highway Research Program study. This comes as no surprise, as it is well known to highway engineers that uncoordinated utility relocation activities often cause expensive delays and disruptions. What can be done to alleviate this problem? To start, the proper use of information obtained using SUE can help engineers avoid the need to relocate many utility lines. When utility relocations cannot be avoided, early and frequent coordination, cooperation, and communication result in more timely and efficient relocation activities.

Pennsylvania (PennDOT), Virginia (VDOT), Texas (TxDOT), Georgia (GDOT), Wisconsin (WisDOT), Florida (FDOT), and California (Caltrans) were selected to be part of this study. DOT project managers and engineers were interviewed in this study.

1. **Pennsylvania:** PennDOT is in the process of developing a SUE best practices manual and a decision matrix tool to determine which projects should include SUE and the appropriate level of SUE for the highways projects.

2. **Virginia:** VDOT has contracts statewide with SUE consultants to designate and locate utilities on projects selected by the department. Upon receipt of the underground utility designation data, preliminary road plans, including hydraulic design, are developed. The designer will then request that the Structure and Bridge and Traffic Engineering divisions submit preliminary information. A review is to be made with these divisions by the designer to determine if there are utility conflicts.

3. **Wisconsin:** WisDOT has the utility accommodation policy, but doesn't have a well-defined best practices guideline for avoiding utility relocation delays.

4. **California:** Caltrans has developed the right-of-way manual for handling all of its utilities, but doesn't have a well-defined best practice manual for utilities.

5. **Georgia:** GDOT has a process for reviewing projects to access potential utility conflicts. GDOT uses a decision matrix for SUE levels (see http://www.dot.state.ga.us/dot/operations/utilities/sue/index.shtml, "SUE Scope of Services").

6. **Florida:** In order to minimize cost and impact upon FDOT and the utilities, established procedures for determining the level of accuracy of a utility survey have been developed. FDOT requires that the survey SUE data acquired during the designating and locating phases be transferred to the project owner's CADD system.

7. **Texas:** TXDOT has a well-structured process for utility investigation, coordination, engineering, and management (see http://www.dot.state.tx.us/gsd/pubs/rowpubs.htm).

RECOMMENDATION

There is a specific recommendation on state DOT utility engineering and management programs that can be justified based upon the following factors:

- A review of Pennsylvania (PennDOT), Virginia (VDOT), Texas (TxDOT), Georgia (GDOT), Wisconsin (WisDOT), Florida (FDOT), and California (Caltrans) utility engineering and management programs;
- Detailed discussions with state DOT engineers and managers;
- Conversations with SUE consultants;
- Comprehensive literature review; and
- Attendance at many seminars and conferences related to utility engineering and management.

Some state DOT utility programs already incorporate this recommendation in whole or in part as common practices. Other states should consider implementing the proposed utility management system, as shown in Figure 4. The components of the proposed Utility Management System are:

1. Utility Engineering Investigation (UEI)
2. Utility Adjustment Coordination (UAC)
3. Utility Design and Engineering (UDE)
4. Utility Construction and Verification (UCF)
5. Utility Data Management (UDM)

The Texas Department of Transportation (TxDOT) is in the process of implementing the proposed Utility Management System. Detailed information regarding the cost, resources, etc. required to develop such a system or the benefits of having the system can be obtained by contacting Jesse Cooper, Utility Manager, ROW Division, TxDOT, Austin (phone: 512-416-2874, e-mail: jcoope2@dot.state.tx.us).

The Georgia Department of Transportation (GDOT) has developed a decision matrix tool to determine which projects include SUE and the appropriate level of SUE investigation required. Detailed information regarding the cost, resources, etc. required to develop such a decision matrix or the benefits of having the decision matrix can be obtained by contacting Jun Bimkammer, State SUE Engineer, Office of Utility Engineering, GDOT, Atlanta (phone: 404-635-8055, e-mail: birnkammer@dot.state.ga.us).

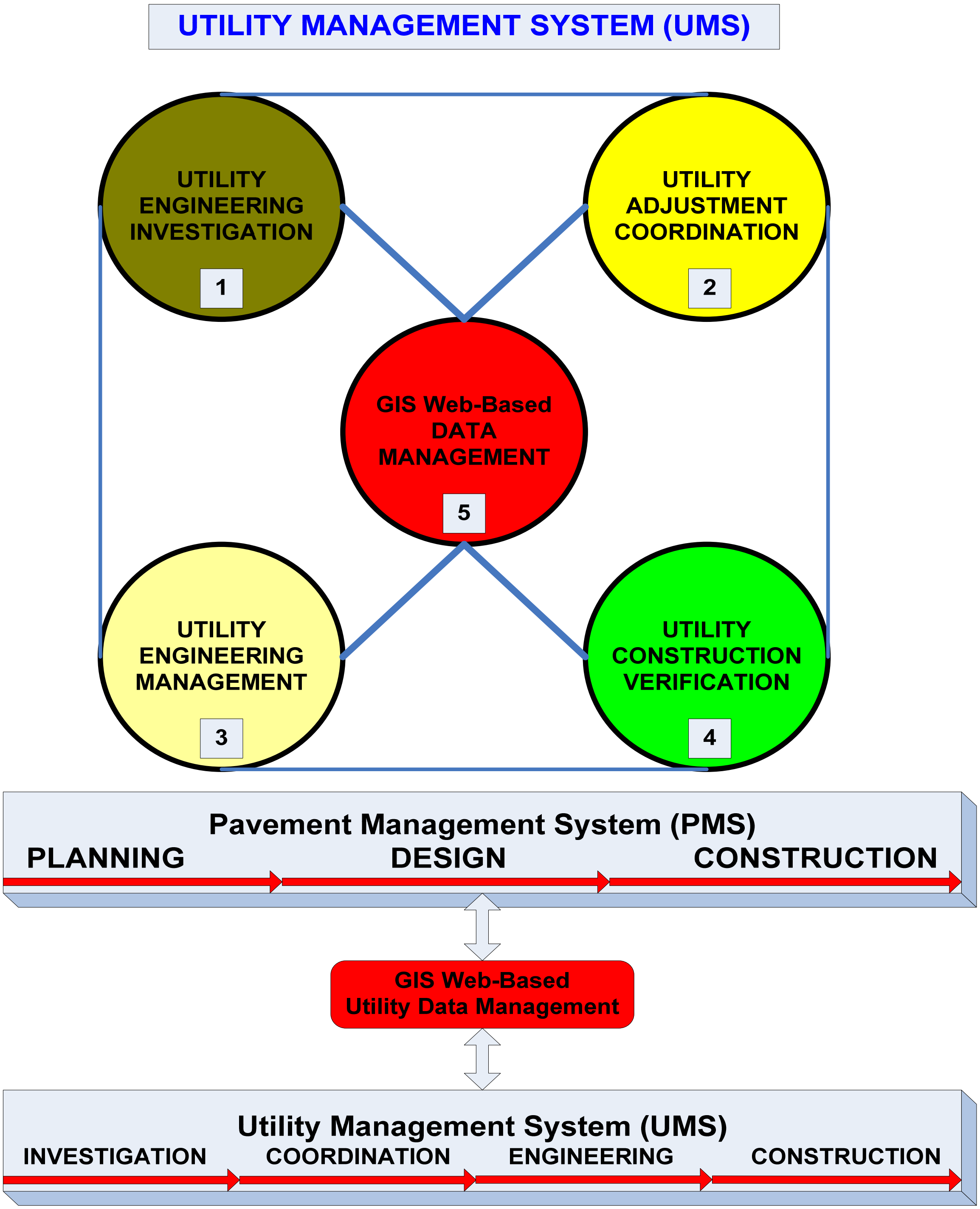

Figure 4. Utility management system and the implementation plan.

