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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 652

Time-Related Incentive and Disincentive Provisions in Highway Construction Contracts

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Research sponsored by the American Association of State Highway and Transportation Officials
in cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2010
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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NCHRP REPORT 652

Project 10-58(01)
ISSN 0077-5614
ISBN 978-0-309-15478-9
Library of Congress Control Number 2010929164

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

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Printed in the United States of America

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AUTHOR ACKNOWLEDGMENTS

This report is the product of research conducted under NCHRP Project 10-58(01) "Time-Related Incentive and Disincentive Provisions in Highway Construction Contracts." Gary Fick, Vice-President of Trinity Construction Management Services, Inc., served as the Principal Investigator and primary author of the report. Other individuals contributing to the research project include Tom Cackler, Consultant; Steve Trost, President, Strategic Solutions International, LLC; and Lee Vanzler, Consultant.

The research team would like to acknowledge the participation and cooperation of six state departments of transportation (DOTs) that contributed greatly to the research effort. Their assistance was critical to the success of the research project: California Department of Transportation (Caltrans), Florida Department of Transportation (FDOT), New York State Department of Transportation (NYSDOT), Ohio Department of Transportation (Ohio DOT), Oklahoma Department of Transportation (Oklahoma DOT) and Utah Department of Transportation (UDOT).

Along with these agencies, thanks are extended to 12 contractors who provided the research team with input and feedback regarding the impact of incentive/disincentive (I/D) provisions on their operations. The contractors were solicited to participate with the promise of anonymity to ensure unbiased feedback.

Finally, the research team wishes to express gratitude to the NCHRP staff and the NCHRP Project 10-58(01) panel.

FOREWORD

By David A. Reynaud
Staff Officer
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This report will be of interest to state and local highway agency construction managers and contractors with regard to learning about best practices of time-related incentive and disincentive contract provisions and their effect on staffing levels, productivity, project cost, quality, contract administration, and the contractor's operations and innovations. The report also presents a decision process guide to use as a template for crafting the incentive/disincentive provisions.

Transportation agencies are under increasing pressure to reduce the duration of highway construction projects. This pressure stems from the desire to reduce traffic delays and other inconveniences to the traveling public. To reduce the duration of construction projects, many agencies have turned to the use of time-related incentive and disincentive contract provisions. There is a need to better understand the use of these provisions in highway construction contracts, including the type of contract provisions, the extent to which they are used, their record of success, the criteria used to determine when they are appropriate, the most appropriate provisions to select, the methods used to determine the dollar amount of these contract provisions, and their effects on the quality of the constructed project.

Under NCHRP Project 10-58(01), Trinity Construction Management Services, Inc. developed recommendations for effective use of time-related incentive and disincentive provisions in highway construction contracts. The researchers reviewed domestic and international literature and collected information from highway agencies and construction contractors on the use and effectiveness of these provisions. After analyzing the effectiveness of these provisions, encountering both effective and ineffective applications, the researchers identified and quantified, where possible, the impacts of these provisions on both highway agencies and contractors' staffing levels, productivity, project cost, quality, contract administration, and contractor operations and innovations. The researchers created a decision process guide for determining the most suitable type of incentive or disincentive contract provision, and for determining the dollar amount to be applied to these provisions and the conditions under which they are the most appropriate. The report also identifies best practices for mitigating negative impact of these contract provisions.

CONTENTS

SUMMARY

Time-Related Incentive and Disincentive Provisions in Highway Construction Contracts

Time-related incentive and disincentive (I/D) provisions have been widely used by U.S. STAs. The vast majority of these provisions have been successful at accelerating highway construction work, resulting in reduced delays to the traveling public. This project's focus was to identify STAs that have had extensive experience with time-related I/D projects and identify best practices and lessons learned that will lead to the effective use of time-related I/D provisions.

Besides reducing road user delays, time-related I/D provisions have other impacts on the STAs and contractors involved with the projects. The impacts of I/D provisions on the following project factors were investigated:

- Cost
- Innovation
- Contract Administration
- Staffing
- Quality
- Safety

The following statements provide a concise summary of the impact of time-related I/D provisions on each of the project factors investigated:

- Cost—Accelerating construction to achieve earlier completion leads to increased costs. The degree of cost increase depends on many factors. However, market influences from the low bid system used by STAs are a primary contributor to the ultimate cost of the acceleration paid by the STAs. Thus, the price paid for acceleration required by I/D provisions is highly influenced by the competitive bidding process. In most cases, this works to the STAs advantage.
- Innovation—I/D provisions motivate contractors to use innovative methods and materials that result in time savings. Incentives for early completion provide the means for contractors to recoup the additional costs associated with these innovative methods and materials.
- Contract Administration—Offering a monetary incentive and disincentive for early or late completion places an emphasis on how contract time is measured. Equally important is an equitable process to determine the time impact of excusable delays. The effectiveness of I/D provisions is quickly eroded by ambiguities in the time measurement process and by the occurrence of excusable delays.
- Staffing—Accelerated work schedules are often accompanied by an increase in number of working hours per week. This increase affects the contractors and STAs personnel equally. Both contractors and STAs acknowledge the "burn out" impact created by I/D provisions on their human resources. However, none of the STAs and contractors investigated was able to offer any strategies to mitigate this impact.

- Quality—Research results did not indicate that time-related I/Ds have a negative impact on quality.
- Safety—Contractors and STAs both indicated that safety practices are unaffected by accelerated work schedules. The safety risk to the public from traveling through construction zones decreases as a result of the shortened time of exposure.

Understanding the impacts of time-related I/D provisions on project factors leads to guidelines for the effective use of I/Ds. A list of these guidelines for the effective use of I/D provisions includes the following:

- Projects that may be candidates for the inclusion of an I/D provision should be identified early in the project development process. Considering I/D impacts throughout the design process will result in plans and specifications that are well coordinated with I/D milestones.
- When a competitive bidding market exists, STAs should consider A+B I/D provisions as the preferred method for obtaining accelerated construction at the lowest cost.
- Increase the pool of available bidders by allowing flexibility between the bid award and start of construction.
- Incentives should be capped as a method to reduce the STA's risk of overpaying for acceleration.
- Measurement of contract time should be based on calendar days as opposed to working days or modified calendar days.
- Incentive rates should use road user cost (RUC) as the basis. Estimates of RUC should be the result of a documented and uniformly applied process.

Improving the state-of-practice for time-related I/D provisions through the implementation of the research findings and proposed guidelines will provide the traveling public with increased value.

TERMS

Many different types of time-related I/D provisions are in use or have been used by state transportation agencies (STAs). At the most basic level, I/D provisions can be categorized into two groups: A+B and I/D. The primary distinction between these two types is that the contractor determines the contract duration for an A+B contract while the STA specifies the contract time for an I/D contract. There are many variations and local modifications on these two basic provisions with state and local laws often impacting the details of time-related provisions. These variations can be confusing because STAs use similar I/D provisions that have different names.

One common factor shared by every STA is the use of liquidated damages. The U.S. Code of Federal Regulations (23 CFR 635.127) requires STAs to establish liquidated damages that, at a minimum, recover the STAs estimated daily construction engineering costs for overruns in contract time. All I/D provisions are used in conjunction with liquidated damages, meaning that the disincentive portion of an I/D provision consists of more than just the minimum agreed to daily engineering construction costs that will be recovered in the case of late completion of a milestone or project. RUC is the most common item included in both the incentive and disincentive rate for a highway project.

Technically, there is not a difference between a disincentive and liquidated damages. They are both contractual provisions in which both parties agree to the payment of a monetary sum that is estimated fairly and would prove to be difficult or impossible to quantify after the fact (*1*). However, in practice, there is a considerable difference between liquidated damages and disincentives because the addition of RUC significantly increases the agreed to monetary

sum that is applied for late completion. For clarity, the guidance contained in this report makes the assumption that liquidated damages are based solely on the recovery of STA daily construction engineering costs and are dealt with independently of I/D provisions that include RUC.

Definitions of I/D Types

Because there is such a diversity of I/D provisions and names found in use at STAs, the following I/D types are defined for the purpose of establishing a common reference for users of this report. In practice, these I/D types are frequently used in combination and often modified to conform with local practices and local statutes.

I/D (calendar or working day)

Contractors are motivated to complete a project and critical items of work (milestones) within the number of days determined by the contracting agency through an addition to the contract amount for early completion or a deduction for late completion (*2*). Calculation of the final incentive or disincentive is the product of a daily rate established by the contracting agency multiplied by the number of days of early or late completion.

Calendar Day. Every day listed on the calendar, regardless of whether work is accomplished or allowed by other specifications.

Working Day. Any day on which work is planned and could be performed; weekends and holidays are frequently omitted from a working day contract.

I/D (complete-by-date)

The contracting agency establishes a fixed date for completion and a calculation of the incentive or disincentive.

Cost Plus Time Bidding (Generic A+B)

Determination of the low (successful) bidder is based on the sum of cost (A) and time (B).

A Portion = Traditional contract cost; the sum of unit prices multiplied by contract quantities (*3*).
B Portion = Time bid; the product of number of days determined by the contractor multiplied by the daily rate determined by the contracting agency (*4*).

A+B without I/D

The bidder determines the contract duration (B). Contract award is made to the bidder that has the lowest combined total of cost (A) and time (B). However, no incentive is offered for early completion, nor is any disincentive assessed for late completion other than normally specified liquidated damages. Standard specifications are applicable for determining actual contract time used.

A+B with I/D

Contract duration is determined by the bidder. Award is made to the bidder that has the lowest combined total of cost (A) and time (B). Incentive is paid for early completion or

disincentive is charged for late completion. Actual contract time may be determined by standard specification or by other methods according to special provision(s) of the contract.

A+B$_1$+B$_2$+B$_n$

Multiple time values (B_1, B_2, B_n) represent critical milestones for which the bidder determines the contract duration and the agency determines the daily rate that is applicable to each milestone. Individual incentives or disincentives are applied to the actual completion of milestones.

Lane Rental

Charges for closing a lane to traffic during construction are established by the contracting agency. These charges are based on a rate of dollars per day, dollars per hour or dollars per fraction of an hour (*3*). Bidders determine the amount of lane rental (lane closure duration x closure rate) needed for completion of the project. In the case where the cost of lane rental is included in other items of work, the contractor is paid for the estimated lane rental and then actual lane rental is deducted from contract revenues, resulting in an incentive or disincentive for completing the project within the estimated lane rental. When lane rental is included as a contract pay item, any underrun in the total lane rental incurred may or may not be paid to the contractor depending on the specification language.

Glossary

AADT: Average annual daily traffic
Contract Item (Pay Item): A specifically described unit of work for which a price (either unit or lump sum) is provided in the contract
Contract Time: The total time (calendar days, working days, or completion date) established to complete the project
CPM: Critical path method of scheduling
RUC (road user cost): The average daily cost to the road user

CHAPTER 1

Project Background, Objectives, and Research Approach

Problem Statement

STAs are under increasing pressure to reduce the duration of highway construction projects. This pressure stems from the desire to reduce traffic delays and other inconveniences to the traveling public. To reduce the duration of construction projects, many STAs use time-related I/D contract provisions. There is a need to better understand the use of time-related I/Ds in highway construction contracts. The following issues were addressed in this project:

- The type of time-related I/D contract provisions used in highway construction contracts and the extent to which they are used.
- The success of time-related I/D contract provisions.
- Criteria used to determine when time-related I/D contract provisions are appropriate and criteria to select the most appropriate provisions.
- Methods used to determine the dollar amount of the time-related I/Ds.
- The effects of time-related I/Ds on projects.

Research Objective

The objective of this research was to develop recommendations for the effective use of time-related I/D provisions in highway construction contracts.

Research Approach

The initial step of this research effort was a comprehensive review of published literature related to the use of time-related I/D provisions. More than 375 articles, research reports, and other publications related to time-based I/D contract provisions were identified. After a thorough review, 164 published documents were deemed pertinent to this research. A bibliography containing most of these documents is included as Appendix A for individuals and agencies needing an in-depth perspective on incentive-based contracting methods that goes beyond the scope of this research.

Next, information on the use of time-related I/D provisions was sought from 50 U.S. STAs, the District of Columbia, and Canadian provinces. This effort involved an initial telephone call to identify the appropriate contact in each STA. This call was followed by an e-mail that provided the STA contacts with a brief overview of the research project.

The final step for the STA information and data collection task was prepared by the research team as follows:

- Develop an e-mail interview form to address the project team's questions about the use of time-related I/D provisions by STAs.
- Meet with the Oklahoma DOT to review the draft e-mail interview form for clarity and applicability to STA personnel who would be responding to the request for information.
- Revise the e-mail interview form based on feedback from Oklahoma DOT.
- Beta test the e-mail interview form with Oklahoma DOT.
- Telephone all the STA contacts and follow up with the e-mail containing the interview form.

This step of the research yielded 32 completed interview forms (Figure 1).

Multiple criteria were used to identify the key sources of information to target for the in-depth follow-up investigations. First was the level of experience that the STAs had with time-related I/D provisions. This level was determined using the responses to the e-mail interview form (each STA provided the number of I/D projects over the last 2 fiscal years) (Figure 2).

The STAs were grouped by level of experience (Table 1).

Results of the literature search were also used as a factor to determine which states would be chosen for in-depth investigations. Florida, Ohio, and New York had published

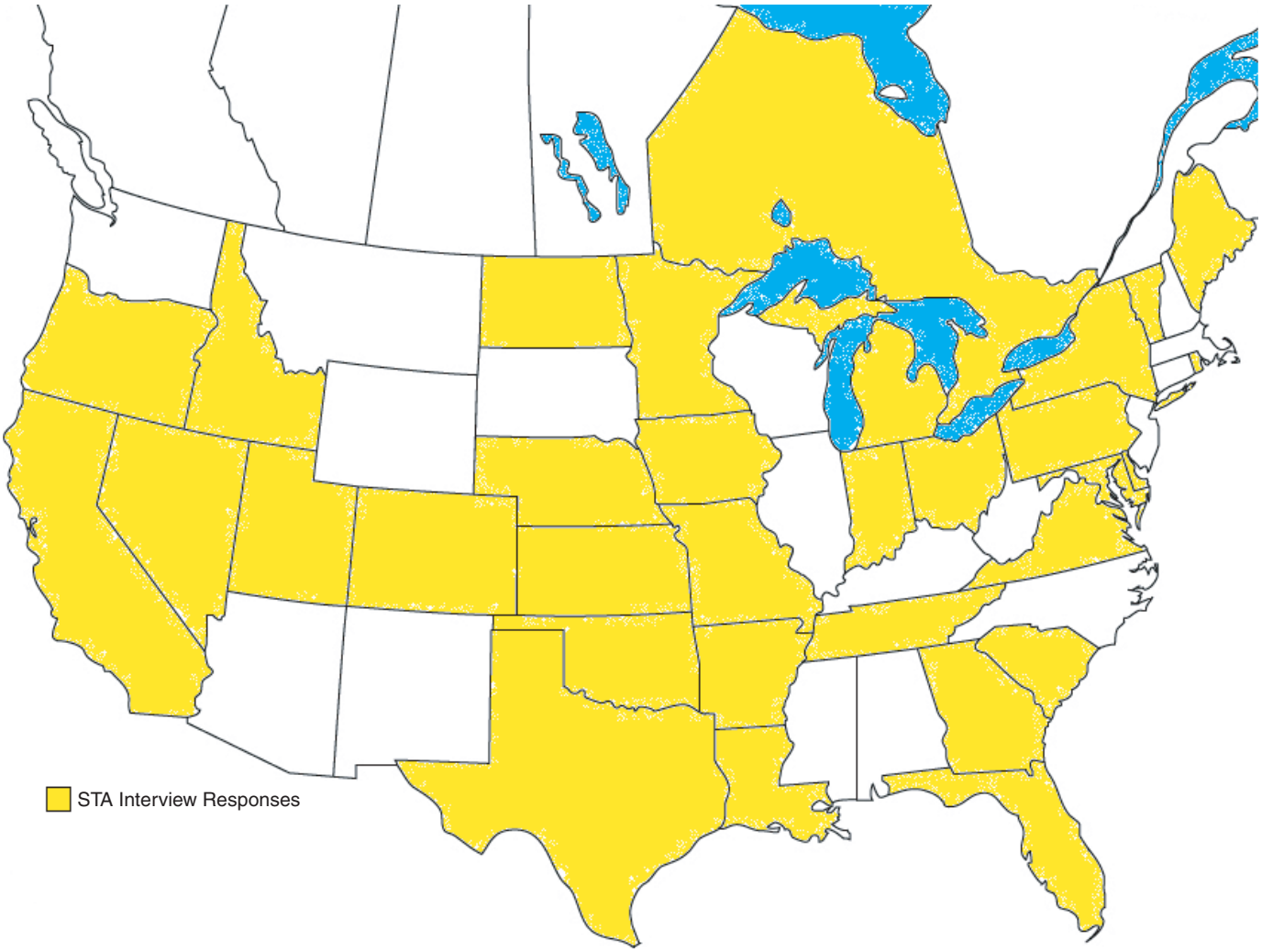

Figure 1. Province and states responding to the time-related I/D e-mail interview.

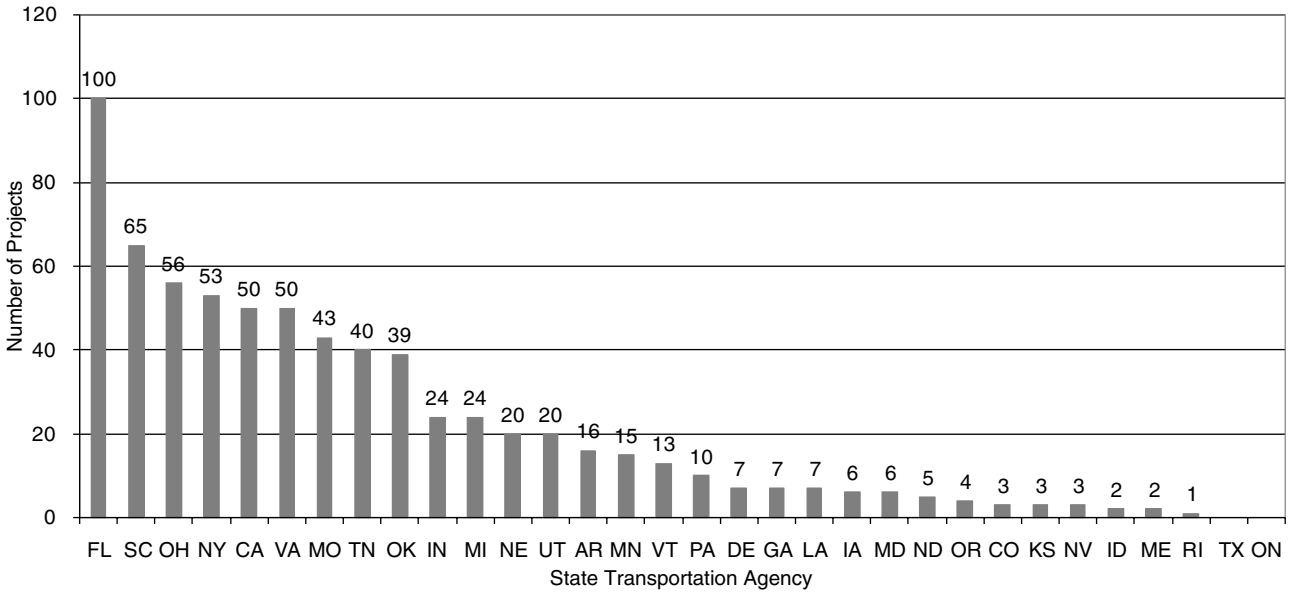

Figure 2. Number of I/D projects by STA (last 2 fiscal years).