Utility Management System and Implementation Plan

1. Utility Engineering Investigation (UEI)

Develop a decision matrix tool to determine which projects include SUE and the appropriate level of SUE investigation required. Establish utility investigations in accordance with AASHTO standards and utility quality levels as follows:

- QL A – 3-D Information (e.g., geophysical techniques for precise location of utilities).
- QL B – 2-D Information (e.g., geophysical techniques to identify horizontal position).
- QL C – Topographic Data (e.g., site survey for surface-visible features such as manholes).
- QL D – Basic Data (e.g., derived from basic utility records).

2. Utility Adjustment Coordination (UAC)

Develop utility coordination meetings with individual utility companies, communication and coordination with utilities, and preparation of utility agreement assemblies including utility agreements, joint use agreements, and advanced funding agreements.

3. Utility Design and Engineering (UDE)

Consider identification of utility conflicts, coordination, compliance with utility accommodation rules, and resolution of utility conflicts. The engineer should coordinate all activities with the district director of transportation planning and development, or their designee, to facilitate the orderly progress and timely completion of the state's design and engineering phase.

4. Utility Construction and Verification (UCF)

Develop coordination of utility construction activities, utility location installation verification, compliance with utility accommodation rules, monitoring, reporting, and as-built surveying as required for the district.

5. Utility Data Management (UDM)

Develop a program of GIS web-based utility data management. The concept of using geo-spatial and/or data-integration technology for managing utility data is not new. However, research directed at identifying the data elements required to perform the categories and sub-categories of the utility functions is needed. The utility data are usually made of two components:

- Geometric Data: Geometry of geographical features like locality boundary, street boundary, plot boundary, building features, etc.
- Attribute Data: Information associated with the geometric data like locality name, street name, nature of occupation of a plot, elevations, ownership, etc.

Data for preparing base maps can be collected from various sources and methods. The basic background can come from aerial photography, USGS maps, right-of-way drawings, street maps, surveys or a combination of sources. Underground and subsurface utility information should be collected using the SUE process.

Appropriate Quality Level

There does not seem to be an appropriate level of quality, nor does it seem appropriate to define one. Instead, a practice applied by several states seems to be workable. It is recommended that states compare the level C and D data. Where significant discrepancies exist, it is appropriate to go to a level B analysis. A level A analysis is reserved for critical infrastructure, such as gas lines, telecommunication lines, electrical lines, etc. Other criteria may also be applied, such as discrepancies between level C and level B data.

Use of Data

SUE data are not often provided to the DOT in CAD format, and they are often provided too late to be incorporated into the design. It is recommended that SUE be provided in a 2-D or 3-D CAD format to the designer with instructions to avoid designs requiring utility relocations. It is important that the SUE information be available during design.

8. CRITIERIA FOR DETERMINING OPTIMUM INCENTIVE VALUES IN A+B AND OTHER PERFORMANCE INCENTIVE CONTRACTS

Using incentive contracts is well known as an innovative contracting technique that minimizes the disruption of traffic flow in highway construction projects. Project planners have used the incentive method as one of their management tools to achieve their objectives for a project. Motivated contractors accept the emphasized goals in the contract and try to achieve them in return for monetary incentives (Workman 1985). At the same time, a contractor is also subject to disincentives agreed upon with the agency if the contractor fails to achieve those goals (FHWA 1989). However, determining the appropriate incentive amount for a particular project remains a challenge for many SHAs.

TYPES OF INCENTIVE PLANS

The various incentive plans can be summarized as follows: schedule-based incentives for early completion of work, cost-based incentives for reducing project cost, and performance-based incentives for improving project quality, safety, productivity, and so on. Among them, the incentive contract for early completion has been the most popular incentive plan in highway construction projects because both the design and the implementation of schedule-based incentives are comparatively easy and inexpensive (Abu-Hijileh and Ibbs 1989). Jaraiedi et al. (1995) stated that a performance-based incentive employs certain parameters of the contractor's project performance as a basis for the use of the incentive. Widely used performance parameters include safety, quality, responsiveness, technology management, business management, and utilization of resources and craft labor productivity (Stukhart 1984). Among these, the most typically measured parameters are quality and safety (Bower et al. 2002). In order to determine a contractor's incentive, the agency generally assigns a score based on the relative achievement of the performance standards (Stukhart 1984). Performance-based incentives are designed to reward or penalize contractors either monetarily or non-monetarily.

Cost-based incentives are designed to reduce project cost through financial ratios shared between the owners and contractors. Two different types of cost-based incentive/disincentive (I/D) are summarized by Jaraiedi et al. (1995):

- A fixed-price firm incentive provides the contractor with both a base payment and incentive/disincentive amounts. The I/D amount is based on a percentage of the target fee, which represents a fair profit for work that comes in at the target cost. Thus, if the project comes in below cost, a percentage of the savings gained by the agency that awards the contract as a result of the performance of the contractor is passed on in the form of an incentive payment. If the contractor's performance results in an overrun on the contract cost, then he or she will be assessed a disincentive amount equal to the incentive rate, as outlined in the contract. A cost ceiling is included in the incentive/disincentive plan, which represents the maximum liability of the contractor should a disincentive be assessed.

- A cost-plus incentive fee places maximum limits on the amount of incentive that can be received by the contractor for cost underruns and a minimum payment the contractor will receive if there are cost overruns. Thus, the contractor is guaranteed some amount of profit regardless of performance on the job.

One form of cost performance incentive is Value Engineering (VE), in which the cost benefits realized by innovative contractor ideas or techniques are shared between the contractors and the owners (Construction Industry Institute [CII] 1995). The FHWA has encouraged states to apply VE to most highway projects and recommended that states' VE programs include VE or cost reduction incentive clauses in construction contracts (FHWA 1998). The Value Engineering Change Proposal (VECP) is the construction phase of the VE program and the VE savings are usually split evenly between owners and contractors. State and federal transportation agencies have implemented the VE technique and reported surprisingly large monetary savings (FHWA 2003).

Abu-Hijileh and Ibbs (1989) stated that incentive contracts could be useful management tools to improve project performance. They determined that the use of schedule-based incentives was particularly attractive because they could create substantial time and cost savings. A schedule-based incentive for early completion of work is described as "a contract provision which compensates the contractor a certain amount of money for each day . . . critical work is completed ahead of schedule and assesses a deduction for each day the contractor overruns the I/D time" (FHWA 1989, p. 1). I/D for early completion is the most popular incentive plan in highway construction projects, and a schedule-based incentive is generally easier to administrator than a cost-based incentive (Stukhart 1984). Abu-Hijileh and Ibbs (1989) also reported that both the design and the implementation of schedule-based I/D were comparatively easy and inexpensive.

Jaraiedi et al. (1995) described various forms of incentive contracts, including an incentive-only plan and a disincentive-only plan in incentive contracts: for example, a project planner might offer a bonus/penalty plan, a bonus-only plan, a penalty-only plan, and non-monetary incentives. The I/D provision may be applied by itself or with such other alternative contracting methods as A+B, lane rental, no-excuse bonus, design-build, and liquidated savings (FDOT 2000). In order to speed up a project, Christiansen (1987) concluded that monetary incentive plans were more effective than non-monetary plans. Abu-Hijileh and Ibbs (1989) reported that the use of bonus-only incentives was more effective than the use of penalty-only. However, although all the various incentive forms have been used frequently for many projects, it is unknown which forms of incentive contracts are the most effective (Jaraiedi et al. 1995).