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Table 1. I/D experience level by group.

Experience Level Number of I/D Projects (last 2 fiscal years)	States
60 to 100	FL & SC
40 to 60	OH, NY, CA, VA, MO & TN
20 to 40	OK, IN, MI, NE & UT

in-house documentation and guidance on their use of time-related I/D provisions (*5, 6, 7,* respectively). This weighed heavily for their inclusion as interviewees for the in-depth investigations. The fact that each of these STAs had established guidance about their use of I/D provisions could mean that these STAs had recent experiences or insight valuable to the results of this project. There were also numerous published articles on California's use of time-related I/D provisions (*8, 9, 10, 11*). Again, it was evident from these documents that California had been through a fairly thorough self examination on the use of time-related I/D provisions. Florida, Ohio, New York, and California were chosen for in-depth investigations based on their level of experience with I/D provisions and existing documentation of their practices.

Oklahoma and Utah were the final two states chosen for in-depth interviews. Oklahoma was included because its experience level was consistent with the goal of having diversity within the in-depth group. But the primary factor that led to Oklahoma's inclusion was its willingness to provide feedback and assist in the development of the in-depth investigation materials. Its cooperation assisted dramatically in the development of in-depth investigation techniques used for the remaining STAs. Finally, Utah was included based on the goal of having diverse experience levels and geographical and climatological diversity in the follow-up investigation task (Table 2).

Time-related I/D information was gathered from contractors in the six states corresponding to the STA in-depth interviews. The research team believed a blanket solicitation for information to contractors across the country would be unproductive and would likely yield biased responses. It was determined that on-site interviews with contractors would be coordinated with the STA in-depth investigations. Matching contractor experiences and perspectives about time-related I/D provisions with the STA in-depth investigations would provide an avenue to compare and contrast contractor and STA experiences on the same project or similar projects under the same I/D provision.

Based on responses to the e-mail interview form, it was evident that the opportunities to obtain meaningful quantitative data such as project duration, relative cost comparisons, I/Ds paid or charged from the STAs would be limited. A review of the documents obtained in the literature search provided access to limited quantitative analyses. It was also known that a few of the STAs were tracking time-related I/D metrics. Therefore, the research team decided to execute the in-depth follow-up investigations with the following strategy:

- In-depth interviews would be conducted with three distinct groups in each state (1) STA headquarters staff, (2) STA field office staff, and (3) a contractor recommended by the STA.
- Each group would be interviewed separately to avoid withholding information as a result of a perceived influence from superiors or the perception that an agency-contractor relationship could be negatively impacted.
- For each interview group, a standard form was completed by each participant. These forms were developed so the "experts" could rank/rate their perceptions about time-related I/D provisions and their impacts on quality, cost, safety, innovation, contract administration, and staffing. The results of these ranking forms provided the opportunity to compare and contrast the impacts of I/D provisions between the groups.
- Interview participants were allowed to offer detailed answers during a question and answer (Q&A) session. Each Q&A session was initially guided by a standard list of questions that generated discussion among the participants. The goals of the Q&A session were to
  - Obtain an understanding of how I/D provisions are used by a specific STA.
  - Offer the experts an opportunity to relate their experiences with I/D provisions.
  - Gather more detailed information about responses to the ranking form.
  - Anecdotally document "lessons learned" on I/D projects.
  - Capture best practices related to the use of time-related I/D provisions.

Table 2. SHRP-LTPP environmental zones and in-depth investigation states.

SHRP-LTPP Environmental Zone	In-Depth Investigation States
Wet-Freeze	Ohio and New York
Wet-Nonfreeze	California, Florida and Oklahoma
Dry-Freeze	California and Utah
Dry-Nonfreeze	California and Oklahoma

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– Request copies of current I/D provisions used by the STA, quantitative measures that the STA uses for tracking time-related I/D projects, and internal unpublished reports related to time-related I/D projects.

During Phase I, contractors from the six states were interviewed about I/D impacts. Although a great deal of beneficial information was gathered during those interviews, there is such a diversity in the way that time-related I/D provisions are implemented by STAs that it was difficult to compile a consensus of time-related I/D impacts from the contractors' perspective. Because of this limitation, the research team received direction from the NCHRP Project 10-58(01) panel during Phase II. The panel's request was to better capture contractor perspective on time-related I/D provisions. To do so, the research team decided that a different approach would be most effective. Thus, a position paper was prepared that synthesized the contractor research results from Phase I with the research team members' knowledge of I/D impacts on the highway contracting industry. This position paper allowed contractors to provide anonymous feedback on how accurately the position paper captured the contractors' perspective on I/D impacts. Issues related to innovation, cost, market factors, risk allocation, and safety were presented in the position paper. Eight contractors were solicited to provide feedback on the position paper. Five responses were obtained from different contractors than those used for the Phase I contractor research. The overall level of agreement with the research team's attempt to capture contractor perspectives was excellent (Figure 3).

Use of I/D Provisions by State Transportation Agencies

A list of STAs that currently use or have used time-related I/D provisions is shown in Table 3. Along with the 32 STAs that responded to the e-mail interview, additional sources were reviewed to complete this list. All practical means were used to make this list comprehensive; however, it is possible that some STAs have used I/D provisions that were not discovered in this effort. Connecticut, Massachusetts, New Hampshire, and West Virginia were the only U.S. STAs the research team could not document as using time-related I/D provisions on at least one project.

The following notes provide further insight into STA perceptions about I/D provisions. These notes were either provided by the STA in its response to the e-mail interview or they were transcribed from telephone conversations between STA contacts and a member of the research team.

- Utah—"We have found that time related incentives do not add costs to our project, plus they are a good method of defining a realistic contract time since the contractor is usually involved in deciding how much time he needs to do the work. On the other hand, incentives can increase the "tension" between client and contractor because the contractor is more inclined to try and get every time extension he feels he deserves to protect earning the incentive. This can create conflicts."
- Delaware—"There are problems with time related I/Ds that are done for political reasons, they are counter-productive. Eventually other contractors want to be included. I don't particularly endorse their use unless there are closures or very high AADTs involved. The problem created by these incentives is that it becomes a hassle for the construction administrators. In order for I/Ds to work to everyone's benefit, the plans and specs have to be near perfect."
- Nevada—"In general, I/D provisions have been successful in Nevada. Typically incentives are capped and are less than 3 to 5% of the total project cost. Their use has been limited to critical projects due to impacts on the infrastructure system (high traffic volumes) or critical items (e.g., school openings, impacts to tourist routes, special events, etc.)."

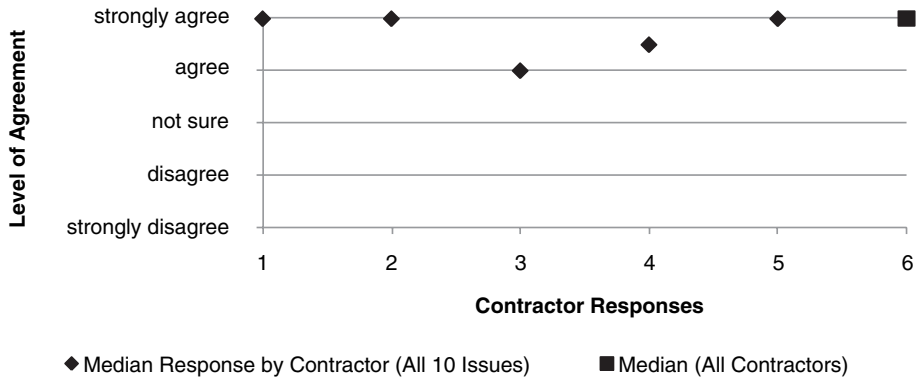

Figure 3. Median contractor response to "Contractor Perspective on Time-Related Incentive and Disincentive Provisions for Highway Construction" prepared by the research team.

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Table 3. States and province with documented use of time-related I/D provisions (June 2007).

State/Province	Source	State/Province	Source
Alabama	internet search	Nebraska	e-mail interview form
Alaska	telephone contact	Nevada	e-mail interview form
Arizona	literature search (*12*)	New Jersey	literature search (*13*)
Arkansas	e-mail interview form	New Mexico	literature search (*13*)
California	e-mail interview form	New York	e-mail interview form
Colorado	e-mail interview form	North Carolina	literature search (*13*)
Delaware	e-mail interview form	North Dakota	e-mail interview form
Florida	e-mail interview form	Ohio	e-mail interview form
Georgia	e-mail interview form	Oklahoma	e-mail interview form
Hawaii	internet search	Oregon	e-mail interview form
Idaho	e-mail interview form	Pennsylvania	e-mail interview form
Illinois	literature search (*13*)	Rhode Island	e-mail interview form
Indiana	e-mail interview form	South Carolina	e-mail interview form
Iowa	e-mail interview form	South Dakota	literature search (*13*)
Kansas	e-mail interview form	Tennessee	e-mail interview form
Kentucky	literature search (*13*)	Texas	e-mail interview form
Louisiana	e-mail interview form	Utah	e-mail interview form
Maine	e-mail interview form	Vermont	e-mail interview form
Maryland	e-mail interview form	Virginia	e-mail interview form
Michigan	e-mail interview form	Washington	literature search (*14*)
Minnesota	e-mail interview form	Wisconsin	literature search (*13*)
Mississippi	literature search (*13*)	Wyoming	literature search (*15*)
Missouri	e-mail interview form	District of Columbia	telephone contact
Montana	internet search	Ontario, Canada	e-mail interview form

- Ontario, Canada—"The Ministry of Transportation of Ontario generally does not use incentive/disincentive for contract completion. Instead we rely almost exclusively on Liquidated Damage provisions both for working day and completion date contracts. However, we do use incentive/disincentive for many interim dates and time constraints, occasionally with multiple incentive/disincentive within the same contract. Example is attached; however we have many for many different situations."
- Kansas—"Don't use incentives much because payment comes out of their general budget."
- Maryland—"Been using for years but often loopholes."

Further details of the findings from this research project are provided throughout the report. Additionally, the I/D discussion and guidelines presented herein are the product of synthesizing information from published literature, research findings, and the researcher team's expertise.

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CHAPTER 2

Discussion of I/D Impacts on Project Factors

Cost

It is assumed that acceleration associated with I/Ds increases project cost. To what degree costs are increased is a function of unique project features and the level of acceleration requested by the STA. The majority of responses to the Phase I e-mail interview form indicate that the STAs perceive the increased cost to be 10% or less. Phase I in-depth ranking forms concur with this perception (Figure 4). On average, interviewees felt that the impact of I/D provisions on costs was neutral. A comparison of A+B projects and non-I/D projects of similar scope in Minnesota showed that the A+B projects had an initial bid price increase of 7.5% when compared with similar non-I/D projects (*16*).

Market Influences

Phase II research results revealed that contractors agreed that under the low bid system used by STAs, influences from market conditions (number of bidders, backlog, and availability of future work) are a primary factor in determining the cost associated with the use of I/D provisions (Figure 5).

Understanding that market conditions influence bid prices as much as or more than acceleration costs has an impact on the effectiveness of I/D provisions. The need for a competitive market environment is especially important for the effective use of I/D provisions. One contractor's comment from the Phase II research effectively captures this point: "*The STA must make the decision about the level of importance or priority for early or accelerated completion of a project, then let the market decide what that priority is worth.*"

Further evidence that market influence can trump acceleration costs comes from two projects bid by the Kansas Department of Transportation (Kansas DOT). These two projects required the bidders to provide an alternate lump sum bid price for accelerating the projects. The base bid for the projects was based on completing the projects in two construction seasons. The additive alternate bid item was designed to capture and compensate the contractor for the acceleration costs associated with completing the projects in one construction season. In both cases, the alternate bid item for acceleration costs did not change the order of the bidders nor does it appear that Kansas DOT was charged a premium for accelerating the projects (Tables 4 and 5).

There is a valid argument that the contractors included an acceleration premium in their base bid because they anticipated Kansas DOT's desire to complete the project in one season and that they did not want to expose their estimated acceleration costs to other competitors. It is the research team's informed opinion that if any of the acceleration costs required to complete these projects in one season was passed on to Kansas DOT, it was minimal. This conclusion is based on the fact that one member of the research team was formerly employed as the chief estimator for one of the unsuccessful bidders on the Harvey County project, and the base bid prices reflected contractor bid prices that were very competitive (acceleration costs were offset by lower profit margins). It should be noted that both projects were completed within one construction season.

These two Kansas DOT examples are presented as an illustration of how market influences often trump acceleration costs. Note that the difference between the low bidder and the average bid on the first project was 12% and was 16% on the second example. Because these projects required the contractors to provide a lump sum bid for acceleration costs, they provide a unique picture of the contractors' approach to acceleration costs that are not visible in the bidding process for other types of I/D projects. In the research team's experience estimating and bidding on over 40 I/D projects, market conditions are the primary influence on the final cost paid by STAs. This applies to all types of I/D projects. STAs must understand that for a given I/D project the cost that they ultimately pay for acceleration and the level of acceleration that they receive is highly dependent upon the market conditions at the time the project is bid. Not only are acceleration costs

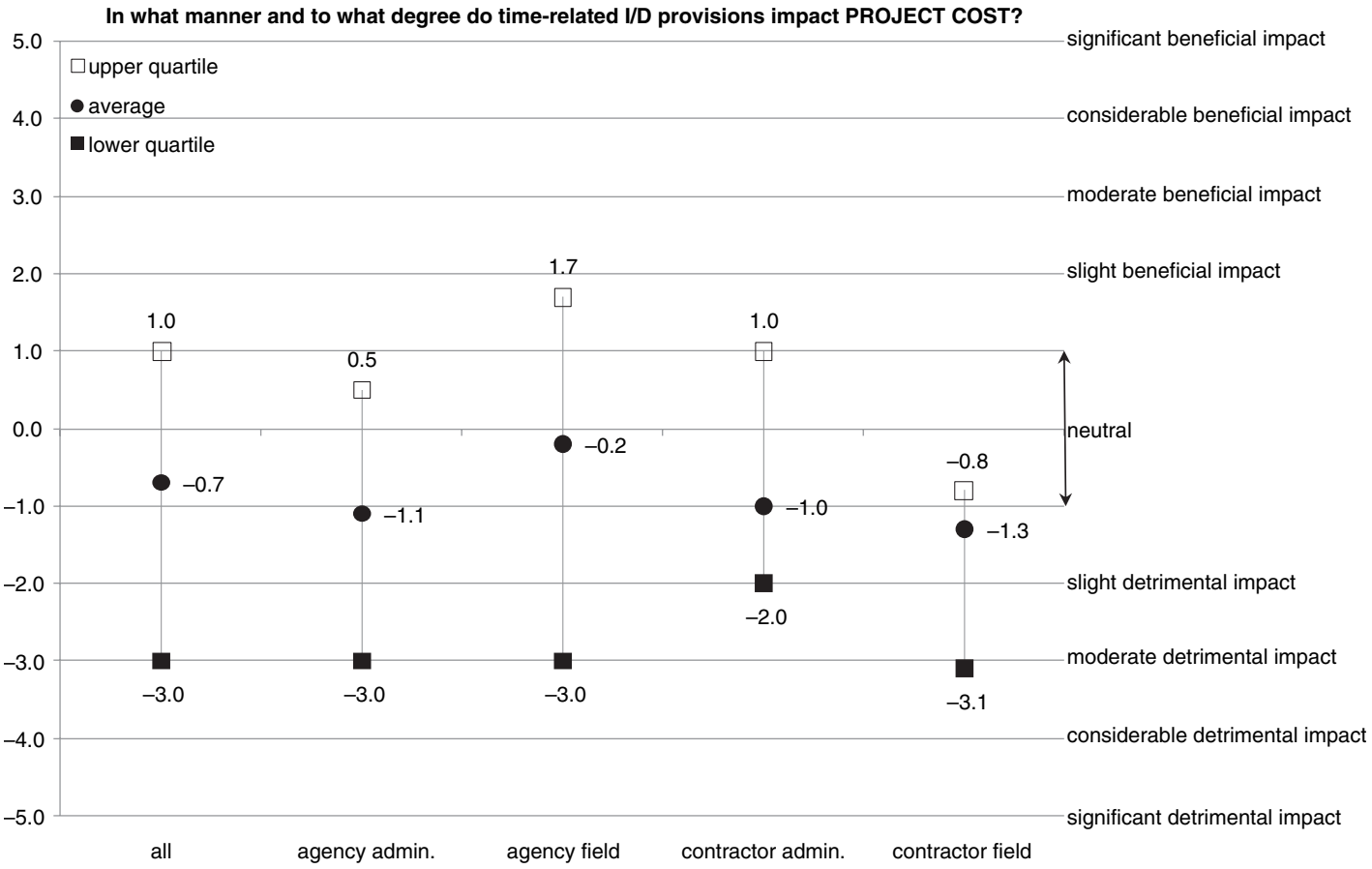

Figure 4. Agency and contractor Phase I on-site interview ranking of I/D impacts on project cost.

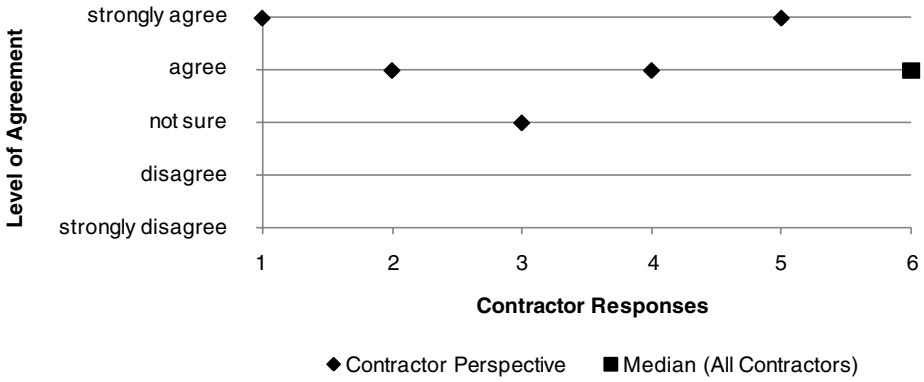

Figure 5. Contractor perspectives on market influences and cost.

Table 4. Kansas DOT Harvey County accelerated bid results (I-135, October 1999).

Bidder	Base Bid: Complete in Two Seasons	Alternate Bid: Acceleration Cost to Complete in One Season	Total Bid to Complete in One Season
Bidder 1	$18,482,549	$1	$18,482,550
Bidder 2	$20,636,141	$812,270	$21,448,411
Bidder 3	$21,035,433	$1,202,000	$22,237,433

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Table 5. Kansas DOT Sedgwick County accelerated bid results (US-54, January 2003).

Bidder	Base Bid: Complete in Two Seasons	Alternate Bid: Acceleration Cost to Complete in One Season	Total Bid to Complete in One Season
Bidder 1	$16,279,056	$0	$16,279,056
Bidder 2	$16,877,890	$5,000	$16,882,890
Bidder 3	$17,962,028	$1,000,000	$18,962,028
Bidder 4	$19,644,504	$1,250,000	$20,894,504
Bidder 5	$20,945,708	$472,271	$21,417,979

unique to each project, they are unique to each contractor as well (Figure 6). The benefit for the STA of competition in the bidding process cannot be over stressed.

Cost Components

Even though market factors are the primary influence on costs associated with the acceleration required by I/D provisions, it is useful for a STA to have a basic understanding of construction cost components and how they are impacted by acceleration. A typical unit price found in a contract for constructing a highway is the sum of four individual unit cost components: materials, labor, equipment, and overhead. Profit is added to the sum of these components. Table 6 contains a simplified list of cost components; from a contractor's perspective, these macro-components are further subdivided into multiple sub-components. Table 6 provides a brief description of acceleration impacts on each of the cost components.

Acceleration impacts on cost will also vary by the type of work. For example, a unit of structural concrete will be impacted to a greater degree than a unit of paving, because the structural concrete has a larger labor component per unit than paving (Figure 7).

Certain aspects of acceleration associated with the use of time-related I/Ds may have minimal impact or reduce the actual cost of construction. Examples of this include the following:

- Improved management and scheduling can enhance resource use.
- Innovative methods and materials used to meet the schedule demands of an I/D provision may result in cost savings.
- When contractor resources and project conditions are such that multiple crews can work on an item simultaneously without interfering with each other (e.g., multiple cut/fill locations), cost impacts are not an issue.

However, highly phased projects do not offer the same opportunity to add resources on the same work item. Extending hours and work weeks may be the only way to accelerate construction because of limited work areas. Thus, acceleration costs will be greater when the construction sequence and plans have limited areas of simultaneous work activities.

Contractors are acutely aware of their unit costs, and the vast majority of successful contractors go to great efforts to track them. Contractors' bid prices rely heavily on past experience (historical costs); even with this detailed information, estimating the impact of acceleration on unit costs is as much art as it is science. This is one of the inherent risks that contractors face each day. Over time as more I/D projects are contracted,

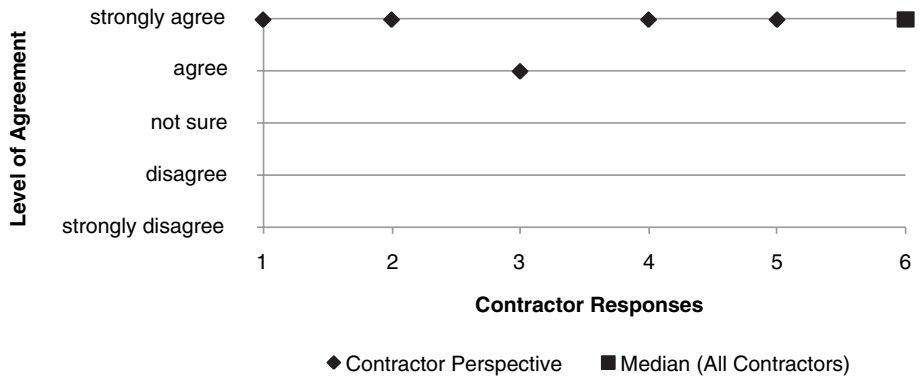

Figure 6. Phase II contractor feedback about acceleration costs and project features.

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Table 6. Description of acceleration impacts on cost components.

Cost Component	Discussion of Acceleration Impacts
Materials	Typically more affected by supply and demand issues (market factors) than by acceleration. Projects that require a sustained high level of acceleration are an exception to this general rule. Some suppliers may not be able to meet the accelerated supply schedule, thus reducing competitive forces on material pricing.
Labor	Typically the most affected cost component. Acceleration directly impacts labor rates through overtime and premium pay. Production rates are typically lower during periods of extended working hours and for multiple shift scenarios.
Equipment	Production rates are typically lower during periods of extended working hours and for multiple shift scenarios, thus increasing unit costs. Additional equipment resources (lease/rent) may be required to meet accelerated schedule requirements resulting in higher costs.
Overhead	Home office overhead is a function of annual revenues. Assuming a contractor is not forced to forego other revenue opportunities due to the resource requirements of an accelerated project, home office overhead would be reduced. Project overhead rates are typically increased for an I/D project due to the need for additional management resources.
Profit	Market driven.

a STA may develop a historical database that can assist in estimating the cost impacts of the use of I/D provisions. From a STA's perspective, estimating the cost impact of acceleration should be based on a macro level. An overall cost adjustment factor should be applied that considers the estimated net effect of market influence and acceleration cost impacts.

A primary concern of STAs is understanding the relationship between I/D amounts, cost, and acceleration. For a STA, there is an optimum minimum I/D amount that will motivate a contractor to safely complete a highway construction project within the time frame set by the STA. In other words, a STA would like to know: what is the minimum I/D amount that will ensure that schedule goals are met?

The answer to this question is complex and in almost every case unquantifiable. It is impractical for a STA to pursue models or algorithms that attempt to estimate the minimum

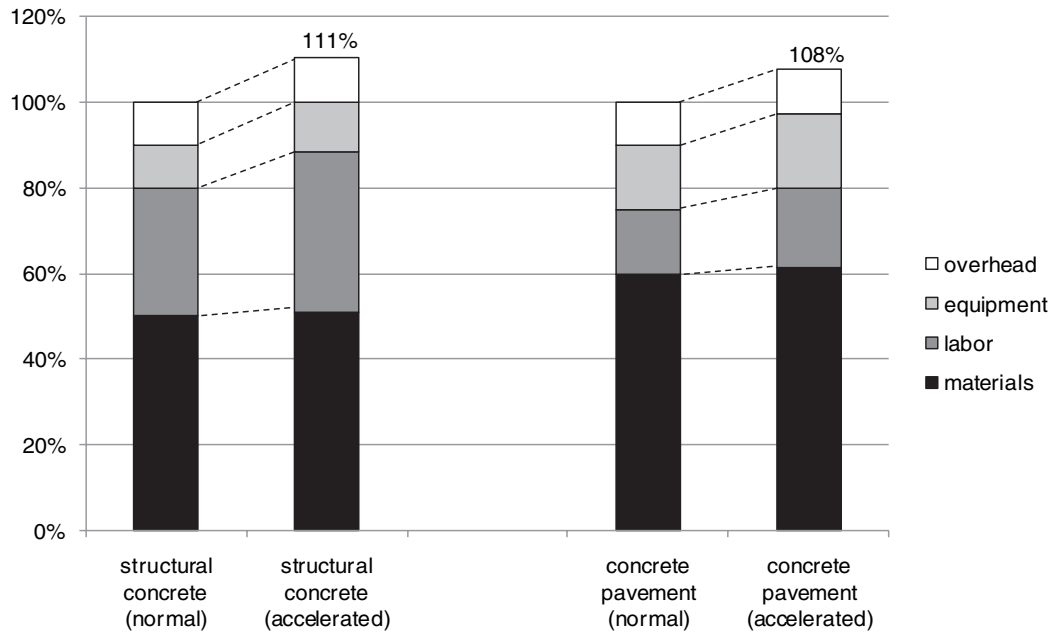

Figure 7. Example of acceleration cost impact.

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I/D rate that will affect acceleration. The primary factor that makes such models/algorithms impractical is the impact of market influences on contractor bid prices and scheduling. It is sufficient to state that market factors can have a greater influence on the final cost paid by a STA than any other factor. That is to say that the competitive bid environment can trump cost impacts created by I/D provisions (almost always to the STA's advantage). This does not mean that STAs should not concern themselves with optimizing the I/D rate. Rather, it emphasizes the necessity of STAs to gain a more thorough understanding of the impacts of I/D provisions and the interdependent nature of many I/D factors. One comment was received from contractors related directly to this issue of what minimum I/D rate will motivate acceleration: "*Five to seven percent of the contract value should be the floor for I/D. This is the amount that it takes to get the contractor's attention and makes the endeavor worthwhile.*" Targeting the maximum incentive at a given percentage of the total contract value may be desirable from a policy standpoint, but will fail to yield effective results from I/D provisions. Incentives and disincentives should be adjusted based on the project conditions, market influences, and the level of acceleration required to meet schedule objectives.

Other Cost Considerations

Incentives Serve as Alternative Revenue for Contractors

The low bid system used by STAs creates a highly competitive bidding environment. Rarely does construction demand stretch the resources available in the contracting industry. As a result, competition dictates that the majority of I/Ds are passed through to the STA. This practice gives the best qualified contractor for a specific project an advantage at the bidding table. Anticipated incentive earnings are treated like contract revenues; which mean I/D provisions create acceleration at minimal cost to the STA. In effect, when a contractor is confident that his/her available resources will meet the objective of an I/D provision and an incentive will be earned, the bid can be reduced by the amount of the estimated incentive. Thus, incentives are treated like regular contract revenues that replace portions of contract profits (in some cases, cost as well). This does not negate the earlier discussion of market factors, but draws focus to the fact that markets are predominantly more competitive than they are flush with available work. Contractors that responded during Phase II were unanimous in their agreement that this practice is not only prevalent, but that it is advantageous to the STA and to the contractor. The competitive low bid system used by STAs results in 75% or more of I/Ds being incorporated into the bid. This practice provides an advantage to the best qualified contractor while achieving the STA's schedule goals at minimal cost (Figure 8).

Unbalanced Bids

The practice of adjusting unit priced bid items for anticipated underruns and overruns (unbalanced bids) is amplified by the use of I/D provisions. In the case of an A+B contract where the contractor determines the contract time, it is common practice for contractors to move some amount of money from the B portion (time) to the A portion (traditional bid items). Consider the example shown in Figure 9.

This same scenario holds true for an I/D project where time is determined by the STA as well. When the incentive is bid into the project (passed on to the STA because of market factors) unit prices must be adjusted to affect this bid reduction. At a minimum, the prudent contractor will reduce items that are anticipated to underrun. It is likely that the contractor will arrive at the final bid (reduced total/unbalanced bid) by adjusting both underrun and overrun items. While not unanimous, the Phase II research results agree with the research team's experience that unbalanced bids are amplified by the use of I/D provisions (Figure 10).

This practice of unbalancing bids is not wrong or unethical unless it is carried to the extreme, which may lead to disqualification of the bid. Unbalancing is inherent to unit price

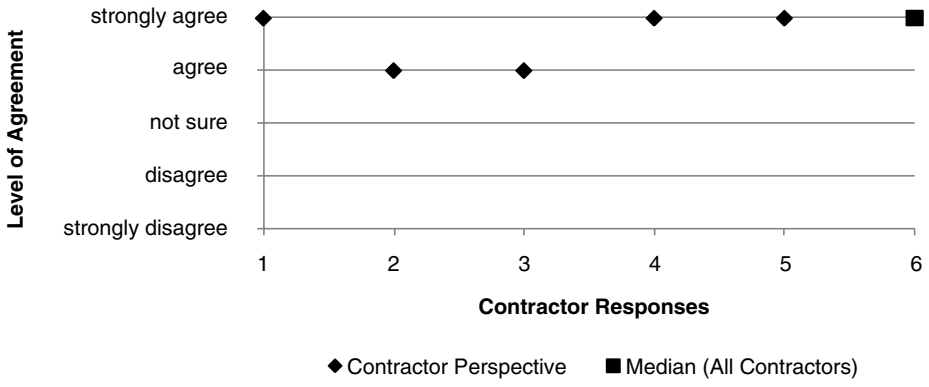

Figure 8. I/D treated as alternative contract revenue.

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Balanced Bid

A Subtotal =	$50,000,000 *
B Subtotal =	$10,000,000

*where Unclassified Excavation = $2,500,000 (500,000 CY @ $5.00)

Total Bid =	$60,000,000
Final Contract Amount Paid by STA =	$50,500,000 **

**Unclassified Excavation overrun = $500,000 (100,000 CY @ $5.00)

Unbalanced Bid

A Subtotal =	$51,000,000 ***
B Subtotal =	$9,000,000

***where Unclassified Excavation = $3,500,000 (500,000 CY @ $7.00)

Total Bid =	$60,000,000
Final Contract Amount Paid by STA =	$51,700,000 ****

****Unclassified Excavation overrun = $700,000 (100,000 CY @ $7.00)

STA Cost Increase from Unbalanced Bid = $1,200,000

Figure 9. Unbalanced bid example.

contracts and has been an accepted buyer's risk borne by STAs for decades. STAs should be aware that I/D provisions amplify this practice, as one contractor stated in the feedback to Phase II research: *"Contractors often perceive STAs as being hesitant to pay the incentives the STA has contracted to pay in contracts containing significant I/D provisions. While the STA may have made the decision that there is value in paying these incentives, Contractor experiences often indicate this commitment breaks down when the due date for paying these incentive approaches. As a result, Contractors often budget this incentive in the cost of their products; meaning the STA is paying the incentive with each product delivered and the contractor's scheduled completion date may actually be later than the STA realizes. Negotiating to end days of damages versus starting days of incentive favors the Contractor most often."* Another contractor expressed the following: *"Typically, only the savvy Contractor can/will unbalance a bid. Is that a bad thing; I think not."*

Thus, STAs should take extra care when estimating plan quantities on projects that will include a time-related I/D provision. The degree to which unbalancing occurs as a result of I/D provisions is related to how the I/D provision addresses adjustments to time during execution of the contract (no-excuse or day-for-day) and the extent to which time impacts are anticipated by the contractor. In simplest terms, if the contractor anticipates that negotiable time delays will occur, they will be more likely to unbalance a bid by reducing the B portion or anticipating incentive payments.

Risk Allocation Between Contract Parties

I/D provisions normally change the way risks are allocated between contract parties. Most contractors are capable of estimating their costs and their schedule. When I/D provisions shift risk for certain time impacts (weather, utilities, quantities, etc.) to the contractor, the cost to the STA increases. This increase in cost to the STA is directly related to two factors: (1) Is the risk quantifiable (how well can the contractor estimate the impact)? and (2) Is the risk beyond the control of the contractor (can the contractor do anything to mitigate the risk)?

An example of changing risk allocation is a no-excuse clause which requires the contractor to complete the project within a given time frame regardless of impacts that are encountered on a project. Without debating whether these clauses are fair or not, it is safe to say that they impact the final cost paid by the STA. In the case of a no-excuse clause, the contractor has

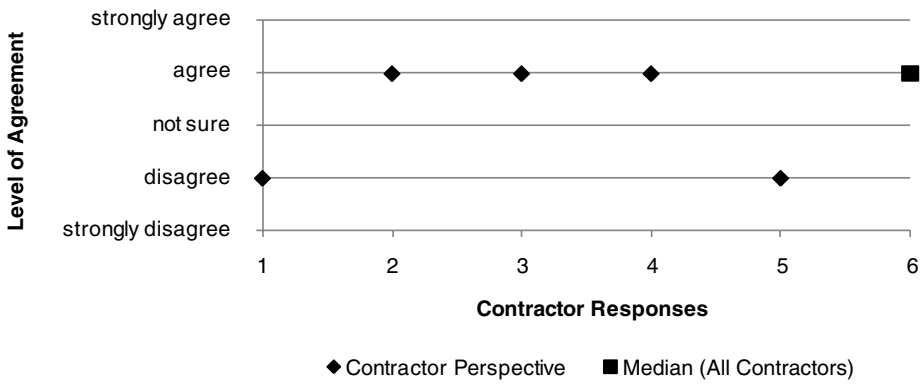

Figure 10. Contractor feedback about unbalanced bid practices on I/D projects.

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assumed all risk associated with weather, site conditions, and so forth. There is no accurate way to estimate the schedule impact of these types of risks. In most cases like this, contractors will be more reluctant to pass any potential incentive earnings back to the STA, because the potential incentive earnings are so dependent on factors that cannot be accurately quantified. Contractors responding to the Phase II research agreed that STAs will incur higher costs in the long term as more risks are shifted to the contractor (Figure 11).

One contractor offered the following comment regarding the issue of risk allocation and long-term costs to the STA: "*Yes, if the contract provision begins to look too much like a gamble to the Contractor, the Contractor will acknowledge the potential damages by budgeting to incur these. The likelihood that the STA then pays for the potential damages, but then never recoups the damages tends to favor the Contractor.*"

The manner in which a contractor estimates the impacts of these types of factors is unique to each contractor. One common thread between contractors is the tendency to err on the side of caution when faced with estimating factors that are difficult to quantify or are beyond their control. As a result, STAs need to understand that transferring risk to the contractor, especially risks that are beyond the contractors' control or those that cannot be quantified will increase the STAs costs in the long run. Methods of risk sharing between the STA and contractor are a critical need that should be addressed by all contract parties.

Innovation

During the Phase I interviews, contractors and STAs agreed that time-related I/D provisions drive innovation. They also agreed that innovation was a positive by-product of I/D provisions. However, some of the contractors voiced a concern that STAs were not always open to the proposed innovation or that the STA expected to negotiate time as a part of the approval process for the innovative method. Contracts are changed in many different manners. Each STA has detailed specifications dealing with the prosecution of contract changes. The use of an I/D provision does not normally modify any of these contract change processes. What is changed by the use of an I/D provision though is the value of time.

When a STA uses an I/D provision, they are placing an increased emphasis on time. This emphasis is expressed by placing a monetary value on early completion. This value of time is almost always based on RUC. Except in rare cases such as emergency projects, there is a practical limit both to the value of early completion and to the amount that a project can be accelerated. Thus, the practice of capping the maximum amount of early completion incentive that can be earned is warranted and would be considered a best practice for STAs to implement with I/D provisions.