INCENTIVE CONTRACT TYPES USED IN FLORIDA

The *Alternative Contracting User's Guide* used by the FDOT (1997) states that incentives may be paid when employing the following contracting practices: No Excuse Bonus (also called Bonus), A+B, I/D, LQSAV, Design/Build, Lane Rental/Bonus, or any combination of those practices. In this study, the Design/Build and the Lane Rental/Bonus contract types were not investigated because of limited project data. The characteristics of various incentive contracts are similar in that incentives are used to encourage the contractor to further reduce the time needed to complete a project. However, their applications and time adjustments for incentives can differ, as discussed below.

DESCRIPTION OF INCENTIVE CONTRACT TYPES

The *Alternative Contracting User's Guide* (FDOT 1997) describes incentive contacting methods as follows:

- A+B: The A+B bidding concept is designed to shorten the total contract time by allowing each contractor to "bid" the number of days in which the work can be accomplished. The A+B specifications may include an incentive/disincentive clause, with the amount being equal to the time bid amount, to encourage the contractor to further reduce the time to complete a project. The contractor will receive an incentive for each day work is completed ahead of the adjusted contract time. Conversely, if the contractor completes the project late, the disincentive will be assessed as well as liquidated damages as per the contract.

- I/D: The I/D concept is designed to reduce the overall contract time by giving the contractor a financial reward for every day the contract is completed early. The I/D technique can also be used to accomplish milestones within the project.

- Bonus: The Bonus concept is designed to provide the contractor with a substantial incentive to complete a project within a specified time frame regardless of any problems or unforeseen conditions that might arise. It is intended to shorten the construction time that would normally be required to perform the work. The contract may include two dates, the bonus date and the normal contract time date. If the bonus date is not met the contractor will not receive the bonus; however, the contractor will be granted weather days and time extensions as per normal processes.

- LQSAV: The liquidated savings concept is the opposite of the existing liquidated damages. The intent of liquidated savings is to encourage the contractor to finish a project early. The contractor will be rewarded for each calendar day the contract is completed and accepted prior to the expiration of the allowable contract time. The amount of incentive of reward is based on the direct savings to the Department (and thus the public) related to construction engineering inspection and contract administration costs.

APPLICATION OF INCENTIVE CONTRACTS

The *Alternative Contracting User's Guide* (FDOT 1997) recommends applying incentive contracts as follows:

- A+B: This technique is best used on projects where shortened contract time is important but not necessarily critical. Urban reconstruction and bridge projects are generally good candidates. A+B bidding focuses the contractor on completing the whole project in a timely manner.

- I/D: This concept can be used on a wide variety of project types and is best applied when the Department is willing to pay the contractor to expedite the work in order to reduce the contract time. It is similar to A+B in that it works well with urban reconstruction and bridge type projects.

- Bonus: This technique can be applied to a wide variety of project types where it is important to complete the project/milestones by a particular date (i.e., a major sporting event) or within a specified time frame (number of calendar days once project begins).

- LQSAV: This concept can be used in a variety of project types. It may be best suited for mill and resurface projects since the Department has experienced some problems with contractors moving off projects once the major items of work (i.e., asphalt) are done.

TIME ADJUSTMENT FOR INCENTIVES

The *Alternative Contracting User's Guide* (FDOT 1997) states the time adjustment for incentives as follows:

- A+B: Only chargeable work days are to be counted. For example, rain days and time extensions for unforeseen work will be added on to the contractor's time bid in accordance with standard practices.

- I/D: Only chargeable work days are to be counted. For example, rain days and time extensions for unforeseen work will be added on to the original contract time.

- LQSAV: Contract time is adjusted for unforeseen conditions, extra work and weather delays.

- Bonus: Bonuses differ from I/D clauses in that bonuses do not ordinarily allow for any time extensions. They are tied to a "drop-dead" date (time frame) that is either met or not met. Unforeseen conditions, weather delays and other such issues, which normally extend contract time, are not a consideration when granting a bonus. Catastrophic events such as Hurricane Andrew may be allowed for time extension.

According to the guide, time adjustment of incentive contracts for incentive days and penalty days can be summarized as shown in Table 14. In the table, the present days mean the final contract days including all time extensions and supplemental agreement days.

Table 14. Time adjustment for incentives.

Contract Type	Weather Day Adjustment	Total Work Order Time Extension Adjustment	Supplemental Agreement Day Adjustment	Final Incentive Days (ID)	Final Penalty Days
A+B	Yes	Yes	Yes	Original ≤ ID ≤ Present days	Present days
I/D	Yes	Yes	Yes	ID = Milestone days or Original ≤ ID ≤ Present days	Present days
Bonus	No	No	No	ID = Milestone days or ID = Original days	Present days
LQSAV	Yes	Yes	Yes	Original ≤ ID ≤ Present days	Present days

I/D FOR EARLY COMPLETION

In 1984, the FHWA policy prohibiting extra payments for early completion was officially withdrawn. FHWA (1989) reported that the present FHWA policy regarding bonus payments is based in part on the assessment of the National Experimental and Evaluation Program (NEEP), which showed that I/D provisions were a valuable, cost-effective construction tool. The current FHWA policy includes provisions that result in significant savings and/or positive benefits to the traveling public. The following guidance is given for the use of I/D provisions (FHWA 1989):

- The approval of I/D provisions will be reserved only for critical projects or phases of projects where traffic inconveniences and delays must be minimized. States should develop guidelines for selection of projects.
- The determination of I/D amount and time should be documented and retained in the project records. The I/D amount and time determination with supporting data should be submitted and concurred with by the FHWA Division Administrator prior to the state's request for approval of the plans, specifications, estimate, and authorization to advertise.
- Project time should be established on either a calendar day or completion date basis. Contractors should have an approved critical path method (CPM) schedule prior to starting work on the project.

- For those states with an approved Certification Acceptance Plan, the procedure for developing I/D projects should be covered under the state's plan, or the projects should be handled as an exception and developed with the Division Administrator's approval.

SELECTION OF INCENTIVE PROJECTS

FHWA (1989) recommended that I/D provisions should not be used routinely and should be limited to the projects that severely disrupt highway traffic or highway services, significantly increase road user costs, have a significant impact on adjacent neighborhoods or businesses, or close a gap, thereby providing a major improvement in the highway system. In order to aid early identification of projects appropriate for I/D, the following characteristics have also been identified by FHWA (1989): high-traffic volumes in urban areas, lengthy detours created by the project, major bridges out of service, and major reconstruction or rehabilitation on an existing facility that would severely disrupt traffic.

Caputo and Scott (1996) developed project selection criteria for the South Dakota Department of Transportation as guidelines of time-based innovative contracting methods, A+B, I/D, and Lane Rental. The stepwise criteria for selecting innovative contracting are as follows: (1) identify candidate projects for expedited completion and estimate road user cost (RUC); (2) identify potential impacts; (3) re-evaluate project, finalize RUC, estimate time, and choose a contract method; and (4) develop special provisions. The recommended project conditions for the use of time-based innovative contracting methods are summarized in Table 15.

The *Alternative Contracting User's Guide* (FDOT 1997) recommended conditions under which incentive contracting methods were best used, as shown in Table 16. However, the FDOT allows the districts flexibility to manage their business using methods with which they feel most comfortable. Thus, the district management controls the selection of incentive projects. The district engineers generally consider the following situations for the selection of incentive projects:

- Whether a project is highly visible and important;
- Whether a project has a high priority;
- What the impacts of construction on the project will be;
- What the economic impacts might be;
- What the financial impacts to the department and/or the public might be; and
- What upcoming events are scheduled in this area.

In addition, recent interviews with FDOT district engineers indicated that most district engineers emphasized quality of contract documents to make incentive projects successful. With regard to the quality of contract documents, several items are necessary:

- Well-coordinated utility relocation schedules;
- A high-quality set of plans and specifications;
- A well-prepared construction schedule; and
- Verified quantities and pay items.

Table 15. SDDOT's criteria for the selection of time-based innovative contracting (Caputo and Scott 1996).

Contract Type	Recommended Project Conditions to Use Innovative Contracts
A+B	• The project does not require completion by a specific date. • RUC is relatively low but other factors warrant expediting the project. • The Department seeks contractor expertise to estimate contract time.
I/D	• RUC is high, and the monetary benefit equals or exceeds the incentives paid to the contractor to finish early. • It is in the public interest to complete the project as soon as possible, or by a specific completion date. • The Department can estimate contract time based on similar projects or CPM scheduling.
A+B with I/D	• RUC is high, and the monetary benefit equals or exceeds the incentives paid to the contractor to finish early. • It is in the public interest to complete the project as soon as possible. • The Department seeks contractor expertise to estimate contract time.
Lane Rental	• The use of detours or alternate routes is impractical. • The work requires the closure of a lane or lanes, or a combination of lanes and shoulders, while maintaining traffic on the remaining lanes and shoulders. • RUC is relatively high, and the benefit to finish early equals or exceeds the incentives paid to the contractor in the form of rental fees. • The Department seeks contractor expertise to minimize the time that the roadway or a portion of the roadway is out of service.

Table 16. FDOT's recommendation for project selection (FDOT 1997).

Contract Type	Conditions Best Used
A+B	• Urban reconstruction, bridge projects, and high traffic areas. • Can be applied to a wide variety of projects when a specific completion date needs to be met.
I/D	• Urban reconstruction. • Can be applied to a wide variety of projects when a specific completion date needs to be met.
Bonus	• Can be applied to a wide variety of projects when a specific completion date needs to be met.
Lane Rental	• Milling and resurfacing, bridge widening, and box-culvert extensions.
Liquidated Savings	• Milling and resurfacing.

Guidelines of the New York State Department of Transportation (NYSDOT) instructed, "User delay and other documented delay costs should be at least $3,000 per day to warrant the use of incentive provisions. However, A+B bidding may be used for projects or phases which produce user delay costs less than $3,000/day if extraordinary concerns exist such as interference with public events or significant public interest and benefit (NYSDOT 1999)." NYSDOT (1999) also recommended the following characteristics associated with projects appropriate for A+B bidding:

- High traffic volume facilities generally found in urban areas,
- Projects that will complete a gap in a significant highway system,
- Major reconstruction or rehabilitation on an existing facility that will severely disrupt traffic,
- Major bridges out of service,
- Projects with lengthy detours of high volumes of traffic,
- Projects with a preconstruction level of D or worse, and
- Projects with high accident locations that may be exacerbated by non-standard features during construction.

Kent (2002) summarized the NYSDOT's experiences in A+B project selection as follows: "Projects or project phases where A+B bidding is used must be chosen carefully. Projects with high user delay that warrant acceleration may also have characteristics that could potentially impede the ability to succeed. Projects that typically experience delays using normal contracting will also experience delays using A+B bidding unless additional measures are taken. If unanticipated subsurface conditions are likely to be encountered due to the nature of the work or its location, i.e. utilities, rock, historical artifacts etc., either exclude this work from the A+B provisions or invest additional design effort to minimize the potential impact <u>and</u> be prepared to make adjustments if required during construction. Bridge deck repair or pavement repair quantities must be estimated conservatively to avoid time extension requests. Projects with sensitive environmental conditions must also be evaluated carefully. Provisions must be included in the contract to protect environmentally sensitive areas from high production construction operations. Lane closure restrictions and time of work restrictions must be clearly stated. Instead of making the whole project duration the B portion time period, consider using A+B provisions for the most critical phases. Consider multiple contractual methods in the same contract to achieve the desired objective, i.e., A+B bidding with night work, Incentive/Disincentives or Lane Rental. A good project for the use of A+B bidding is a bridge replacement project with an off-site detour and no utility involvement. New construction is typically easier to define versus rehabilitation and when the contractor has clear access and control of the work, the chances for success are better (Kent 2002)."

Kent (2002) stated that NYSDOT has used A+B bidding on over 140 contracts since implementation in 1994 and summarized the evaluation results of A+B bidding and performance in New York State as follows:

- Contractors bid on average 32% below the Department's estimated time <u>and</u> complete the work ahead of schedule.
- 120 contracts completed "B" portion work. The approximate original contract value of these contracts is $2.0 billion.
- 90 of the 120 contracts were awarded to the low "A" portion bidder, i.e., the bidder with the lowest A+B total also had the lowest "A" portion contract amount. The other 30 contracts were awarded to a bidder with a higher "A" cost and a shorter "B" duration. The added "A" cost of these 30 contracts is less than 1%.
- 103 Contractors earned incentives. Total incentives paid = $49,069,174. Total incentives paid are approximately 2.5% of original contract value for these 103 contracts.
- 9 Contractors completed on time. No incentives or disincentives.
- 8 Contractors accessed disincentive. Total disincentives = $592,000.
- 59 contracts (50% of completed contracts) required "B" time adjustments.
- Estimated user cost savings for completed contracts = $246 million.
- Estimated construction days saved = 20,000.

A+B bidding evaluation in California summarized by PinnacleOne (2004) showed that A+B bidding resulted in time savings at the beginning of the contracts. Sixteen A+B projects were evaluated and the average percentage of time savings was 27% (an average savings of 91 days). The California Department of Transportation (Caltrans) resident engineers recommended that A+B contracting be used when the following project conditions were present (PinnacleOne 2004):

- A very good, completed design,
- No uncertain or unresolved right-of-way or utility relocation issues,
- A project that isn't overly complex,
- A project in a "sensitive" area or where there tend to be many complaints from the public that could be reduced via A+B's shorter timeframes, and

- A project that will have solid CPM scheduling support to assess the schedule at the beginning of and throughout the project.

The Minnesota Department of Transportation (MnDOT) published a manual titled *Innovative Contracting Guidelines* to provide guidance in identifying projects that can utilize innovative contracting techniques. This manual summarized benefits and drawbacks for each innovative contracting from the MnDOT's experiences. As a project selection guideline, good candidate projects and poor candidate projects for A+B, I/D, and Liquidated Savings were recommended, as shown in Table 17. The MnDOT also emphasized that "A+B bidding should focus on projects with significant impacts to motorists, businesses, emergency services, or other groups that will be directly impacted by the project." In addition, they recommended, "Incentive/Disincentives can be used in a wide variety of projects. It is best applied when Mn/DOT is willing to pay the contractor to expedite the work to reduce the contract time. It is similar to the A+B in that it works well with urban reconstruction and bridge-related projects (MnDOT 2005)."

For the implementation of A+B projects, the MnDOT has a seven-step process (MnDOT 2005):

- Step 1: Is My Project a Good Candidate for A+B?
- Step 2: Determine How to Use A+B
- Step 3: Determine Road User Costs
- Step 4: Determine Contract Time
- Step 5: Determine Incentives and Disincentives
- Step 6: Draft Special Provisions
- Step 7: Construction Considerations

In Step 1, there were 15 questions in eight categories to determine whether or not to use A+B. The Yes or No questions are as follows (MnDOT 2005):

- RIGHT OF WAY
    - Will all right-of-way be secured prior to letting date?
    - If not, do the staging plans allow the contractor to sequence work around the conflicts and is a right-of-way time determination schedule in the special provisions?