If an I/D provision caps the maximum incentive that can be earned for early completion, time savings should be a non-negotiable issue when a contractor proposes an innovative method. By capping the incentive, the STA has limited their potential to overpay for early completion. Under the capped incentive scenario, contractors should not be required to negotiate a new schedule simply because the innovation will save time and they will earn incentive. Requiring contract time reductions when innovative methods or materials are proposed defeats the motivation for innovation and the associated early completion. Quite often the incentive earned is used to offset additional costs that are connected to the innovative method or material.

Phase II research shows that contractors are in harmony on this issue, with four of the five contractors strongly agreeing that approval of innovative proposals should be independent of the time savings associated with the innovative proposal (Figure 12).

Contractors offered the following comments supporting their perspective on this issue:

- *"The STA also realizes cost & time savings—their own inspection staff, QA or QC staff, Management overhead and or Consultant inspection fees."*

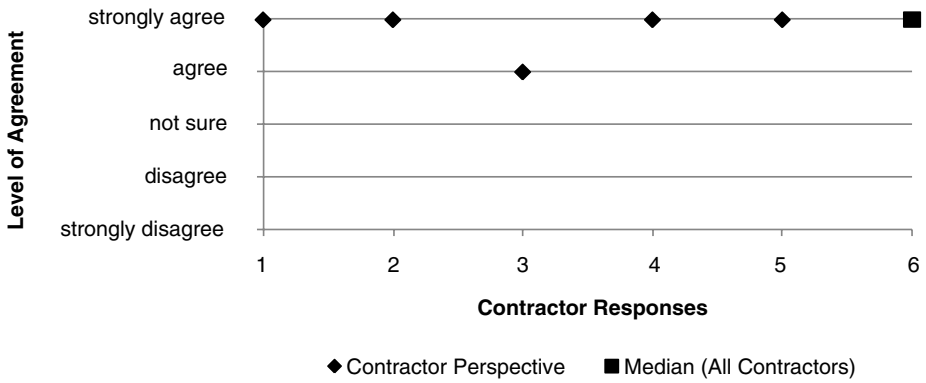

Figure 11. Long-term cost impacts of shifting risk to contractors.

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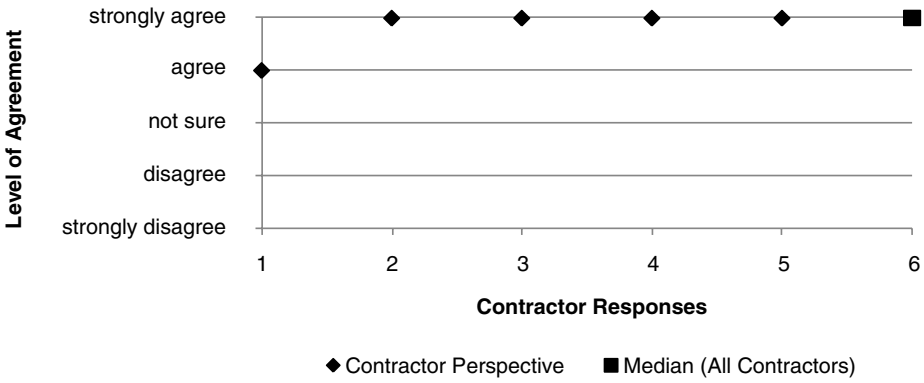

Figure 12. Contractor agreement on the treatment of contract time coupled with innovative proposals.

- *"The STA must be unequivocal within its own management and engineering staff that contractor proposals that save time may result in added profit for the Contractor, and this is the intent of the contract provision—to provide both a financial incentive to the Contractor to minimize the construction duration."*
- *"It is important for the STAs to understand that each idea or dollar is considered an off-set to each other. Put another way a dollar can only be saved against a specific idea. The next idea is considered a separate negotiation. Money can only be saved one time; against one idea. Agreement to the first idea for money savings does not carry on for the life of the job. It is a 1 to 1 type concept."*

This issue should not be viewed as contractor posturing. When dealt with properly by capping the incentive at an amount that will motivate the contractor to meet the STAs desired duration for completion, a win-win scenario is created. The STA and public receive an accelerated project at a price that they pre-determined is desirable to them and the contractor is motivated to pursue innovative methods and materials that will improve the odds of early completion.

Contract Administration

In contrast to typical highway construction contracts that use liquidated damage clauses, an I/D provision establishes a sizable pool of money for early completion. The adage stating that "time is money" is appropriate. I/Ds definitely alter the contract administration landscape. When schedule impacts begin to threaten either party's claim to the pool of money set aside for early completion, the potential for conflict will be elevated. Time-related I/D provisions magnify the need for contract administration policies that provide clear direction for determining how contract time is charged and modified throughout the life of the contract.

The treatment of contract time charges varies widely across STAs. Climate variation and local statutes are the primary reasons that STAs have different methods for determining how time is measured for highway construction projects. Because of these regional differences, there is not a single optimum solution for time measurement. Implementing I/D provisions may require a STA to modify its standard specification for time measurement (prosecution and progress). The following items highlight the primary areas that should be considered when developing or modifying a specification for measurement of time on an I/D project:

- For an I/D contract, the preferred method of measuring time is the calendar day. The use of working days or modified calendar days (6 day week, no holidays, credit for abnormal weather, etc.) can introduce ambiguity into the schedule.
- Contractors should be required to submit a baseline schedule for approval. Once approved, this baseline schedule should be used to evaluate all contract changes.
- The process for evaluating the impact of excusable delays must be clearly defined.
- Schedule impacts should be evaluated and agreed to in a timely manner. Once agreed to, the changes should be reflected in an updated baseline schedule.
- The occurrence of excusable delays erodes the effectiveness of I/Ds. Plans and specifications for I/D projects should be carefully reviewed for potential schedule impacts arising from project unknowns and plan errors.

The effective use of I/D provisions entails some transfer of risk to the contractor. Otherwise, the STA is left vulnerable to paying an incentive for early completion when the project was not actually completed early. On the other hand, when too much risk is transferred to the contractor, a disincentive may be charged to the contractor when he/she actually completed a project on time or early but encountered delays beyond his/her control. Risk sharing strategies should be implemented that

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allow both parties to reasonably meet their objectives. Contractors that participated in Phase II believed strongly about this issue (Figure 13).

One of the contractors added the following comment about risk sharing and I/D provisions: "*The STA must recognize and accept that a Contractor is not going to accept additional risk when negotiating change orders for a contract that contains significant I/D provisions. This becomes acutely problematic when the contract includes a significant damages clause associated with a "due-by" date that cannot be changed. If a change order is needed to add some small, but necessary, product to the contract and negotiations breakdown as to whether or not the duration required for delivering this product results in a project completion after the due date, nobody wins.*"

Some examples of risk sharing strategies that have been used by STAs were identified through the research project. A brief description of these strategies follows:

- In lieu of a strict no-excuse clause where the contractor bears all of the risk for schedule delays, a modified no-excuse clause should be considered. A modified no-excuse clause has been successfully used by FDOT. Under FDOT's modified no-excuse clause, contract time may be adjusted when an excusable delay has a schedule impact greater than 15% of the remaining contract time when it occurs. This type of solution is a compromise that allows the contractor to potentially recoup some of its acceleration costs incurred while overcoming excusable project delays.
- The VDOT has used a contractually binding decision making matrix that defines the time frame for making project decisions. A time frame for either making a decision or elevating the issue up the chain of command is specified for the contractor and STA management hierarchy. Similar arrangements are common to partnering agreements. Incorporating such a decision timetable into the contract relieves some of the risk borne by a contractor under an I/D provision.
- Time-related overhead (TRO) has been used as a bid item by the California Department of Transportation (Caltrans). By doing so, the contractor establishes the daily overhead rate during the bid process. This rate is used to compensate the contractor for the contract time used and for any excusable delays that occur. This type of specification applies market pressure to the overhead rates that would otherwise be sole source negotiations between the STA and contractor.

Staffing

Managing an I/D project presents unique challenges to the STA and to the contractor. Extended work hours and 6- or 7-day work weeks are not uncommon. The in-depth interviews conducted during Phase I with STAs and contractors revealed that both STAs and contractors acknowledge that staff fatigue and burn out occur on I/D projects. But, the in-depth interviews did not produce any results that would point to effective management techniques for dealing with staff fatigue and burn out. The use of consultants for project management and inspection by STAs is becoming more common according to a report by the General Accounting Office (*17*). Using consultants on an I/D project adds a layer of complexity for the STA and the contractor that does not solve the fatigue/burn-out issue; the burden just shifts to the consultant's personnel.

From the STAs' perspective, the use of consultants is a reality forced by the changing workforce at STAs and difficulties in attracting and retaining staff with key skills (*17*). Proper consideration should be given to developing and implementing performance measures and oversight for consultants that will ensure that the STAs' and public's interest are being served. When consultants are used, STAs should structure the contract with the consultant in a manner that will equitably compensate the consultant for extended hours as well as protect the STA from changes due to the contractor's accelerated schedule. Because timely decision making is critical on accelerated projects, the STA needs to be sure there is clear understanding with

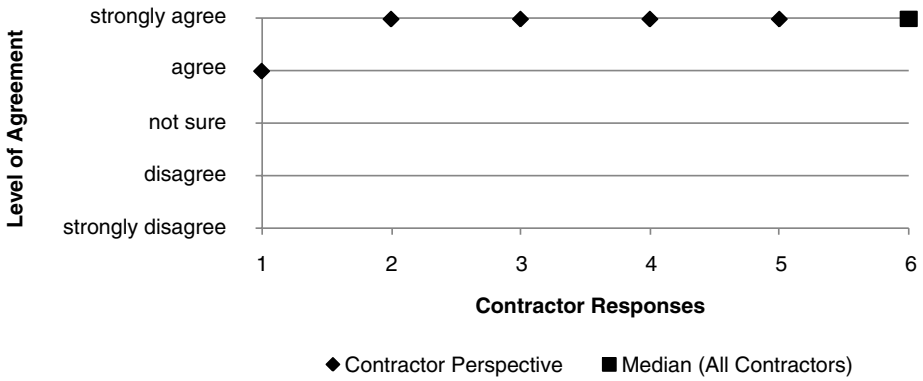

Figure 13. Contractor perspective on risk sharing.

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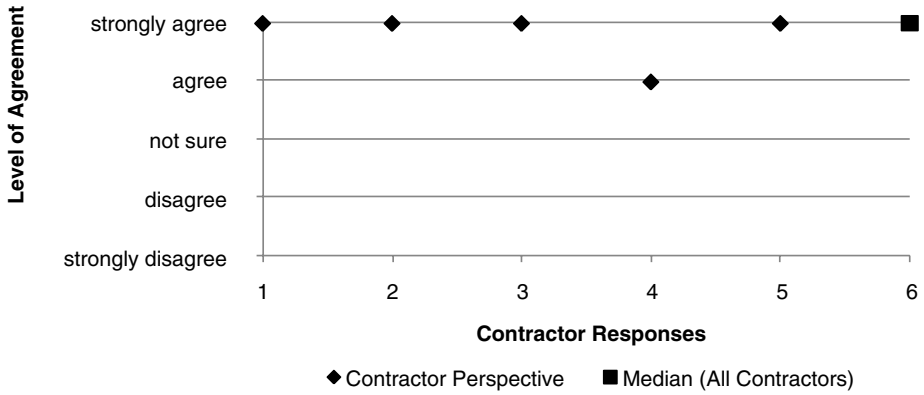

Figure 14. Contractor perspective on flex starts.

the consultant on decision making authority so that the use of a consultant does not introduce another layer in the decision making process and delay the contractor.

One technique that contractors were in favor of was a "flex start." When STAs allow the contractor to adjust the start of an I/D project into the contractor's portfolio of work where it fits best, some staffing and resource issues are alleviated (Figure 14).

Contractor feedback regarding flex starts was as follows:

- *"If the STA can offer flexibility in when a project is scheduled, the cost to the STA will be lowered."*
- *"Consideration should be given of flex starts up to 180 days, not limited to 90 days."*

Except when the completion of a project is tied to a critical date (school opening, special event, etc.), flex starts should be allowed whenever possible to allow contractors the best opportunity to balance resources between projects. Doing so will minimize the cost associated with an I/D provision and should contribute to maintaining acceptable quality levels. Given materials that comply with specification, quality is most affected by the human resources used on a project. Many solutions exist to add equipment and material resources to a project. However, it still takes people to operate the equipment and incorporate the materials; adding human resources while maintaining quality is a much more difficult task. Flex starts are a valuable tool for the contractor to manage staffing issues created by I/D provisions.

Quality

Maintaining acceptable quality levels for work that is performed under a time-related I/D provision is an issue that should not be overlooked. In-depth interviews with STA and contractor personnel revealed that I/D provisions have no impact on the quality of work. STA personnel were unanimous in their statements that enforcement of specified minimum quality requirements are independent of time-related I/D provisions. Results of the e-mail interview form generally agree with the in-depth Q&A responses, but do indicate that some quality deficiencies are related to I/D provisions (Figure 15).

An analysis of 477 projects finalized by a STA for fiscal year 2007 was performed by the research team. No statistically significant difference between the quality of I/D and non-I/D projects was found. A summary of the analyses performed and the conclusions drawn is as follows:

- The population of 477 projects finalized for FY2007 included 455 non-I/D projects and 22 I/D projects.
- Of the 477 projects, 157 of them had a quality adjustment made to the final contract revenues.
- 19% of the non-I/D projects incurred a quality deduction while 18% of the I/D projects incurred a quality deduction.
- The net quality adjustment (sum of quality incentive and disincentive) as a percentage of contract value was 0.39% for non-I/D projects and 0.45% for I/D projects, thus the net quality adjustment was higher for I/D projects, indicating slightly higher quality.
- An analysis of variance (ANOVA) was used to evaluate the net quality adjustment as a percent of contract value for

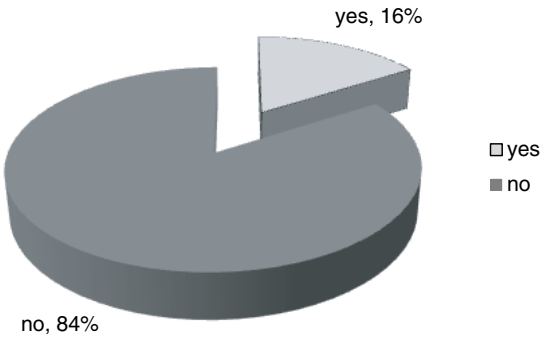

Figure 15. Quality deficiencies related to I/D provisions.

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non-I/D projects and I/D projects; no statistically significant difference was observed ($\alpha = 0.01$).
- This conclusion regarding no statistical difference between the two data sets (non-I/D and I/D) was unchanged even after removing two contractors from the non-I/D data set that accounted for 20% of the non-I/D projects that were charged only negative quality adjustments.
- A third analysis evaluated the results for a single contractor that included 4 I/D projects and 3 non-I/D projects; again, no statistical difference existed for the net quality adjustment as a percent of contract value.

It is important to realize that the quality adjustments observed in the data set may or may not be impacted by acceleration. For example, the majority of quality incentives are for pavement smoothness. Without knowing the details of every project, it is impossible to know if the paving activities were actually accelerated by the I/D provision. Finally, it should be noted that I/D provisions have been used extensively by many STAs. By all indications, these STAs intend to maintain their use of I/D provisions. Common sense dictates that if quality was negatively impacted by the use of I/Ds, STAs would have discontinued their use by now.

While it is comforting to know that time-related I/Ds have little or no perceived effect on quality, it would be remiss to ignore the potential for quality issues to arise from acceleration of the work. Items that should be noted with respect to quality and I/D provisions include the following:

- Conformance with specifications is independent of time-related issues; meeting schedule milestones should not influence a decision to accept failing or marginal work.
- Schedule milestones may influence contractors to use alternative methods and materials that would not otherwise be used on non-I/D projects. This does not imply that minimum specifications will not be met. However, although many contractors perform work that exceeds minimum criteria, the STA may perceive a reduction in quality because the finished product is of a lower quality than what the STA is accustomed to, even though minimum acceptance criteria were met.
- The potential to trade off quality for time exists whenever quality pay factor specifications are used in conjunction with time-related I/Ds.
- Adequate lighting is a necessity for night work.

While quality has not been an issue for the vast majority of I/D projects completed, STAs and contractors should be proactive about dealing with the potential for time/quality tradeoffs.

Safety

Time-related incentive provisions are normally used for one or more of the following objectives:

- Shorten contract period to reduce overall exposure and impact of construction.
- Complete for special event or winter condition.
- Limit capacity impacts during high traffic flows.

The construction contract may contain one or more provisions to address the objectives of the STA as discussed in detail the Discussion of I/D Variables section in Chapter 4. Without repeating that discussion, it is important in this section to consider how these strategies may impact safety. Each project is unique and needs to be thought through carefully. Not only does the project itself need to be carefully planned but also one needs to anticipate how the project may impact the transportation network in the area with potential secondary impacts.

A traffic demand mitigation strategy is commonly an objective to reduce traffic volumes through a project. But, this may result in unanticipated impacts on the parallel network. For example, when I-15 was shut down for reconstruction prior to Salt Lake City hosting the Olympic Games, an increase in off system accidents was noted (*18*). In their report titled "User Costs on the I-15 Design-Build Reconstruction," Martin et al. note: "When the I-15 project began on April 15, 1997, increased travel times, queues, congestion, and accidents became common driving experiences. Public support for the project declined. News media reported that people were concerned about increased accident numbers on streets surrounding I-15 reconstruction areas. On January 7, 1998, a *Salt Lake Tribune* article titled 'Communities Seek Help With Traffic Trouble' stated that '30 percent of Interstate 15 traffic [had] poured onto city streets,' that there was a '300 percent jump in automobile accidents,' and that 'Police Department overtime expenses [had] jumped 87 percent.'"

This is not to infer that the overall safety exposure to the public was greater by using this acceleration strategy, but to illustrate that other safety impacts on off system routes can occur and that the planning for the project needs to anticipate these potential tradeoffs. Martin et al. conclude that the design build approach chosen by the Utah DOT was the safest of the alternatives he analyzed.

Further complicating the decisions involved with accelerating work activities is that there are often other tradeoffs involved when minimizing impact to the traveling public through a construction project. Night work is increasingly used to give the contractor a sufficient window of non-peak traffic flow to accomplish the work activities. Putting restrictions on the

contractor that require night work results in construction activities being accomplished in a more challenging period of the day. However, this does not necessarily result in less safe work zones compared with the alternatives. Several excellent resources are available to assist the STA in planning night construction activities, including *NCHRP Report 475* and *NCHRP Report 476* (*19, 20*). *NCHRP Report 475* presents procedures to assist highway agencies in determining whether to perform nighttime construction or maintenance. *NCHRP Report 476* contains guidelines for design and operation of nighttime traffic control.

STAs in many locations are often balancing the tradeoff of completing a project or phases of work before winter conditions occur to prevent work during adverse weather conditions. Acceleration strategies that allow for a less restricted traffic flow condition through the winter certainly have positive safety benefits to the public. However, the reality is that construction work zones are inherently more dangerous than normal free flow traffic conditions. Narrow lanes, barriers, traffic merges, restricted ramp merges, fewer total lanes, distractions from the construction activities and additional signage are all elements experienced in a work zone that make the environment more difficult for the driver. This is especially important as one looks to the future with increasing traffic volumes on the systems that STAs are managing (*21*):

- Between 1982 and 2002, vehicle miles traveled increased by 79%, while highway lane miles only increased 3%.
- An estimated 3,110 work zones were present on the National Highway System (NHS) during the peak summer roadwork season of 2001.
- Motorists encountered an active work zone 1 out of every 100 miles driven on the NHS, representing over 12 billion hours of vehicle exposure to work zones during 2001.
- Highway workers spent 246.4 million hours working on the NHS during the year 2001.
- In 2005, 1,074 fatalities resulted from motor vehicle crashes in work zones. This has grown from 1,028 in 2003 (a 4% increase) and 693 in 1997 (a 55% increase).
- More than 41,000 people were injured in 2003 as a result of motor vehicle crashes in work zones. This has grown from 36,000 in 1996, an increase of 14%.
- 53% of work zones are designated as day work, 22% as night work, and 18% are active all day or nearly all day (18 or more hours).

It is clear that the use of acceleration strategies will increase in the future. The challenge for transportation professionals is to minimize or eliminate any additional complexity by the use of acceleration strategies on projects and, if possible, to reduce overall safety impacts to the public and construction workers.

The following four sections contain questions posed by the NCHRP Project 10-58(01) panel and the research team's responses.

Is there data available that compare work zone accident rates for contracts that incorporate acceleration clauses and similar contracts that do not contain acceleration clauses?

The research team was not able to identify enough data to directly answer this question. There may be several reasons for that. Foremost is analyzing all the variations and factors that could affect the results so that a useful analysis would result. Most construction projects where acceleration strategies are used are on higher traffic volume, larger projects that are very complex in nature. Traffic diversion, improvements to the parallel network, special traffic enforcement, and the complexity that there may be several acceleration approaches incorporated into an overall project are a few of the issues that make the matrix of variables large and result in a very complicated analysis. No one the research team interviewed was aware of any attempt to conduct such on analysis. Several interviewees indicated that, in their judgment, it is nearly impossible to conduct such a comparison.

Even a pre and post construction accident rate analysis, without considering acceleration clauses that may have been incorporated in a project, is very complex. However, the research team was able to identify one STA that has performed this type of analysis, the results of which are summarized as follows:

The Ohio DOT (*22*) has conducted extensive analysis of its construction work zones. While the data are not linked with the use of particular contract acceleration provisions, the findings in general are excellent for identifying how to improve safety in work zones. The analysis of 2002 and 2003 work zone crash data and free flow comparables indicated a 60% to 70% increase in accident rates during construction compared with the post construction condition. Ohio DOT analyzed hundreds of work zone crashes looking for abnormally high concentrations of crashes and identified the following areas of focus for improving safety during construction:

1. Geometrics—Off ramp capacity, inadequate ramp merges, insufficient paved shoulders, and
2. Speed reduction.

Further analysis to determine whether the use of an acceleration clause on the contract had a positive or negative impact

on safety is so complex that none of the STAs contacted were aware of any conclusive studies that would provide insight on I/D impacts on safety.

If data is not available or is incomplete, what judgment and experience do transportation professionals offer relative to the use of acceleration clauses as it relates to safety?

The relationship between exposure time and work zone accidents was discussed with all the traffic professionals interviewed. The consensus was that, all other factors being equal, reducing construction time will reduce exposure time, which will correspond to fewer accidents overall. Acceleration strategies are normally used on higher traffic volume facilities, and all interviewees supported the concept of reducing the overall work zone exposure time.

What strategies and considerations can a STA use to reduce risk to the motoring public, pedestrians, and construction workers on accelerated projects?

During the interview process a number of helpful ideas were identified:

- Apply good traffic control principles applicable to all construction work zones. Contracts containing acceleration provisions are no exception. Ensure that traffic control requirements do not create a situation where the contractor can take short cuts on traffic control to gain speed of construction. This is largely a function of having good traffic control standards and requirements that the contractor must follow.
- Be aware of potential secondary impacts on the parallel highway network around the project. Depending on travel time and traffic flow condition restrictions resulting from the project activities, route diversion may occur. On many projects, some diversion is desirable to maintain acceptable levels of service through the project. A network level analysis should be done so that appropriate countermeasures can be taken on diversion routes.
- The actual safety impact becomes more complex on higher traffic routes. Carefully analyze the anticipated traffic volumes through the project work zone and match the available capacity to the acceleration boundary conditions.
- Numerous technologies can be effective such as rumble strips, speed monitoring displays, facilitating merge operations, smart work zone technology, drone radar, and improved nighttime traffic control practices.
- The use of cameras to enforce speed, if permitted by state law, is a good alternative to uniformed officers. In many states, it is much more difficult to hire officers than it was 10 years ago.

How do extended work hours impact construction worker safety?

Research conducted in the field of occupational health reveals that extended work hours (either per day or per week) have a significant impact on the occurrence of work place accidents (*23*). A summary of the findings from a study conducted from 1987 to 2000 by Dembe et al. reports the following:

- Working 60 hours per week or more increases the risk of injury by 23%.
- Working 12 hours per day or more increases the risk of injury by 37%.

It should be noted that this study was not specific to the construction industry. More than 110,000 job records were analyzed across all types of occupations. Because construction ranked in the top third of industry classifications for occurrences of injuries, the actual increased risk due to extended hours is likely greater for construction than the overall combined rates reported.

Although hard data are not available, there appears to be no safety related reason not to use appropriate strategies to accelerate construction contract completion. In fact, there is likely a positive public safety benefit to completing a project in the shortest possible time and having the improved facility in use sooner. Each project needs to be planned so that the traffic management requirements and the use of contract acceleration strategies are consistent. Project and network level reviews of anticipated traffic flows may be helpful in identifying potential secondary impacts. The contractor should be required to follow accepted standards for traffic control even when work is being accelerated.

Acceleration strategies that rely strictly on extended work hours pose an increased risk of work place injury. Contractors and STAs should be encouraged to use management techniques that mitigate this risk. These techniques might include the following:

- Multiple shifts
- Replacement crews for alternating weekends
- When project conditions permit, use of additional equipment and human resources to increase production instead of extended hours

Additional Comments Received from Contractors during Phase II

Part of the Phase II research efforts involved soliciting feedback from contractors regarding their perspectives on time-related I/Ds. Additional comments that have not been included in the discussion of I/D impacts on project factors are provided in the following list:

- *"Road user fees, increased accident rates in construction zones and public perception are a value to STAs. Shorter construction durations generally are viewed positively by the General Public which may lead to increased funding for roads and bridges. This benefits both the STA and the Contractor."*
- *"In general I think A+B I/D projects are a good tool as long as parameters for things that are beyond the contractors control are looked at for both the incentive and disincentive. In the time frame that a contractor has to bid a project, it is impossible to look at all situations that may arise and the owner should bear some of the risk."*
- *"The STA should realize that I/D provisions are "insurance" to protect contractor markups. These cost reimbursements are for the inefficiencies and unproductive nature of compressed schedules. Incentives are not a bonus. STA should not underestimate the impact of I/D provisions on their employees on the line. They work off peak hours without shift premium or compensation while the contractor's employees may be compensated for the same time. They see the contractor receiving an incentive while their work is not recognized or rewarded."*
- *"I/D provisions bring more focus to management, supervision, and workers. Shortened durations for activities allow more focus for safety issues."*
- *"Any argument that a Contractor will lower their safety standards for an economic return is a weak argument."*

CHAPTER 3

Estimating Incentives and Disincentives

I/Ds, Acceleration, and Market Factors

Accelerating the completion of a highway project through the use of an I/D provision is a widely used practice by STAs. While there are many reasons for pursuing an accelerated project schedule (emergency, special events, economic impacts, etc.) the justification for offering an incentive for early completion is almost always based on RUCs. RUCs have been accepted as the standard method for establishing I/D rates on projects. Even though construction of a highway project may have other impacts that beg the need for accelerated completion (environmental, safety, impact on surrounding businesses, etc.), these impacts are difficult to quantify and the RUC for a heavily trafficked roadway will more than adequately justify the need for an I/D.

Using RUC as the starting point for establishing the project I/D rate will identify whether a project is actually a viable candidate for an I/D provision. For example, lower volume roadways may not yield an RUC that is high enough to motivate acceleration (i.e., acceleration costs exceed RUC). On the other hand, higher volume roadways will yield an RUC that is a multiple of acceleration costs. In this case, the incentive need only be a portion of the estimated RUC. Because there are so many factors that impact the effectiveness of an I/D provision, determining the optimum I/D rate is more art than science. Even though it is impractical to conceive of a theoretical model for determining the ideal I/D rate for a given project, a system that considers a few basic factors will improve the state of the practice for most STAs. An empirical system for determining effective I/D rates should at a minimum consider the following three principles:

- Market influences such as the number of qualified bidders and the availability of other work to contractors should be factored into the determination of I/D rates. Allowing as much flexibility as possible for the contractor between the bid award and the start time will be of great benefit to the STA because this will increase the available pool of contractors that can fit the project into their schedules as well as allow for project materials to be obtained.
- I/D rates for projects with similar RUC impacts should have similar I/D rates. Inconsistencies in I/D rates between similar and/or adjacent projects should be avoided. In some cases, maintaining consistency when RUC impacts are similar can be contrary to adjusting RUC for market influences. However, since I/D rates derive their justification from RUC, and adjustments to the I/D rate for market influences are less precise than RUC estimates, consistency should trump market influences when a conflict between the two arises.
- Capping the total incentive provides a level of risk mitigation to the STA to protect against grossly overpaying for acceleration. One method to arrive at an I/D rate is to start with the maximum incentive amount that is fiscally responsible in the STA's budget. Once this figure is known, the daily I/D rate can be set as long as it does not exceed the impact on RUC created by the project. Again, consistency with similar projects must also be considered. This may require adjusting the number of days for which an incentive for early completion will be paid. Offering a longer time frame where incentive can be earned at a lower rate will encourage earlier completion. For example, if the total amount of incentive that a STA is willing to pay for early completion equals $900,000, it would be more advantageous to allow the contractor to earn $10,000 per day for a maximum of 90 days rather than $30,000 per day for 30 days.

Highly phased complex projects will have multiple RUC conditions because traffic patterns change during the project. Often, an I/D may be offered on the same project for a critical milestone. It is imperative that each I/D used on a project is based on the difference in RUC associated with the estimated traffic conditions that exist during construction of that specific phase and then after completion of the milestone. Also, I/Ds

for multiple milestones should not overlap or be based on the same RUC, in effect exposing the contractor to the potential of being charged disincentive twice for the same RUC. Consider the following hypothetical example as an illustration of these concepts:

> An urban interstate reconstruction project involves widening the facility from 4 lanes to 6 lanes. The first phase consists temporarily widening the eastbound lanes so that 4 lanes of traffic can be maintained during construction of the westbound lanes. After westbound traffic is detoured to the widened eastbound lanes, the second phase of construction commences. This phase consists of constructing the westbound lanes, which will prohibit westbound traffic from exiting and entering the roadway at an interchange within the limits of the project.
>
> The STA would like to accelerate the first phase, limiting eastbound traffic to one lane while the temporary widening is constructed. Thus, an I/D is offered for completion of the first phase based on the estimated increase in RUC for single lane traffic in the eastbound lane. For this case, it is necessary to estimate RUC first for the condition during construction of the eastbound widening (one lane eastbound traffic) and second for the condition after completion of the first phase (two-way traffic on the eastbound lanes). The difference between these two RUC estimates is the STA's starting point for establishing an I/D rate for the completion of the first phase. Based on these two RUC estimates, the STA sets an I/D rate of $25,000 per day for a maximum duration of 21 days. Completion in less than 21 days will earn an incentive of $25,000 per day, while completion in more than 21 days will incur a disincentive of $25,000 per day.
>
> Overall completion of the project is also an objective of the STA. As such, the STA establishes an I/D for early completion; the contractor is offered $10,000 per day for completion of the entire project in less than 240 calendar days (not to exceed $600,000 total incentive) and is also subject to a disincentive of $10,000 per day for each day used in excess of 240 calendar days. Now, assume that the contractor finishes the first phase in 31 days, incurring a $250,000 disincentive. Also assume that final completion of the project takes 245 calendar days resulting in an additional $50,000 disincentive.
>
> Under this scenario, the contractor is being penalized twice for the same RUC that occurred during the first phase. There could be a number of arguments about the schedule impact of the first phase and subsequent work. The contractor could argue that he/she is actually due an incentive payment of $100,000 for the work occurring after the first phase. Regardless of the various outcomes that may arise from a schedule impact analysis, it is highly likely that the contractor has been doubly penalized for the same RUCs from the first phase of work. First, the contractor was charged a disincentive of $25,000 per day for project days 22 through 31 and was again charged an additional disincentive of $10,000 per day for project days 27 through 31. Conversely, the same "double dipping" of RUCs is possible in an incentive scenario as well.

When I/Ds are offered for critical milestones within a project, an I/D should not be offered for the overall completion of that project. Similarly, coupling lane rental provisions with I/Ds for milestones or overall project completion may also expose the contract participants to double dipping on RUC impacts. Best practice would dictate that I/Ds for critical project phases should be offered individually based on the RUC impacts of each phase. This type of provision can be applied to I/D projects where the STA determines the duration of each milestone phase or the contractor can determine the milestone duration through the use of an $A + B_1 + B_2 + B_n$ type of contract. Alternatively, an incentive may be offered for the completion of the entire project, where RUC impact is estimated as the difference between conditions during construction and post construction conditions. In any case, development of a consistent method for estimating RUC impacts and I/D rates should be a priority for STAs.

Estimating RUC

There are many methods available for STAs to estimate RUC impacts associated with a highway construction project. It is not the intent of this report to either endorse a method or product, or to provide detailed guidance for calculating RUC. The following discussion of estimating RUC is provided as a means for the reader to understand why and how the estimation of RUC impact is important to the effective use of I/D provisions for highway construction. For those interested, the following references provide a more in-depth review of RUC methods and tools:

- *Improved Models for User Costs* Analysis, Salem and Ashraf, 2007 (*24*)
- *Road User Cost Manual,* State of New Jersey Department of Transportation, 2001 (*25*)
- *Estimating Road User Costs as a Basis for Incentive/Disincentive Amounts in Highway Construction Contracts,* Gillespie, 1998 (*26*)
- *Effectiveness of Accelerating Highway Rehabilitation in Urban Areas,* Olguin, Allison, and McCullough, 1995 (*27*)

An array of computer applications is available for use in estimating road user delay cost. These include RealCost (*25*), Quickzone, QUEWZ, Alternat (*28*), HCS, MicroBENCOST (*26*), FREWAY, QUADRO2, CARHOP, CORQ-CORCON, INTRAS, FREQ, and FRECON2 (*27*). Please refer to the aforementioned references for detailed information on the use of these tools and their applicability to estimating RUC impacts.

According to FHWA, the only legal precedent that has invalidated an I/D specification was *Milton v. Alabama* (*28*). In this decision, the court ruled that Alabama's use of an I/D provision was a penalty and therefore unenforceable. The primary evidence that influenced the court's decision was (1) the I/D amount was not based on RUCs, (2) the disincentive was capped and (3) there was no language in the specification that described the disincentive as a means to recover road user

Table 7. RUC components.

Road User Cost Component	Comments
Travel Time Delay	Based on a simulated project with 60,000 AADT (40% trucks) and an average 5-minute delay due to construction, the travel time delay accounts for more than 90% of total RUC (estimated using travel time values from HERS model, USDOT 2005). Valuation of travel time delay should be based on a weighted average hourly rate by vehicle type that is based on appropriate factors for business travel, personal travel and average vehicle occupancy (23, pp. 18-25).
Vehicle Operating Cost	Based on a simulated project with 60,000 AADT (40% trucks) and an average 5-minute delay due to construction, the vehicle operating cost accounts for approximately 5% of total RUC (estimated using RealCost default values adjusted for current transportation CPI values, 3rd quarter 2008). Hourly operating costs by vehicle type should be used.
Accident Cost	Not normally used in RUC estimates for justifying the use of an I/D provision.
Environmental Cost	For the one project example that was found using hydrocarbon, carbon monoxide and nitrous oxide emissions as a component of RUC, the total of these costs were less than one percent of total RUC.

delay costs resulting from the construction project. Based on the lack of any other legal precedent or an overturning of the *Milton v. Alabama* decision, it is likely that most claims involving I/D projects have been settled to avoid setting any further precedents. To be defensible, it is critical that I/D rates be based on reasonable estimates of the RUC associated with the delay caused by the highway construction project.

RUC consists of the following components: travel time costs (user), vehicle operating costs, costs associated with accidents, and environmental costs from exhaust emissions (*27*). In practice, most STAs limit the calculation of RUC to travel time and vehicle operating costs. There are two primary reasons for limiting RUC estimates to these two components. First, limited reliable data exists for accident and environmental costs due to construction delays. Second, travel time delay and vehicle operating costs are normally high enough to justify the use of an I/D provision. I/D rates use RUC estimates as a basis for justification, but the actual I/D rate used is almost always a fraction of the estimated RUC and should never exceed the RUC impact due to construction. Table 7 provides additional information for each of the RUC components:

A step-by-step method for calculating road user delay costs follows (*26*):

1. Estimate the highway's capacity before, during, and after construction; performing multiple capacity estimates during construction may be required if capacity changes during different phases of the project.
2. Determine which capacity estimates will be compared as a basis for establishing I/D rates; in the case of an I/D that is tied to opening the finished facility to unrestricted traffic, the capacity during construction would be compared with the capacity after construction.
3. Forecast the volume and composition of traffic for each of the capacity estimates that will be compared.
4. Perform a traffic analysis of each of the conditions that will be compared (mean speed, mean delay, etc.). This may require several analyses of each condition (peak rush hour, off peak, and evening) to arrive at representative values for the average delay encountered over a 24-hour period.
5. Calculate the desired RUC components for each capacity condition that will be used as a basis for the I/D rate; results of step 4 are used in conjunction with the best available data for each cost component.
6. Calculate the difference between daily RUC of each capacity condition that will be used for establishing an I/D rate (RUC impact due to construction).