- PLANS
    - Is there high confidence in the design?
    - Has a thorough field review been conducted?
    - Has the design been coordinated with construction at various stages (e.g., 30%, 90%)?
    - Has a constructability and bid-ability review been conducted by design and construction?

Table 17. MnDOT's innovative contracting project selection guideline.

Contract Type	Good Candidates	Poor Candidates
A+B	• Mill and overlay • Un-bonded concrete overlays • Detour projects • New construction and reconstruction (grading and structures) • Bridge painting • Intersection upgrades • Bridge rehabilitation (if confident with quantities)	• Traffic Management System (TMC) (Mn/DOT-provided items can cause delay) • Steel fabrication (minimal benefit to public) • Concrete rehabilitation (due to high probability of overruns) • Signal systems (Mn/DOT-provided items can cause delay) • Landscaping (minimal disruption to traffic) • Signing projects

I/D	• Projects with high road-user or business impacts
	  ○ Urban reconstruction projects
	  ○ Bridge replacement projects
	  ○ Detour projects
	  ○ Urban pavement rehabilitation projects (if confident with quantities)
	  ○ Interstate (high-volume) projects with major traffic impacts
	• A+B projects
	• Bridge rehabilitation projects
	• Projects with commitments to open a roadway as quickly as possible
		• New construction projects with minimal impacts to road users
		• Projects where right-of-way or utilities are not clearly identified
		• Traffic Management System (TMC)
		• Steel fabrication (minimal benefit to public)
		• Landscaping (minimal disruption to traffic)

Liquidated Savings	• Smaller urban and rural rehabilitation and reconstruction projects • Smaller bridge rehabilitation projects • Projects with reduced contract administration time because staffing resources need to be utilized on other projects	• Large construction projects – liquidated savings may be too small an incentive • Projects with minimal traffic impacts • Projects with minimal staffing concerns

- UTILITIES
  - Is there little or no chance that utilities will significantly delay the contractor?
  - Are utility conflicts clearly identified in the plan and special provisions?

- THIRD-PARTY AGREEMENTS
    - Will all permits be secured by the letting date?
    - Will all municipal agreements be secured by the letting date?

- PROGRAM IMPACTS
    - Have you considered the district-wide impacts of using an accelerated schedule?
    - Have you considered the potential cost and delivery to other projects?

- SOIL CONDITIONS
    - Is there little risk of contaminated or poor soils adding significant extra work?

- TRAFFIC CONDITIONS
    - Do construction traffic impacts relate to any of the following conditions?
    - Lengthy detours
    - Significant delays to motorists
    - Significant impacts to businesses, schools, or emergency services

- STAFFING CONSIDERATIONS
    - Do you have the staff available if the contractor has an aggressive schedule?
    - Do you have the budget for any additional overtime?

The answers to the above questions can determine whether or not to use A+B for a project with the following interpretation (MnDOT 2005): "If the answer is Yes to most of the questions, the project may be suitable for A+B. If you answered No to some of the questions, your project may still be a good candidate for A+B, but give careful consideration to the items with a No response."

DETERMINATION OF INCENTIVE AMOUNT

Many studies (e.g., FHWA 1989, Jaraiedi et al. 1995, Gillespie 1997) have emphasized that the determination of the appropriate dollar amount paid as I/D per day has been one of the most important issues in the use of I/D provisions. FHWA (1989) outlined the determination of the I/D amount as follows:

> The dollar amount must be of sufficient benefit to the contractor to encourage his/her interest, stimulate innovative ideas, and increase the profitability of meeting tight schedules so as to be effective and accomplish the objectives of I/D provisions. If the incentive payment is not sufficient to cover the contractor's cost for the extra work, then there is little incentive to accelerate production, and the I/D provisions will not produce the intended results (FHWA 1989).

The following guidelines for determining the I/D amount are also stated by FHWA (1989):

- A daily I/D amount is calculated on a project-by-project basis using established construction engineering inspection costs, state-related traffic control and maintenance costs, detour costs, and road user costs. Costs attributed to disruption of adjacent businesses should not be included in the daily I/D amount. Engineering judgment may be used to adjust the calculated daily amount downward to a final daily I/D amount. A daily I/D amount should provide a favorable benefit/cost ratio to the traveling public and be large enough to motivate the contractor.

- Accepted SHA procedures for estimating road user costs may be used.

- The vehicle operating costs should be based on the most recent information available.

- Generally, the incentive daily rate should equal the disincentive daily rate. If different rates are selected, the incentive daily rate should not exceed the disincentive daily rate.

- A cap of 5% of the total contract amount has been recommended as the maximum incentive payment. The 5% was based on the NEEP study average of incentive payments made on experimental I/D projects. However, no cap is recommended to be placed on the maximum disincentive amount.

Jaraiedi et al. (1995) pointed out that determination of the I/D amount was a difficult issue since each individual contracting situation was different. The authors suggested that the I/D amount be based on the implicit cost factors: safety of the users, loss of user time due to traffic, increase in gasoline consumption, and increased administrative and monitoring costs associated with the use of an I/D contract. However, while monetary losses sustained by businesses adjacent to a project should be used to determine whether that project justifies the use of I/D provisions, these losses are not recommended for use in determining the I/D amount (Jaraiedi et al. 1995).

From the summary of the MnDOT interview, a Road User Cost (RUC) is generally the basis for the B-value in Minnesota. However, the calculated RUC may be excessively high, especially in the Minneapolis/St. Paul metro area. If the RUC is too high, it really throws off how A+B works, since the B-value is going to have too much influence over who gets the job. This could result in an A price that the Department cannot afford, as shown in Step 3 of Appendix A. To mitigate this, a project manager may reduce the B-value down to something more manageable within the project. This is done on a case-by-case basis depending on the project cost and time duration estimate. The project managers in MnDOT were asked to set something "reasonable" between $3,000 and $15,000 for most of their projects. In some mega-projects, the project managers may set it as high as $25,000 to $30,000. There is no set procedure to determine the daily B-value, it is all done on "gut" feeling.

MnDOT (2005) developed general guidelines to determine I/D amounts as follows:

- Incentives should be based on items such as Road User Costs.
- Incentives must be sufficient to encourage contractor interest, stimulate innovative ideas, and increase profitability of meeting tight schedules. Recent experience indicates that daily incentives between $5,000 and $10,000 with caps in excess of $50,000 are substantial amounts for contractors.
- If incentives are not sufficient to cover the contractor's cost for the extra effort, there is little motivation for the contractor to accelerate production.

- Maximum incentive should not exceed 5% of the total contract amount.
- Incentive should be equal to or less than the disincentive rate.
- A maximum incentive should be specified.

A+B DATA ANALYSIS

Project data on A+B contracting were collected from three SHAs, NYSDOT, MnDOT, and FDOT. A total of 154 A+B project data sets from NYSDOT, 26 from MnDOT, and 115 from FDOT were obtained. Data analysis was performed to evaluate project time performance and to investigate the relationship between the B-value and the DOT Engineer's Cost Estimate. First, an evaluation of time performance data from NYSDOT showed 29.7% average time savings measured by Contractor's Award Days versus DOT Engineer's Time Estimates and 16.6% average time savings measured by Actual Days versus Award Days. In the same way, time performance evaluated from MnDOT data showed 18.5% average time savings measured by Contractor's Award Days versus DOT Engineer's Time Estimates and 6.0% average time savings measured by Actual Days versus Award Days. Similarly, time performance evaluated from FDOT data showed 21.7% average time savings measured by Contractor's Award Days versus DOT Engineer's Time Estimates and 3.8% average time savings measured by Actual Days versus Award Days.