In summary, I/D rates derive their value from an estimate of the RUC increase that is attributable to the highway construction project. The fact that RUC estimates are commonly very high (greater than $100,000 per day) and the associated I/D rates are considerably lower should not lead a STA to the conclusion that RUC estimates need only be cursory. On the contrary, to be enforceable, the RUC estimates that lead to the I/D rates must be based on sound engineering practice. STAs should have a documented process for calculating RUC impacts due to construction. This process must also be consistently applied. Complex projects with multiple I/Ds for milestones will require multiple RUC estimates that capture the changes in capacity as milestones are completed. Also, RUC factors should be based on proper assumptions regarding AADT, percent of traffic by vehicle type, vehicle operating costs that reflect current CPI adjustments, and hourly RUCs that have been adjusted for personal/business trips and average vehicle occupancy. Failing to correctly estimate RUC impacts may render an I/D provision unenforceable.

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CHAPTER 4

Guidelines for the Effective Use of I/D Provisions

Objectives for Considering I/D Use on a Specific Project

When a STA considers the use of an I/D provision for a project, perhaps the first question is what is the STA trying to accomplish through the use of an I/D provision? The answer to this question may be simple or complex, depending on the project specifics. I/D provisions are commonly used to accomplish one or all of the following objectives:

1. Reduce contract duration to minimize overall exposure and the impacts of construction.
2. Complete for a special event or winter conditions.
3. Limit capacity impacts of high traffic flows during construction.

While these are the most common objectives, they are not all inclusive. Each project may have unique conditions that warrant the use of I/D provisions. STAs must determine if the use of an I/D provision is appropriate on a project-by-project basis.

A clear distinction needs to be made between the reason(s) for using an I/D provision (objective) and the criteria used for determining if an I/D provision is appropriate. It may be desirable to complete a project or milestone before winter weather impacts work and traffic conditions, but unless the ends are justified by quantifiable benefits (RUC), use of an I/D provision is inappropriate. Similar to the previous distinction made between objectives and criteria, there are benefits to using I/D provisions such as reduced impact on local businesses, improved contractor management, and innovation that are desirable but not always justified.

Criteria for Using I/D Provisions

Whatever the objective for using an I/D provision, there are criteria for determining if an I/D provision is warranted. Regardless of the motivation, projects should meet these criteria and also be justified by RUC. I/D provisions should not be considered for contracts that cannot be justified through reduced RUC.

FHWA has identified five characteristics that can be used to evaluate the appropriate use of time-related I/Ds (*28*):

1. Projects on high traffic volume facilities, generally in urban areas.
2. Projects that will complete a gap in a significant highway system.
3. Major reconstruction or rehabilitation on an existing facility that will severely disrupt traffic.
4. Major bridges out of service.
5. Projects with lengthy detours.

STAs that have written guidance on the use of I/Ds identify additional factors for using an I/D provision:

6. Construction requires temporary traffic barrier on both sides of a lane and/or a lack of shoulder area (especially critical through a winter season) (*29*).
7. Special events (school openings, holiday, etc.)(*29*).
8. Environmental or political commitment requiring work to be completed (*29*).
9. Agreements requiring completion within a given time frame (*29*).
10. Disruption of emergency services (*6, 30*).
11. Adjacent neighborhoods or businesses would be impacted significantly (*6, 30*).

E-mail interview responses show that STAs consider RUCs as the most important factor for determining if a project warrants the use of an I/D provision. On average, STA respondents felt that RUCs were approximately 60% more important than special events, anticipated feedback, and public/political input as a decision making factor for the use of I/D provisions (Figure 16).

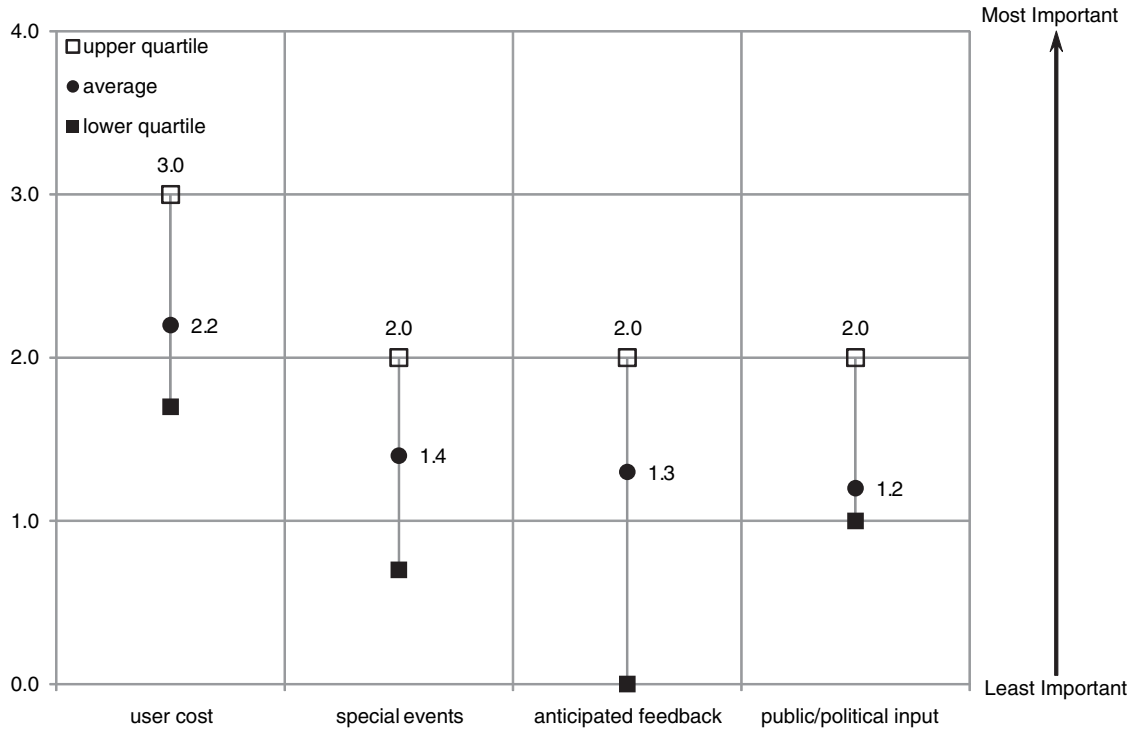

Figure 16. Relative importance of factors affecting the use of I/D provisions: average, upper quartile, and lower quartile (STA responses to e-mail interview form [n = 32]).

Many STA documents used for internal guidance (*6, 7, 30, 31*) include additional criteria and descriptions of project features that can be used for identifying whether an I/D specification is suitable for a given project. However, assessing the suitability of a project for an I/D provision is separate from justifying the need for an I/D provision. In other words, the need for an I/D must be justified by RUC and/or safety considerations before any consideration is given to what type of provision is most suitable to a project.

Types of I/D Provisions

Because there is a diversity of time-related I/D provision nomenclature among STAs, the definitions provided in the Terms and the Glossary sections in the Summary are repeated here.

I/D provisions can be categorized into two groups: A + B and I/D. The primary distinction between these two types is that the contractor determines the contract duration for an A + B contract while the STA specifies the contract time for an I/D contract.

I/D Provisions

I/D (calendar or working day)

Contractors are motivated to complete a project and/or critical items of work (milestones) within the number of days determined by the contracting agency through the payment of an addition to the contract amount for early completion or the assessment of a contract deduction for late completion (*2*). Calculation of the final incentive or disincentive is the product of a daily rate established by the contracting agency multiplied by the number of days of early or late completion.

Calendar Day. Every day listed on the calendar, regardless of whether work is accomplished or allowed by other specifications.

Working Day. Any day on which work is planned and could be performed; weekends and holidays are frequently omitted from a working day contract.

I/D (complete-by-date)

The contracting agency establishes a fixed date for completion and calculation of the incentive or disincentive instead of quantifying the number of days allowed for completion.

Cost Plus Time Bidding (Generic A + B)

Determination of the low (successful) bidder is based on the sum of cost (A) and time (B).

A Portion = Traditional contract cost; the sum of extended unit prices multiplied by contract quantities (*3*).

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B Portion = Time bid; the product of number of days determined by the contractor multiplied by the daily rate determined by the contracting agency (*4*).

A + B without I/D

The bidder determines the contract duration (B). Used only for the determination of the successful bidder, contract award is made to the bidder that has the lowest combined total of cost (A) and time (B). No incentive is offered for early completion, nor is any disincentive assessed for late completion other than normally specified liquidated damages. Standard specifications are applicable for the determination of actual contract time used.

A + B with I/D

Contract duration is determined by the bidder. Award is made to the bidder that has the lowest combined total of cost (A) and time (B). Incentive is paid for early completion or disincentive is charged for late completion. Actual contract time may be determined by standard specification or by other methods according to special provision(s) of the contract.

A + B_1 + B_2 + B_n

Multiple time values (B_1, B_2, B_n) represent critical milestones for which the bidder determines the contract duration and the agency determines the daily rate that is applicable to each milestone. Individual incentives or disincentives are applied to the actual completion of milestones.

Lane Rental

Charges for closing a lane to traffic during construction are established by the contracting agency. These charges are based on a rate of dollars per day, dollars per hour, or dollars per fraction of an hour (*3*). Bidders determine the amount of lane rental (lane closure x closure rate) needed for completion of the project. In the case where the cost of lane rental is included in other items of work, the contractor is paid for the estimated lane rental and then actual lane rental is deducted from contract revenues, resulting in an incentive or disincentive for completing the project within the estimated lane rental. When lane rental is included as a contract pay item, any underrun in the total lane rental incurred may or may not be paid to the contractor depending on the specification language.

There are two basic types of lane rental provisions. In the first type, the contractor estimates how much lane rental will be incurred to complete the project and that amount is included in other items of work. For the second type of lane rental provision, the contract has a line item for lane rental. Lane rental charges are drawn against that contract item, and if there is any unused lane rental budget remaining at the end of the contract, it is paid to the contractor. The net cost to the contractor and STA is the same for both types. However, the first approach distorts the bid prices, and both approaches distort the bonding amount and the contract value.

Lane rental specifications do not necessarily accelerate the work. They are designed to minimize RUC and safety concerns associated with lane closures on a project. Minimizing the impact on the public requires work to be performed at night or during short disconnected time periods. Construction efficiency is reduced (overall durations increase) when the continuity of the work is disrupted, work is performed at night, or both. If lane rental is used in conjunction with other I/D provisions, STAs should pay particular attention to avoid using the same RUC for lane rental and I/D rates during the same time period. Contractors should not be subject to incentive or disincentive charges that in effect double dip on the same RUC. When I/D and lane rental durations overlap, both should be based on RUC that are completely independent of each other.

Liquidated Savings

Although rarely used, liquidated savings have been included in other publications as a form of I/D provision. FDOT has used liquidated savings on a limited basis in the past. Because the incentive rate is equal to liquidated damages and only considers the STA's daily engineering cost for time savings, it does not meet the definition of an I/D based on RUC.

Discussion of I/D Variables

Determination of Contract Time

Who determines the contract duration? Two options exist: the contractor or the STA. Lane rental and A + B are the two I/D provision types in which the contractor determines the contract time. The STA specifies the contract duration in all other types of I/D provisions.

Unit of Time

When some form of time-related I/D is associated with a given project, how will the STA determine if the contractor has earned an incentive or will be assessed a disincentive? I/D milestones can be evaluated based on calendar days where every day is counted toward the milestone deadline. A modified calendar day approach does not count certain specified days, these "no-count" days could include Sundays, holidays, holiday weekends, weather days, weather days in excess of normal adverse weather, winter shutdown periods, and so forth. Working days may also be specified as the unit of time that is

used. The definition of a working day varies by STA. The I/D specification must be explicit regarding the unit of time that is specified. One other item to consider is what constitutes a day. For example, if a contractor meets the milestone at 12:02 a.m., is the contractor charged a full day? This is an extreme example, but daily incentive rates of $25,000 are not uncommon. Some I/D provisions state that a day begins at 12:00 a.m., and any portion of a day used is considered a full day.

I/D Amount

How much is early or late completion worth? I/D amounts should be stated in the specification. The STAs detailed calculation of I/Ds need not be explicit in the specification. But, the basis for the I/Ds (e.g., RUC) should be referenced. There must be a quantifiable benefit for early completion or quantifiable damages for late completion (*27*).

I/D Accrual and Capping

Is the total I/D amount based on a lump sum or a daily rate? I/Ds are normally calculated on a daily rate. It is also common for the incentive to be capped at a maximum amount, while disincentives are not normally capped. Lump sum I/Ds can be used as well.

A note about lump sum I/Ds. The equity and effectiveness of lump sum I/Ds was an issue raised by numerous parties during the in-depth Q&A sessions. In certain circumstances, the contractors had taken extensive efforts to accelerate the project but missed the lump sum milestone date by only a few days. The STA recognized that it received nearly all of the benefit of the accelerated schedule yet the contractor did not receive any compensation for the acceleration. In another instance, the contractor came to the conclusion that the lump sum milestone could not be met when the project was approximately 60% complete. Consequently, the contractor stopped all efforts at acceleration and concentrated on mitigating the disincentive by documenting delay and disruption claims. The STA acknowledged the inequity and regretted the ineffectiveness of these outcomes from the use of lump sum I/Ds. As a result, the STA will rarely if ever use lump sum I/Ds on future projects. The use of lump sum I/Ds is not considered a best practice.

A note about incentive capping. Some of the contractors interviewed questioned the practice of incentive capping. From the STA perspective, there are two issues to consider. First, there is an optimum combination of cost and schedule. STAs want the project to be accelerated, and they are willing to pay an incentive for acceleration, to a degree at least. The relationship between cost and acceleration, though unique for every project, is definitely not linear (Figure 17). Almost all highway construction projects have characteristics that practically limit how much they can be accelerated at a reasonable cost. In other words, acceleration costs associated with overcoming the limiting characteristics of a project would not

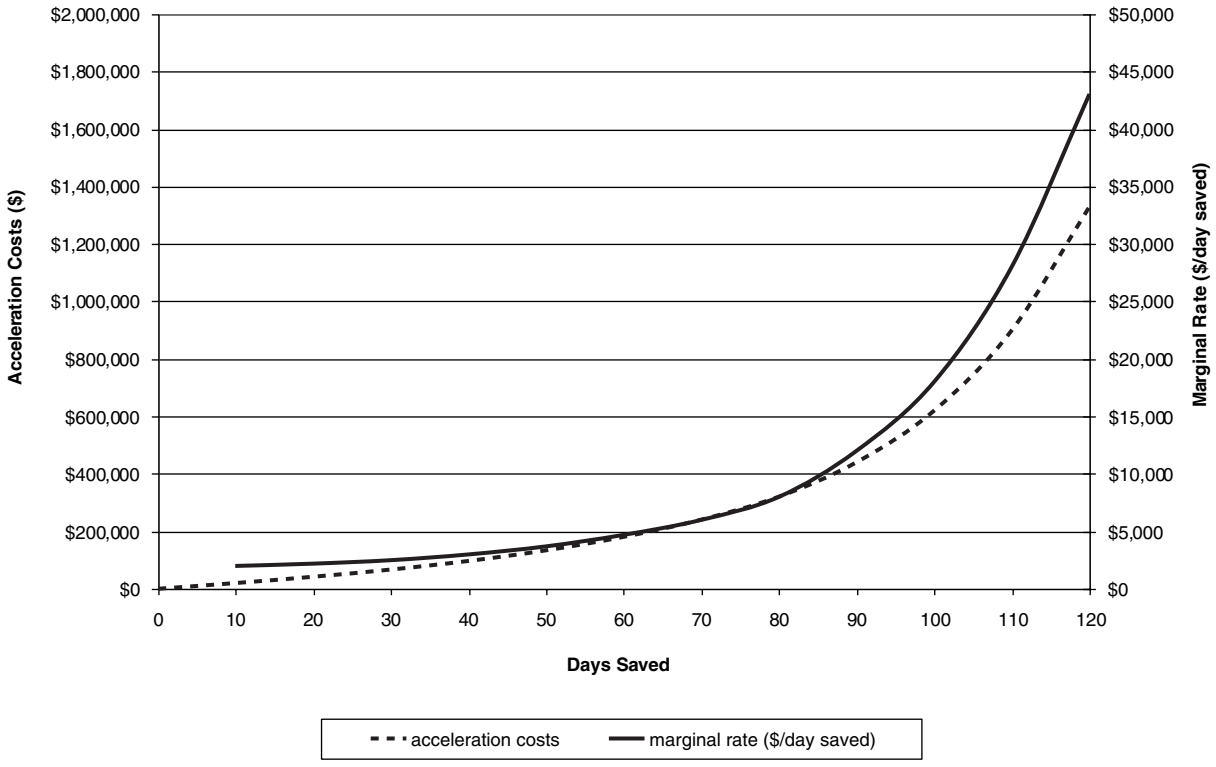

Figure 17. Hypothetical project acceleration cost curve.

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be incremental; they may be exponential. As shown in the hypothetical example in Figure 17, the marginal rate of acceleration ($/day) increases dramatically at approximately 70 days; requesting additional acceleration beyond this point would not be cost effective. Incentive capping not only provides the STAs with a predictable budget, it also puts them in a position to buy an accelerated project at a lower marginal rate, thus reducing the STAs' risk of overspending for acceleration.

Disincentive

How much will the contractor be charged for failing to meet the milestone date? When daily rates are used, the total disincentive is equal to the product of the daily disincentive rate × days of late completion. Lump sum disincentives are applied when the contractor fails to meet the specified milestone. The disincentive amount is the same whether the contractor finishes 1 day late or 1 month late.

Incentive

If the contractor finishes early, will he/she earn an incentive? If so, what amount will be earned? The incentive portion of a contract is not always used. Some STAs use a disincentive provision only. For daily incentives, the amount earned is equal to the product of the daily incentive rate multiplied by the days of early completion. Lump sum incentives are applied when the contractor completes the specified milestone early. The incentive amount is the same whether the contractor finishes 1 day early or 1 month early.

Substantial Completion

What determines when the I/D milestone is completed? Very specific criteria regarding the definition of substantial completion of the I/D milestone should be provided in the specification. It does not matter if the I/D milestone is an interim completion item such as opening a ramp to traffic or if it is the total project completion. Examples of substantial completion include the following:

- All pay items are completed.
- Traffic is in its final configuration and no work requiring lane and/or shoulder closures is required.
- The ramp is open to traffic and all traffic signals are operational.