Second, correlation analysis between the B-value and the DOT Engineer's Cost Estimate was performed and the results were 0.470 for NYSDOT, 0.454 for MnDOT, and 0.710 for FDOT. These results indicate a moderate relationship between the B-value and the DOT Engineer's Cost Estimate in the states of New York and Minnesota and a moderately strong relationship between the B-value and the DOT Engineer's Cost Estimate in the State of Florida. Scatter plots of the B-value versus the DOT Engineer's Cost Estimate for NYSDOT, MnDOT, and FDOT are show in Figures 5, 6, and 7. Summary statistics of data used for this analysis are shown in Table 18.

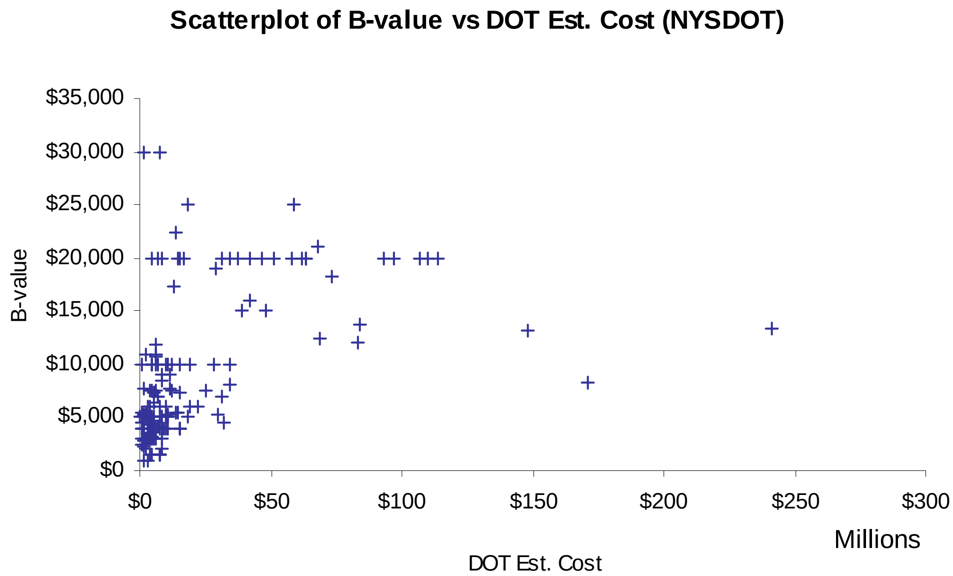

Figure 5. Scatterplot of B-value versus DOT Engineer's cost estimate for NYSDOT A+B data.

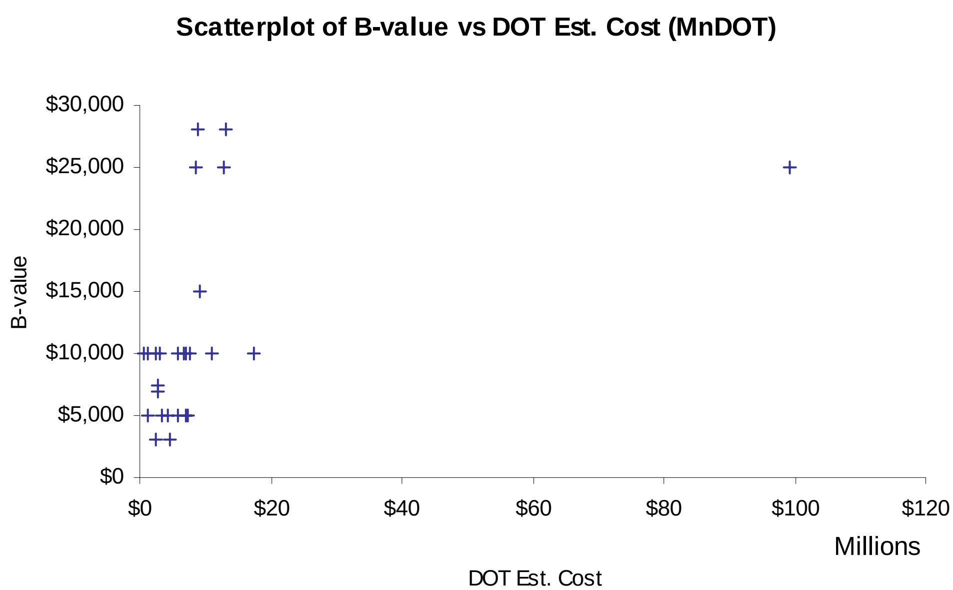

Figure 6. Scatterplot of B-value versus DOT Engineer's cost estimate for MnDOT A+B data.

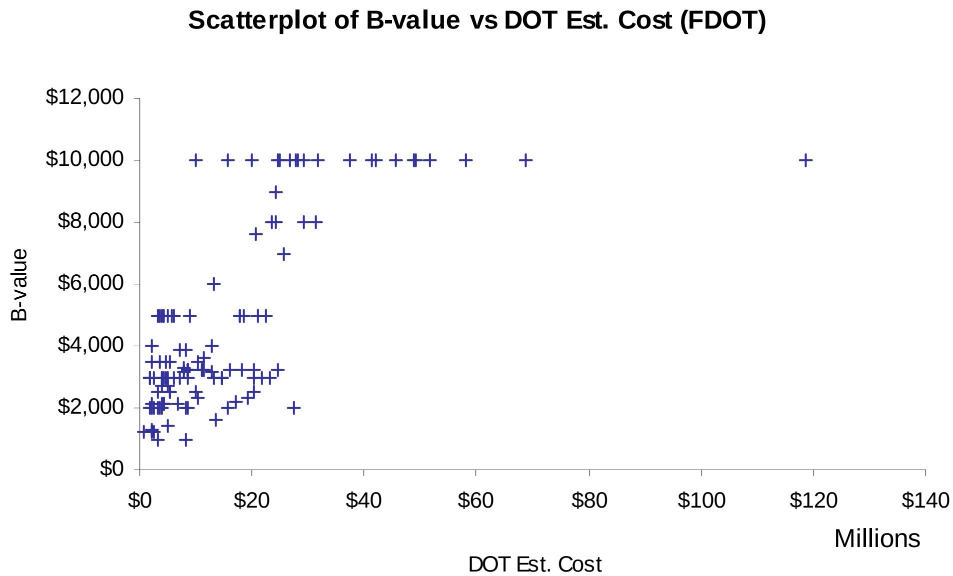

Figure 7. Scatterplot of B-value versus DOT Engineer's cost estimate for FDOT A+B data.

Table 18. Summary statistics of A+B data used for analysis.

Agency	Number of Projects	DOT Engineer's Cost Estimate			B-value		
		Average	Minimum	Maximum	Average	Minimum	Maximum
NYSDOT	154	$20,571,633	$299,418	$241,261,105	$8,888	$1,000	$30,000
MnDOT	26	$9,848,812	$618,947	$99,154,100	$11,408	$3,000	$28,000
FDOT	115	$15,315,017	$849,246	$118,731,868	$4,554	$1,000	$10,000

PERCEPTIONS ABOUT INCENTIVE CONTRACTS

Arditi and Yasamis (1998) studied whether there exists an agreement or disagreement between the Illinois DOT's and the contractors' perceptions of I/D contract provisions using a survey conducted on a sample of I/D contract projects in Illinois highway construction. A survey on the objectives of I/D contracts was given to both ILDOT engineers and contractors. Resident engineers indicated that schedule was the most important objective and quality, safety, and cost were next. However, contractors indicated that cost was the most important target followed by safety, quality, and schedule. Consequently, as shown in Table 19, the contractors' perceptions about I/D contracts were quite different from the agency's.

Another question asked the reasons for including I/D provisions in contracts. Most respondents indicated that the main reasons were that the projects involved high-volume roads, high visibility, high road-user delay costs, major reconstruction of an existing highway, benefits in terms of cost savings and/or safety, and the prolonged closure of one or more highway lanes (Arditi and Yasamis 1998).

Table 19. I/D object ranking.

Superintendent's Objective	Ranking Score	Ranking*	Resident Engineer's Objective	Ranking Score
Cost	2.11	1	Schedule	2.14
Safety	2.44	2	Quality	2.36
Quality	2.67	3	Safety	3.07
Schedule	2.73	4	Cost	3.64
Management	4.33	5	Management	4.86
Technology	4.44	6	Technology	4.93

* Ranking 1 is most important. Ranking 6 is least important. (Source: Arditi and Yasamis 1998)

CASE STUDY: USE OF INCENTIVE CONTRACTS IN FLORIDA

In Florida, I/D provisions have been applied alone or with such other contracting methods as A+B, lane rental, no-excuse bonus, liquidated savings, and design/build. I/D contracts were directly applied to approximately 16% of all alternative contracts in the fiscal years between 1996 and 2000. I/D provisions combined with other contracting methods were applied to approximately 60% of all alternative contracts in the same fiscal years.

Florida Administrative Code (FAC 2002) and Sections 337.18(4)(a) and (b), Florida Statutes (FS 2000) give guidelines on determining the incentive amount. To determine the daily incentive amount, the following factors should be considered: (1) maintenance of traffic cost, (2) road user cost, (3) detour impacts on the public, and (4) the cost of construction engineering inspection and administration of the project (FAC 2002). A maximum incentive amount is capped at $10,000 per calendar day by Florida Statutes, except for revenue-producing projects (FS 2000). Recently, the FDOT Office of Quality Initiatives (OQI) eliminated the step guidelines, in Section 14-93.003 (FAC 2002), which placed limitations on the incentive amount and time.

In 1999, the FDOT Office of Quality Initiatives published a report entitled *Alternative Contracting Program Preliminary Evaluation for July 1, 1996 – June 30, 1999* (FDOT 1999). In this report, the OQI performed a cost analysis and a time analysis for 16 completed I/D projects. The report also summarized survey responses from two contractors, three consultants, and eight DOT project engineers. A survey on the impact of I/D contracts on project acceleration indicated that contractors thought I/D contracts reduced project duration, while most consultants did not; the DOT respondents' opinions were divided on this topic. However, the majority of respondents indicated that contractors working on I/D projects were more willing to cooperate in project coordination. Additional questions asked about the impact of I/D contracts on project performance and whether contractors paid more attention to extra quality measurements. The conclusion was that a majority of all respondents stated that project performance was not impacted and additional quality measures were not implemented by contractors during construction (FDOT 1999). Despite the respondents' reservations, 12 out of 16 contractors were awarded incentives, implying that the contractors might be awarded some incentives without doing anything to improve project performance or quality. The message is that I/D contracts should be granted more carefully and separate incentive plans might be necessary for additional quality control.

The OQI stated that the determination of incentives and bonus amounts should be based on the following factors: road user cost, construction engineering and inspection (CEI) costs, and other relevant factors, such as business impacts, importance to the public, etc. It should also be based on recommended guidelines for the formula to determine bonus amounts ranging from 2% to 10% of project costs (FDOT 2000).

The Florida Office of the Inspector General (OIG) interviewed district construction staff to determine how districts calculated incentive amounts, lane user costs, bonus amounts, and construction time (FDOT 2000). They reported that there is no standard formula for calculating incentives available for use by the districts and also noted that the sample of incentive amounts ranged from 2.9% ($8,000) to 13.1% ($475,000) of the awarded contract amount. In addition, the following interview responses from district construction staff state how incentives were set (FDOT 2000): (1) ad hoc process, generally 2% to 5% of construction costs; (2) liquidated damages multiplied by the number of estimated early completion days; (3) based on CEI and user delay costs; (4) based on gut feelings; (5) based on road user costs + CEI costs; (6) within 5% of the construction costs, some as much as 7 percent; and (7) nothing in writing regarding formulas.

According to an investigation by the OIG, alternative contracting methods realized distinct time and cost advantages over the conventional contracting method. However, completion time on all incentive contracts was not reduced because the contractor completed the original work by the bonus date, but did not complete the additional work within the original time allowed.

RECOMMENDED CRITERIA FOR ESTABLISHING INCENTIVE VALUES

Based upon a review of SHA procedures and discussions with project managers, the authors recommend the following approach to setting incentive values.

Step 1: Determine the maximum incentive available for the project. Incentives are typically limited by funding availability. Incentives cannot be offered unless the funds are available to the project. Most SHAs limit incentives to a maximum of 5% of the contract amount.

Step 2: Calculate the project liquidated damages and daily direct administrative cost for the project. Note that road user cost can also be estimated. However, many SHAs find that these costs usually are extremely high and far exceed their incentive funding limits. As a practical matter most use LDs and administrative cost as an incentive benchmark.

Step 3: Estimate the normal time required for construction. Performance acceleration of 20% to 40% over normal work time is achievable under an incentive contract plan. Determine the maximum amount of time reduction reasonably possible.

Step 4: Determine the daily incentive value available. Compare the available incentive daily value to the daily project cost value.

Step 5: Daily incentive values between $1,000 and $3,000 appear to provide adequate motivation to the contractors. Values below $1,000 are considered by contractors to be not worth the effort. Values above $5,000 are considered by SHAs to be more than necessary.

EXAMPLE INCENTIVE DETERMINATION

The project consists of a bridge deck replacement on a major roadway. Given the high traffic volume and possible construction congestion, the SHA is considering using an incentive contract. The engineer's estimated cost for the project is $2,290,120 and the estimated construction time is 200 days.

Step 1: Determine Available Incentive Funding

The maximum incentive funding available to the project is $120,000.

Step 2: Calculate the Estimated Daily Project Cost

Liquidated Damages = $1,288 per day.
Construction Engineering and Inspection = $1,916 per day.
RUC = $22,916 per day.

Step 3: Determine the Reasonable Time Savings

Estimated Savings = 200 days x 0.30 = 60 days.

Step 4: Determine Daily Incentive Value

Maximum available = 120,000/60 = $2,000.
Estimated Daily Cost = Direct > $1,916, RUC = $22,916.

Step 5: Determine Incentive Value

Set incentive daily value at $1,500 with a maximum amount of $120,000.
Choosing a somewhat lower value provides the opportunity to achieve more than the projected 60-day time improvement.

9. CONCLUSIONS

Based on this research, it was concluded that most states have rather weak processes in place for minimizing time performance of designers and construction contractors. Only the punitive measures of liquidated damages are widely used. On some high-profile projects, one may see the design-build concept used; a number of states have experimented with A+B bidding; and in some states there is widespread use of bonuses, incentives, and disincentives. But nowhere is there an organized, systematic effort to identify time-sensitive projects and ensure they are completed on time.