Time Adjustments

Under what circumstances will the I/D milestone date be adjusted? This is one of the most complicated issues associated with time-related I/D provisions. There are I/D specifications that use a "no-excuse" clause. In its purest form, a no-excuse clause states that no time extensions will be considered in the calculation of a time-related I/D. Whether the contract time is determined by the contractor or the STA, a no-excuse clause in effect creates a complete-by date for milestone completion. Other I/D provisions treat time extensions in exactly the same manner as any other contract with the STA; standard specifications are used to evaluate requests for time extensions (additional time is allowed for all excusable delays).

In between the two extremes of the no-excuse clause and the day-for-day excusable delay approaches is where things get complicated. Weather is one variable that is handled in different ways. Some STAs transfer all the weather risk to the contractor, others share the risk by allowing time extensions for abnormal weather, and yet other STAs absorb all the weather risk through work day contracts. Other excusable delays such as plan errors, third party conflicts, and unforeseen conditions are treated in a variety of ways. There are I/D provisions that treat time extensions differently with respect to the incentive and disincentive. In these cases, time extensions may not be considered for the incentive milestone date but they will be considered for the disincentive milestone event.

A note about no-excuse clauses. FDOT has been a leader in the implementation of innovative contracting methods. Its approach to no-excuse clauses has evolved. FDOT has what it refers to informally as an "excusable no-excuse" clause. Under this specification, excusable delays that have a total impact greater than 15% of the time remaining are considered for a time extension. This is a compromise that recognizes a contractor may still earn an incentive even though the contractor was delayed due to circumstances beyond contractor control. However, this approach does not recognize the cumulative effect of multiple small delays, or what is commonly referred to as disruption delays. Best practices for I/D provisions should include a shared risk approach to no-excuse clauses, contractors should not be unduly penalized for circumstances beyond their control and they should be rewarded for overcoming delays and still meeting milestone criteria.

A note about specifying minimum and/or maximum B values. Specifying a not-to-exceed B value and/or a minimum B value is not a suggested best practice. For A + B projects, some STAs specify that a contractor may not bid less than or more than a specified number of days for B. Specifying a maximum or not-to-exceed B value is seen as a method to protect the STA from overpaying for an incentive in a non-competitive market or forcing a completion date to meet the STA's objectives. Similarly, specifying that contractors may not bid less than a minimum B value is seen as a way to protect the STA from excessive bid manipulation, which may inhibit the use of innovative materials and/or processes. In short, A + B is best applied when there are adequate market forces to influence accelerated construction and when plans, specifications, and project conditions are such that the potential for bid manipulation is mitigated. When these conditions exist, the need for a STA to specify minimum or maximum B limits is negated.

Types of Time-Related I/D Provisions and Suggested Combinations of Variables

A list of all the variations of time-related I/D provisions used by U.S. STAs would be impractical to compile. The local modifications are so numerous that it would be difficult to understand and could potentially lead to misapplication of I/D provisions. Instead, a matrix that identifies the suggested combinations of I/D types and variables is provided in Table 8.

It is also important to determine what type of project is compatible with a time-related I/D provision. Because there

Table 8. Matrix of I/D types and suggested variables.

I/D Provision Variables	I/D Calendar Day	I/D Working Day	I/D Complete-by-Date	A+B without I/D	A+B with I/D	$A+B_1+B_2+B_n$ (interim milestone(s) and/or total duration)	Lane Rental
Determination of Contract Time							
Owner	🟢	🟢	🟢	🔴	🔴	🔴	🔴
Contractor	🔴	🔴	🔴	🟢	🟢	🟢	🟢
Unit of Time							
Calendar Day	🟢	🔴	🟢	🟢	🟢	🟢	hourly or daily
Modified Calendar Day	🟢	🔴	🔴	🟢	🟢	🟢	
Work Day	🔴	🟢	🔴	🟡	🟡	🟡	
Disincentive Accrual & Capping							
Daily Capped	🔴	🔴	🔴	n/a	🔴	🔴	n/a
Daily Uncapped	🟢	🟢	🟢	n/a	🟢	🟢	n/a
Lump Sum	🟡	🟡	🟡	n/a	🟡	🟡	n/a
Incentive Accrual & Capping							
Daily Capped	🟢	🟢	🟢	n/a	🟢	🟢	n/a
Daily Uncapped	🟡	🟡	🟡	n/a	🟡	🟡	n/a
Lump Sum	🔴	🔴	🟡	n/a	🔴	🔴	n/a
Substantial Completion							
All pay items	🟡	🟡	🟢	🟡	🟡	🟡	n/a
Partial completion	🟢	🟢	🟢	🟢	🟢	🟢	n/a
Time Adjustments							
No-excuse	🟡	🔴	🟡	🟡	🟡	🟡	n/a
Excusable delays	🟢	🟢	🟡	🟢	🟢	🟢	n/a
Modified no-excuse	🟢	🟢	🟢	🟢	🟢	🟢	n/a
Time Adjustments Applied To							
Disincentive Only	🟢	🟢	🟢	n/a	🟢	🟢	n/a
Incentive and Disincentive	🟡	🟡	🟡	n/a	🟢	🟢	n/a

🟢	Use of this variable is acceptable
🟡	Use this variable with caution
🔴	Do not use this variable

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are so many types of highway construction projects, and all types have the potential to be accelerated, perhaps the better way to view this issue is to discuss what types of projects should not use a time-related I/D provision. Projects that have unknowns such as utility conflicts, right-of-way conflicts, sizable excavation where the material type(s) have not been identified, and innovative materials and/or techniques are being specified for the first time are not good candidates for time-related I/D provisions. The primary reason is that the occurrence of excusable delays erodes the effectiveness of I/D provisions. Contractors have a distinct advantage when negotiating the time impact of an excusable delay. Implementing a no-excuse clause to compensate for this potential erosion of I/D effectiveness is not an equitable solution nor is it a cost effective one. Although the risk of unknowns is passed to the contractor; when it reaches a certain level, it is returned to the STA through increased costs. As one of the contractors that participated in the Phase II research stated, "*. . . if the contract provision begins to look too much like a gamble to the Contractor, the Contractor will acknowledge the potential damages by budgeting to incur these. The likelihood that the STA then pays for the potential damages, but then never recoups the damages tends to favor the Contractor.*"

Table 9 contains general guidance on I/D provision type and project type.

Another way to look at the applicability of I/D provisions is provided in the following example:

Assume a suburban interstate reconstruction project that under normal circumstances would require 300 working days to complete. The approximate number of days saved by changing the working schedule from a 5-day work week to other alternatives is shown in Table 10.

For the given example, Table 10 shows that, without acceleration, this 300-working-day project would take approximately 483 calendar days to complete. When alternative work schedules are used, the approximate calendar days to complete this hypothetical 300 working day project varies from 386 to 217 calendar days. The conversion from working days to calendar days includes an adjustment for anticipated weather impacts. Quite often acceleration can be achieved by improved resource use and improved project management, shown in the second row of Table 10. This example is a simplified way to look at the approximate level of acceleration that can be achieved through various work week schedules. In reality, acceleration is achieved through a combination of increased working hours per week and improved resource use.

Many STAs have standard specifications that do not allow work on Sundays or holidays, some even limit Saturday work. Limiting the work week and hours conflicts with the desire to accelerate a project, which is inherent in the use of an I/D provision. Rather than specifying a work schedule (number of days per week) on an I/D project, STAs should specify that time will be measured by the calendar day and allow the contractor to adjust working hours as necessary to meet its schedule.

When specifying calendar days is not an available option for an I/D project, care should be taken when using I/D provisions other than A+B. Figure 18 shows the applicability of I/D provision types by specified work week schedule, as well as the approximate time savings that can be realized by adjusting the work week and hours.

A note about multiple shifts. Specifying multiple shifts should be limited to extreme circumstances. Human resources

Table 9. I/D provisions and appropriate projects.

I/D Provision	Appropriate Projects
Lane Rental	• Projects where the primary concern is minimizing the disruption of traffic and the nature of work items results in predictable lane closure durations • Overlay • Full depth patching • Dowel bar retrofit • Diamond Grinding • Full depth reclamation • Cold recycle
A+B (all variations)	• All types of projects except for emergency projects where competition is limited or projects that must be completed by a certain date (e.g., special event) • Use whenever the STA does not have the expertise to accurately estimate the project duration and the level of acceleration that is reasonable based on the incentive offered • Projects that have adequate competition to assure B durations are aggressive
I/D	• Emergency projects where competition may be limited • Projects that must be completed by a certain date (e.g., special event) • Use only if the STA has the expertise or is able to obtain the expertise to accurately estimate the project duration and the amount of acceleration that is reasonable to expect based on the incentive offered

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Table 10. Conversion of working day schedule to calendar days for different work schedules (using a 300-working-day project with normal production rates, normal resource allocation, and normal management techniques).

Work Schedule	Second Shift Efficiency Factor (adjust for estimated actual conditions)	Net Working Days per Week	Calendar Weeks	Calendar Days	Weather Factor	Weather Adjusted Calendar Days (adjust for estimated actual conditions)	Estimated Time Reduction (%)	Suggested Accelerated Schedule Multiplier	Suggested Contract Calendar Days
Normal 5-day week	n/a	5	60	420	1.15	483	n/a	n/a	n/a
5-day week with additional resources and/or improved management techniques	n/a	6	50	350	1.15	403	17%	0.90 to 0.80	435 to 386
6-day week	n/a	6	50	350	1.15	403	17%	0.90 to 0.80	435 to 386
7-day week	n/a	7	43	300	1.15	345	29%	0.75 to 0.65	362 to 314
*5-day week with 2 shifts	0.6	8	38	263	1.15	302	38%	n/a	n/a
*6-day week with 2 shifts	0.6	9.6	31	219	1.15	252	48%	n/a	n/a
7-day week with 2 shifts	0.6	11.2	27	188	1.15	216	55%	0.50 to 0.45	242 to 217

*Shown for illustration only, specifying 5- or 6-day weeks with 2 shifts is impractical. If conditions require the contractor to utilize 2 shifts, the contractor will likely work 7 days per week to accelerate as much as possible, with the aim of returning to normal working hours more quickly.

are a valuable commodity to contractors. Requiring multiple shifts may severely hamper a contractors' ability to manage their portfolios of work or prevent them from acquiring backlog that could be addressed if human resources were freed up from a multiple shift scenario.

I/D Decision Process Guide

The decision to incorporate an I/D provision into a contract should be considered from the onset of project planning. The following project development framework is used as a template for the I/D decision making process.

Project Development Phases

1. Scoping and Environmental Approval
2. Project Design
3. Plans, Specifications, and Estimates (PS&E)
4. Contract Award
5. Construction

Multiple activities related to the proper implementation of I/D provisions occur within each of these project development phases. Guidance is provided for the effective use of I/D provisions within each of the project development phases.

Scoping and Environmental Approval

The initial phase of project development establishes the objectives of the project. Project needs and conditions must be characterized. Environmental approval documents must be prepared and submitted. Feasible alternatives should also be identified and evaluated. Activities directly related to the use of I/D provisions include the following:

- Preliminary cost estimates
- Preliminary time estimates
- Assessment of project impacts on the public

Project Design

Activities and decisions regarding I/D provisions should progress through the design phase of project development. As project designs are developed and refined, I/D provision types and variables should be identified that are compatible with the project details. The project design development phase is broken down into these three activities:

- 30% design
- 60% design
- 90% design

Plans, Specifications, and Estimates (PS&E)

The final phase of project development includes the following activities directly related to the use of I/D provisions:

- Final plans
- Final specifications
- Final cost estimate
- Final time estimate

This is the final opportunity to coordinate plans, specifications, and time-related I/D objectives. A thorough review of

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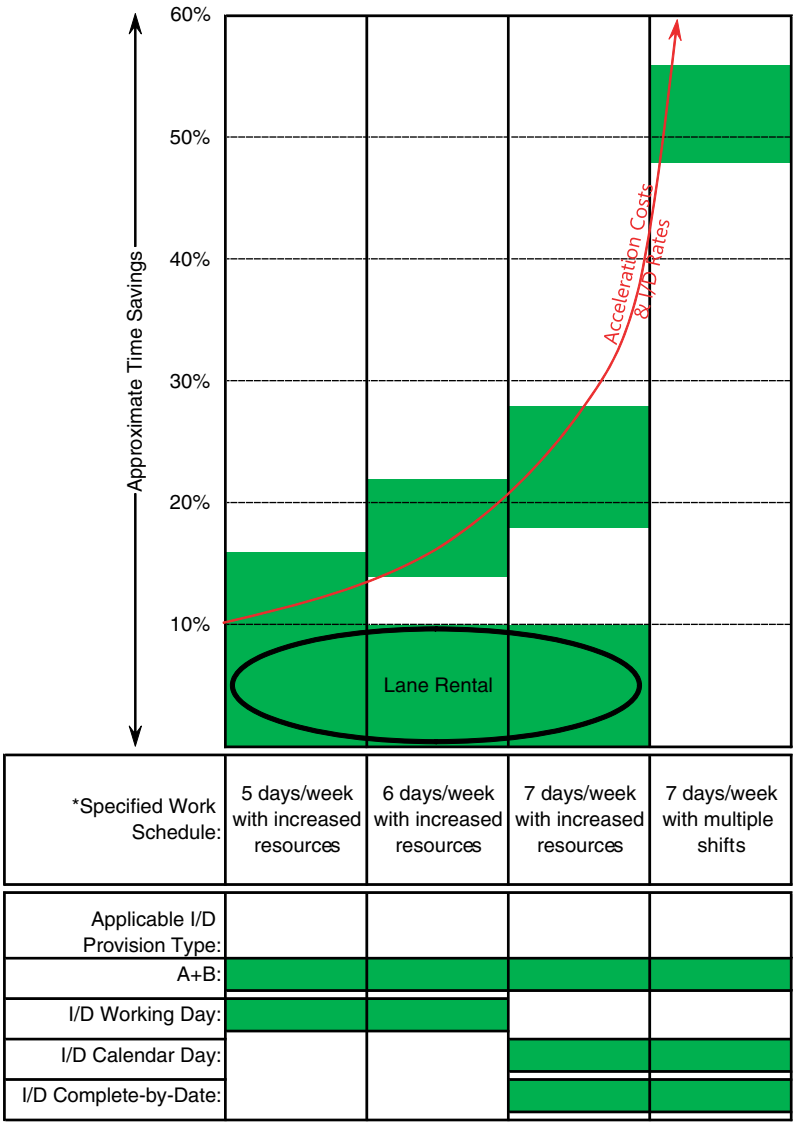

*Specified work schedule dictates how contract time is measured. Contractors may elect to utilize a different work schedule to construct the project.

Figure 18. Approximate time savings by scheduled work week/hours.

all contract documents should be accomplished to identify and correct any conflicts between the documents. Also, a pre-bid meeting should be conducted to clearly communicate the I/D provision objectives and to receive feedback from contractors. Any revisions made to the project during the PS&E phase should trigger a thorough review to ensure that the I/D provision is still compatible with the revised project plans and specifications and that no conflicts have been created by the revisions.

Contract Award

Before award is made, bids should be reviewed for obvious unbalancing, which may be attributable to the use of an I/D provision.

Construction

Contract time charges and field changes should be thoroughly documented for equitable calculation and assessment of any earned I/Ds.

Time-Related I/D Checklist

- Gauge the level of competition for bidding on the project; apply the appropriate I/D type for the estimated level of competition and offer I/D rates that will motivate accelerated construction.
- Increase the pool of available bidders by allowing flexibility between the bid award and start of construction.

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Preliminary Cost Estimates

Objective:	• Determine the cost of the project
Key items for consideration:	• Project length • Number of structures • Magnitude of excavation and embankment • Right of way acquisition • Utility relocation
Methods:	• Historical data—cost per mile (and feature) for comparable project scope • Contingency costs for perceived unknowns
Output related to the use of I/D provisions:	• Project budget

Preliminary Time Estimates

Objective:	• Establish the schedule for project development phases • Determine the approximate construction duration of the project
Key items for consideration:	• Project length • Number of structures • Magnitude of excavation and embankment • Existing conditions and maintenance of traffic requirements that will dictate multiple phases • Right of way conflicts during construction • Coordination of utility relocation
Methods:	• For STAs in regions where climate conditions prevent performance of work throughout the year, a determination of whether the project can be completed in one construction season or whether it will require multiple construction seasons • Measured mile techniques based on historical performance for similar projects • Bar chart scheduling by major phase • Time contingencies for unique project features and unknown conditions
Output related to the use of I/D provisions:	• Project development schedule milestones including proposed bid opening year and month (The schedule should include allowing flexibility between the bid letting and the start date to increase competition. This can save significant cost for the STA.) • Estimated project duration for construction activities (calendar days)

Assessment of Project Impacts on the Public

Objective:	• Characterize the impact the project will have on the public
Key items for consideration:	• AADT and preliminary RUC estimate • Traffic mix—commercial traffic vs. commuter/leisure traffic • Detour alternatives • Special events • Construction noise, dust, and construction traffic on local roads
Methods:	• Analysis of traffic data • Public meeting(s) to obtain community feedback
Output related to the use of I/D provisions:	• Brief report summarizing the project's impact on the public, indicating whether the use of an I/D provision would be effective at reducing that impact and the degree to which an I/D provision would likely be justified by RUC (low, medium, or high)

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30% Design

Objective:	• Identify project specific details that could become potential barriers to the successful use of an I/D provision

Key items for consideration:	• Identify and characterize the potential for project unknowns (low, medium, or high) that may result in compensable delays during construction
	  ○ Unstable/unsuitable soils and other geotechnical issues
	  ○ Utilities
	  ○ Unique design and construction features
	  ○ Right-of-way conflicts
	  ○ Third party conflicts
	• Evaluation of detour alternatives vs. accelerated construction during full closure that would dictate the use of an I/D provision
	• Maintenance of traffic requirements
	• Refinement of the time estimate
	• Initial RUC estimate

Methods:	• Geotechnical site investigation • Utility location survey and relocation of utilities before the project start where possible • Internal review by experienced personnel assessing the status of project unknowns and their potential for contributing to compensable delays • Critical path method scheduling using project phases and major work items as the activities
Output related to the use of I/D provisions:	• Summary document listing potential barriers to the successful use of an I/D provision that should be fully evaluated during the 60% design stage • RUC estimate • Maintenance of traffic criteria that will dictate project design details and construction activities (e.g., maintain 2 through lanes at all times, one lane may be closed only between 7:30 pm and 5:30 am, Ramp A may be closed for a maximum of 14 days between March 1 and April 30)

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60% Design

Objective:	• Final determination of whether an I/D provision is appropriate for a specific project and, if so, which type(s) of I/D provisions should be considered