Some specific conclusions are outlined below.

1. The authority of the awarding agency was reviewed. It was concluded that administrators have broad discretionary powers that will not be overturned by the judiciary so long as there is no favoritism, fraud, or other form of impropriety.

2. Except for a few large, high-profile projects, most states do not differentiate projects according to time sensitivity. All projects are treated alike.

3. A certificate program based on time sensitivity is proposed. For contractors to qualify, they would need to have completed a minimum of three projects on time within the last 3 to 5 years. Only certified contractors would be qualified to do time-sensitive projects. Late completion of a time-sensitive project would jeopardize a contractor's certificate.

4. A database from one state showed that if the recommendations presented herein were implemented, there would still be a large pool of contractors eligible to bid.

5. The more criteria used in an evaluation, the less weight is given to each criterion. While almost all states rate the contractor's time performance, it is given little weight because of the structure of the evaluation. Thus, time is no more important than any other criterion. A certificate program based on time would cure this deficiency.

6. No legal or practical barriers were identified to prevent the application of a certificate program. Good performing contractors like the concept.

7. The qualification practices for designers/consultants were found to be weak, as they relate to timely completion of projects. The evaluation of time, while combined with numerous other criteria, is generally based on the timely delivery of the design, not the project. Further, many evaluations are done before construction begins. Thus, designers are usually not rated on their contribution to the design-construct team. The report proposes that the designer be evaluated on the delivery of the project, not the delivery of the design. No legal or practical barriers were identified to preclude this from happening.

8. SUE is not routinely used except in a few states, notably Virginia, Georgia, and Texas. Cost savings vary widely, as would be expected, but seem to be in the average range of 10-15%. While there is no single technique that will work all the time, the more important consideration seems to be when the data are collected and how they are used, rather than the technique. The research found that the data were often collected after the design was complete, and sometimes not shared with the designer. Thus, one of the significant benefits of SUE, avoiding utility conflicts, was not being fully realized. The research recommended that SUE data be provided in 2-D or 3-D CAD format to the designer in the early design phase. The framework of a utility management system was proposed.

9. The A+B bidding scheme is widely used, but practices vary widely. The most common practice is for the B-value to be equal to the liquidated damage amount. This report recommends a procedure for establishing incentive values.

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APPENDIX A

IMPLEMENTING A+B PROJECTS (MnDOT 2005)

Step 1: Is My Project a Good Candidate for A+B?

YES	NO	
		RIGHT OF WAY
☐	☐	Will all right-of-way be secured prior to letting date?
☐	☐	If not, do the staging plans allow the contractor to sequence work around the conflicts and is a right-of-way time determination schedule in the special provisions?
		PLANS
☐	☐	Is there high confidence in the design?
☐	☐	Has a thorough field review been conducted?
☐	☐	Has design coordinated with construction at various stages (e.g. 30%, 90%)?
☐	☐	Has a constructability and bid-ability review been conducted by design and construction?
		UTILITIES
☐	☐	There is ***little or no chance*** that utilities will significantly delay the contractor.
☐	☐	Are utility conflicts clearly identified in the plan and special provisions?
		THIRD-PARTY AGREEMENTS
☐	☐	Will all permits be secured by the letting date?
☐	☐	Will all municipal agreements be secured by the letting date?
		PROGRAM IMPACTS
☐	☐	Have you considered the district wide impacts of using an accelerated schedule? Have you considered the potential cost and delivery to other projects?
		SOIL CONDITIONS
☐	☐	There is ***little*** risk of contaminated or poor soils adding significant extra work.

☐	☐	**TRAFFIC CONDITIONS** Do construction traffic impacts relate to any of the following conditions? • Lengthy detours • Significant delays to motorists • Significant impacts to businesses, schools, or emergency services
☐ ☐	☐ ☐	**STAFFING CONSIDERATIONS** Do you have the staff available if the contractor has an aggressive schedule? Do you have the budget for any additional overtime?

If the answer is **YES** to most of the above questions, the project may be suitable for A+B. If you answered **NO** to some of the questions, your project may still be a good candidate for A+B, but give careful consideration to the items with a **NO** response.

Step 2: Determine How to Use A+B

A+B techniques can be applied to many aspects of a project. Determine how you can best use A+B on your project.

☐ *Entire contract length*

☐ *Intermediate dates*
- Detour duration
- Interchange closure period
- Lane closure timeframe
- Stages

☐ *Multiple timeframes (A+B+C)*

☐ *Any other project aspect*

Step 3: Determine Road User Costs

☐ Obtain Road-User Costs (RUC) from Mn/DOT's Office of Investment Management (OIM). The contact is Ed Idzorek (651) 205-4391.

☐ Project engineer/supervisor needs to weigh how the RUC may affect the bid to determine the appropriate balance between the 'A' and 'B' portions of the bid. Adjust the RUC if necessary.

> ***Example:*** RUC calculated by OIM = $75,000 per day
>
> Bidder #1: $1,000,000 at 50 Days (A+B = $4,750,000)
> Bidder #2: $1,500,000 at 40 Days (A+B = $4,500,000) – Awarded Contract
>
> **Question:** Are you willing to spend an extra 50 percent to complete the project 10 days early? Adjusting the RUC may minimize this effect.

Step 4: Determine Contract Time

☐ Perform a constructability review on the plan set.

☐ Assess the time, manpower and equipment impacts to other projects in the area.

☐ Determine the Contract Type
- Working Days (recommended for projects <100 working days)
- Calendar Days (recommended on multi-year projects)
- If using a CPM schedule, use Calendar Days.

☐ Determine the amount of contract time and any intermediate dates. Use this as the maximum amount of time Mn/DOT would allow.

> ***Note:*** If you calculate an overly aggressive schedule, you might not see a significant reduction in the days bid, or you may see an increase in the $ portion.

Step 5: Determine Incentives and Disincentives

Incentives (Optional)

☐ Do I want to include an incentive? Check with management.
☐ Determine incentive amount
- Often equal or less than RUC
- Incentive should be capped by the days and/or dollar amount)
- Total incentive < 5 percent of the engineers estimate

Disincentives

☐ Recommended for all projects
☐ Determine disincentive amount
- No limit is recommended
- Often equal to RUC
- Should not exceed RUC

> ***Note:*** Assess the feasibility of assessing a disincentive with a high value. The disincentive can be a different amount than the RUC to determine the bid.

Step 6: Draft Special Provisions

☐ Use standard template on the Innovative Contracting Website:

http://www.dot.state.mn.us/const/tools/innovativecontract.html

☐ Inform the design squad so that contract time can be added as a bid item.
☐ Special Provisions 1806 & 1807 must be clear and concise.

> ***Note:*** Clarify in specification 1807 if the dis-incentive is in lieu of liquidated damages, or if it will be assessed in addition to liquidated damages.

Step 7: Construction Considerations

- ☐ Consider using a CPM Schedule to help administer contract time.
- ☐ Prepare staff for aggressive contractor schedules.
- ☐ Obtain frequent schedules updates if needed.
- ☐ Resolve issues proactively to reduce owner delayed time.
- ☐ Minor work orders, supplemental agreements and change orders need to be processed in a timely manner.
- ☐ Minor work orders, supplemental agreements and change orders need to be address contract time extensions/reductions.
- ☐ Work with the contractor to revise the schedule if plan additions occur
- ☐ Consider safety impacts to the roadway user, contractor personnel and Mn/DOT staff during construction. Consider impact to clear zones during construction, drop-off requirements, and lane-closure requirements.