Key items for consideration:	• Compatibility of the design with the maintenance of traffic criteria developed in the 30% stage
	• Design details and refinement of the design assumptions made during the 30% stage that affect the following items:
	  ○ Unstable/unsuitable soils and other geotechnical issues
	  ○ Utilities
	  ○ Unique design and construction features
	  ○ Right-of-way conflicts
	  ○ Third party conflicts
	  ○ Other items that may result in a excusable delay during construction
	• Refinement of the time estimate
	• Refinement of the RUC estimate
	• Appropriate I/D provision types and variables
	  ○ Level of acceleration necessary
	  ○ Project budget and reasonable I/D rates that will achieve the acceleration requested

Methods:	• Internal review by experienced personnel • Constructability review by industry • Evaluate and update the summary document produced in the 30% stage; specifically address the status of the potential barriers to I/D implementation (resolved or unresolved) based on the 60% design details • Critical path method scheduling using project phases and major work items as the activities; durations based on average production rates and design quantities • Recommended I/D provision types and variables (Figure 18 and Tables 8 and 9)

Output related to the use of I/D provisions:	• Recommendation of whether or not an I/D provision is appropriate for the project
	  ○ Indicate what type of I/D provision is most suitable and which I/D variables should be used
	  ○ List critical milestone events which will be subject to I/Ds (e.g., re-opening of a ramp, completion of a detour, substantial completion of Phase I)
	• List potential barriers to the successful implementation of an I/D provision that need to be resolved in the 90% design stage

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90% Design

Objective:	• A project design that is compatible with accelerated construction, the maintenance of traffic criteria, and I/D provisions

Key items for consideration:	• Compatibility of the design with the maintenance of traffic criteria developed in the 30% and 60% stages
	• Design details and refinement of the design assumptions made during the 60% stage that affect the following items:
	  ○ Unstable/unsuitable soils and other geotechnical issues
	  ○ Utilities
	  ○ Unique design and construction features
	  ○ Right-of-way conflicts
	  ○ Third party conflicts
	  ○ Other items that may result in a excusable delay during construction
	• Baseline time estimate
	• Accelerated time estimate
	• Final RUC estimate and proposed I/D rates

Methods:	• Internal review by experienced personnel • Resolution of potential barriers to I/D implementation that still remain after the 60% design stage • Critical path method scheduling; activities and durations should be based on project quantities, average production rates, and a normal work calendar • Accelerated time estimate; based on a conservative reduction in construction time based on the desired work schedule (Table 10) • Final recommendation of I/D provision type and variables (Figure 18 and Tables 8 and 9)

Output related to the use of I/D provisions:	• Revise and refine the recommendation of whether or not an I/D provision is appropriate for the project
	  ○ Indicate what type of I/D provision is most suitable and which I/D variables should be used
	  ○ List critical milestone events which will be subject to I/Ds (e.g., re-opening of a ramp, completion of a detour, substantial completion of Phase I)
	• Indicate that all potential barriers to the successful implementation of an I/D provision have been considered and are either fully resolved or present a level of risk that can be tolerated

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- Avoid overloading the market with I/D projects.
- Clearly define the I/D milestone(s) and the method for resolving excusable delays. Clearly state when time charges begin, when they cease, and under what conditions they may be adjusted.
- For non-A + B I/D projects, evaluate whether schedule milestones can be reasonably achieved.
- Perform a comprehensive site investigation and plan review to minimize the potential for excusable delays and unit price manipulation.
- Coordinate plans, construction sequencing, and I/D provision language with constraints imposed by local ordinances (noise, work hours, etc.).

Guidelines for Maximizing the Effectiveness of I/D Provisions

1. If a competitive market exists, use an A + B I/D provision.
2. Increase the pool of available bidders by allowing flexibility between the bid award and start of construction.
3. Use an A + B I/D provision if the STA is not capable of accurately estimating the construction duration and the level of acceleration that is reasonable based on the incentive offered.
4. Cap incentives as a means to limit the STA's exposure to overpaying for acceleration.
5. Because a capped incentive is the product of the specified daily I/D rate and the maximum number of days that the STA is willing to pay for early completion, set the daily I/D rate at a level that will motivate the contractor and also allow the greatest number of days that incentive will be paid. Offering 100 days of incentive at $10,000 per day will likely produce earlier completion than offering 50 days of incentive at $20,000 per day.
6. Use calendar days to measure time. Using working days or modified calendar days introduces ambiguity that may lead to an inequitable assessment of incentive or disincentive.
7. Base I/D rates on an RUC estimating procedure that is uniformly applied for all projects. The percentage of RUC that is used as the I/D rate should be a function of available budget, market conditions, and the level of acceleration desired.

CHAPTER 5

Evaluating I/D Effectiveness

Metrics to Quantify I/D Performance

The primary factor for determining whether a time-related I/D was indeed effective is whether the contractor was able to meet the I/D milestone and was paid an incentive for early completion. Beyond this analysis, STAs should implement a process for reviewing the effectiveness of I/D provisions. This "look back" process should at a minimum provide unbiased feedback on the following items that have the greatest potential to erode the effectiveness of I/D provisions:

- Tabulation of the frequency and impact of excusable delays that were actually encountered on the project.
- An analysis of overrun and underrun quantities that actually occurred on the project. Review the final quantities and hypothetical total contract cost for all contractors that originally bid on the project.
- A summary report should be prepared by the STA's project engineer providing lessons learned that can be implemented in future project designs and specifications. Post construction meetings held with both agency and contractor personnel have been very beneficial as an approach for capturing these lessons learned.

Every highway construction project provides unique situations that make quantitative comparisons between them very difficult, if not impossible. However, qualitative assessments can be made that enable the STA to refine its use of I/D provisions, ultimately leading to more effective use of time-related I/Ds.

Future Research Needs

Future research efforts related to time-related I/D provisions should focus on three areas. First, the enforceability of no-excuse and modified no-excuse clauses should be characterized. Many projects have been completed using no-excuse provisions, yet there are no publicized precedents of these clauses being challenged in court. This lack of legal precedent leads one to believe that claims related to no-excuse clauses have been strategically settled to avoid setting any precedent.

Second, further research should be undertaken to investigate the construction industry's ability to cope with issues related to performing more work at night and under multiple shift scenarios. As STAs continue to move toward a strategy that places a higher value on satisfying road user demands, it seems logical that an increasing amount of work will be performed at night and under multiple shift schedules. The guidance contained in this report suggests that multiple shifts should only be scheduled under extreme circumstances. Contractors and STAs need to have a clear understanding of the impacts on human resources (fatigue, changing work hours between different projects, safety, etc.) before proceeding with an increased use of night work and multiple shift schedules.

Finally, innovative risk sharing strategies should be implemented and evaluated.

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APPENDIX B

Summary of I/D Provisions

The following table presents a summary of 49 I/D specifications that were gathered during the research project. Approximately one-third of these provisions are project specific, the other two-thirds are boilerplate templates. These specifications represent a wide cross section of STAs and their differing approaches to time-related I/Ds.

State/Province	I/D Specifications Obtained Title and Key Features
Arkansas	**Site Use (A+C Method)** o C = working days x daily RUC o No work allowed on Sundays and holidays o Time extensions allowed for quantity overruns, change orders, delays resulting from acts or omissions of the agency o Incentive is capped o Disincentive accrued based on working days in excess of those established by the contractor o Liquidated damages are separate and in addition to disincentive
California	**A+B** o B does not include plant establishment period o Maximum B is set by the agency, any bids which exceed this maximum B are considered non-responsive o One example from District 7 has an incentive of $50,000 per day capped at $3,000,000 and a disincentive of $16,500 per day o A second example from District 7 uses A+B for the entire duration but also has an interim milestone I/D of 40 calendar days for the completion of a bridge
Florida	**Incentive-Disincentive, & "Bonus" Payment and Waiver of Contractor Claims** o Completion date(s) set by the agency o No-excuse, except for catastrophic events and appeals to the Chief Engineer for impacts that exceed 15% of the remaining time o The contractor waives all rights to any claims if incentive payments are accepted o Incentive payments are capped o Disincentives are capped **Incentive-Disincentive for A+B** o All of the same features as above except the contractor determines contract time **Liquidated Savings for Early Completion** o Payment for early completion is not considered an incentive, but liquidated savings related to Construction Engineering Inspection and Contract Administration costs o Contract time includes all adjustments in accordance with standard specifications **Incentive-Disincentive for Lane Rental Days** o Maximum lane rental days is set by the agency o Lane rental days are measured in ½ day increments o The difference between allowable lane rental days established by the agency and the actual lane rental days used by the contractor is paid to the contractor or deducted from contractor earnings o Recovery costs are assessed for every 30 minutes that all lanes are not open in accordance with the traffic control plans

State/Province	I/D Specifications Obtained Title and Key Features
Georgia	**Special Provision 108—Prosecution and Progress, De Kalb Co.** o Fixed completion date set by the agency o $10,000 per day incentive capped at $1,000,000 o No time extensions except for catastrophic events o Waiver of all claims if incentive payment is accepted by the contractor o Disincentive calculations are adjusted for delays in accordance with standard specifications o Disincentive of $10,000 per day is clearly defined as a liquidated damage and not a penalty o Interim milestones related to specific maintenance of traffic conditions have separate liquidated damages
Hawaii	**Rental Fees for Unauthorized Lane Closure or Occupancy** o Lane rental fees charged in 1 to 15 minute increments for each lane that is closed beyond the specified time frames in the contract o Lane rental can be waived for factors beyond the contractors control o "Equipment breakdown is not a cause to waive liquidated damages"
Idaho	**Project Acceleration (Incentive/Disincentive)** o Bidder determines time (A+B) o Calendar days bid should not include holidays o Maximum B is set by the agency o 5% maximum incentive and disincentive o Additional liquidated damages begin to accrue 30 days after the completion date set by the contractor o Time extensions based on CPM analysis o Time extensions allowed for overruns, changes, differing site conditions, utilities, owner delays in approving submittals, any day when weather prevents work on the critical path for more than ½ of the day
Indiana	**Incentive for Opening Project to Traffic Ahead of Schedule** o Fixed date set by the agency o Daily incentive rate with a cap o Time extension granted for agency delay in issuing the notice to proceed and if the work is materially changed
Iowa	**Incentive/Disincentive for Early Completion** o Closure days is defined as a calendar day occurring during a critical closure activity o Allowable closure days are set by the agency and include normal adverse weather o Time is adjusted for non-weather related items: overruns, strikes, legal stoppages, material shortages, and natural disaster o Time extensions are based on CPM analysis o Weather delays must exceed 5 consecutive days to be considered for time extension o Incentive/Disincentive based on actual closure days compared with allowable closure days—incentive is capped **A+B Bidding** o Daily RUC defined as average daily cost of interference and inconvenience to the road user o No I/D associated with this specification

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State/Province	I/D Specifications Obtained Title and Key Features
Iowa (continued)	**Lane Rental (Hourly)(A+B Bidding with Incentive/Disincentive)** o Bidder determines lane rental days (B) o Lane rental I/D is based on actual lane closures compared with the lane rental estimated by the contractor o Lane rental charges may be adjusted for extraordinary circumstances after the contractor has absorbed the first 10 consecutive hours of delay o Time extensions granted for circumstances similar to I/D for Early Completion specification
Maine	**Additional Bidding Requirements and Contract Conditions** o I/D rate = $25,000 per day o Work allowed 24-7 except for work near the hospital (pier #5 to abutment #2) **Incentive/Disincentive for Early or Late Completion for the B Portion of the Work** o B work cannot begin before 11FEB2006 and must be complete by 31MAY2006 (109 days) o $25,000 incentive for completing before the B time established by the contractor o $25,000 disincentive is increased to $35,000 per day after 90 days elapse o Time and I/D adjustments are made based on standard specifications **Time** o CPM schedule must be submitted with the bid o Detailed CPM requirements o Pay items for initial schedule and bi-weekly updates
Michigan	**Extension of Time and Extra Cost for Incentive/Disincentive Projects** o No time extensions except for labor disputes and material shortages o Cost increases related to keeping the project on schedule may be considered for no access to right-of-way, utility conflicts, interference from related contracts, suspension of the work, increased quantities and extra work **Lane Rental** o Contractor bids estimated lane rental o Lane rental is measured in hours o Lane rental is charged against the contractor's estimated amount—any balance remaining is paid to the contractor, if lane rental exceeds the estimate, it is deducted from earnings due on other items o Lane rental may be adjusted for increased work
Minnesota	**A+B Calendar Day and A+B Working Day** o Agency sets both a Minimum B and a Maximum B—contractor time bids outside this range will be rejected o Incentive is capped o If B encompasses the entire project, liquidated damages are added to daily RUCs **Incentive-Disincentive** o Fixed completion date set by the agency o Daily incentive rate o Capped incentive

State/Province	I/D Specifications Obtained Title and Key Features
Minnesota (continued)	**Lane Rental Method** o Bidder estimates lane rental—incentive or disincentive is based on actual lane rental charges o Lane rental is not charged for extra work o No lane rental charges for lane restrictions that are left in place during shut downs due to adverse weather or major equipment breakdowns unless the situation could have been avoided by reasonable planning Liquidated Savings o Liquidated savings are capped
New York	**Incentive/Disincentive** o Multiple I/D periods may exist on a single project—they are uniquely identified by maximum calendar days to complete, start and end dates, daily rate, maximum incentive, and time frames allowed o Time and I/D extensions are allowed in accordance with standard specifications, based on CPM o Liquidated damages do not apply to I/D portions of the work; however, actual engineering and inspection costs may be charged **Incentive Payments/Disincentive Assessments for Work Subject to the Special Note Incentive/Disincentive Clause** o I/Ds shall be paid on completion of the I/D portion of the project **Provisions for A+B Bidding** o Multiple B portions may be specified o Incentive is capped o Time and I/D extensions are allowed in accordance with standard specifications, based on CPM **Provisions for Lane Rental** o Bidder estimates lane rental o Lane rental overruns are deducted from the contractor o Lane rental may be modified for extra work and delays
North Dakota	**Contract Time for Completion—Incentive/Disincentive** o Fixed completion date set by the agency (22SEP2006) o Limitations on when work may commence o Interim milestones with disincentive only: $2,500 per day o No extension for changes, increased quantities or delays; but, the incentive date may be moved up if quantities underrun or the scope of work is decreased o Incentive capped o Time extensions may be considered for adjustment to the disincentive only o No work on Sundays
Ohio	**Incentive/Disincentive Contract** o Fixed date(s) set by the agency—multiple I/D periods may be specified o Incentive capped at 5% of contract o Incentive does not have to be equal to the disincentive o Daily I/D accrual o No time extensions for weather, except flooding, blizzard, tornado, etc.

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State/Province	I/D Specifications Obtained Title and Key Features
Ohio (continued)	**Lump Sum Minus Incentive** o Fixed completion date(s) set by the agency o Lump sum incentive paid if milestone dates are met o Daily disincentive accrual if milestones are not met o Time is extended for weather **A+B Bidding** o Maximum B set by the agency o Time extensions considered in accordance with agency policy o Incentive is capped o Agency sets maximum days to finish the entire project after the B milestone has been met **Lane Value Contract** o Disincentive for lane closures o Contractor must estimate lane closure charges and be included in other items of work **Unauthorized Lane Use** o Disincentive for lane closures o Contractor must estimate lane closure charges and be included in other items of work **Window Contract** o Interim milestones have maximum calendar days set by the agency o The contractor has the flexibility to schedule the milestones at any time during the project
Oklahoma	**A+B Bidding** o Maximum B set by the agency o Incentive is capped o The B time sets a complete-by-date that the contractor is expected to "overcome all" to reach o Incentive is not adjusted for any reason o Disincentive may be reduced due to delays caused by unforeseen subsurface utilities o Unusually severe weather impacts are only considered for liquidated damages which are separate from I/D
Oregon	**Multiple Project I/D Specifications (*11*)** o Many project specifications include capped disincentives o Many combinations of calendar day and fixed date completion times set by the agency o Multiple interim milestones all subject to I/Ds
Tennessee	**Project Completion and Incentive/Disincentive Payments: Davidson Co.** o Fixed completion date set by the agency o Daily incentive of $7,500 capped at $2,500,000 o Time extensions in accordance with standard specifications o Very restrictive lane closure requirements—only allowed nights and weekends o Rolling roadblocks specified for blasting operations and bridge beam erection

State/Province	I/D Specifications Obtained Title and Key Features
Utah	**Bidding Contract Time** o A+B can be used with multiple milestones o Agency sets: start milestone, finish milestone, I/D rate, minimum and maximum calendar days allowed o Incentives are capped o Agency sets maximum calendar days for the contractor to achieve final completion after substantial completion has been accepted o Time extensions are in accordance with standard specifications **Lane Rental** o Bidder estimates lane rental—incentive or disincentive is based on actual lane rental charges o Lane closure outside the allowable times are assessed a liquidated damage 1.5 times the highest lane rental rate for that day of the week o Lane rental measured to the nearest ¼ hour
Ontario, Canada	**Operational Constraint—Incentive/Disincentive** o I/D tied to very specific milestone—all surface course completed within xx days of the start of pavement milling operations o Lump sum incentive of $30,000 for meeting calendar day requirement set by the agency o Also daily incentive of $2,000 per day for early completion—capped at $30,000 o Disincentive is lump sum and daily, too

APPENDIX C

Research Results

Results for the E-mail Interview Form

Types of Time-Related I/D Provisions in Use

Complete-by-date and A+B I/D provisions are used by more than 90% of the STAs that responded to the e-mail interview form. Lane rental provisions are used by 59% of the respondents. Incentives and disincentives associated with interim milestones ($A+B_1+B_2+B_n$) are used by nearly one-third of the states represented in the data set. Liquidated savings provisions are far less common than the other types of I/D provisions. Figure C.1 illustrates the percentage of states using different types of I/D provisions. These data do not show the frequency at which each type of provision is used; rather they reveal which types of provisions are more widespread among the STAs that responded to the e-mail interview form.

One additional type of I/D provision was discovered in the literature search. ADOT used a travel time I/D specification on a design-build project. This provision used the average travel time through the project as the measurement criteria for awarding incentive or assessing disincentive.

Plans to Use Time-Related I/D Provisions in the Future

The majority of the STAs that responded to the e-mail interview form appear to be comfortable with their use of I/D provisions, as 69% of them plan to keep using I/D provisions at about the same frequency as they have in the past. Only two of the STAs indicated that they would not use time-related I/D provisions in the future. Additionally, two more STAs plan to use I/Ds less frequently than they have in the past (Figure C.2).

The responses indicate that STAs are heeding FHWA's suggested guidance that "I/D provisions should not be used routinely."

Factors Used to Determine If I/D Provisions Should Be Used

E-mail interview responses show that RUCs are the most important factor considered for determining if a project warrants the use of an I/D provision. On average, STA respondents felt that RUCs were approximately 60% more important than special events, anticipated feedback, and public/political input as a decision making factor in the use of I/D provisions (Figure C.3).

A note regarding the graphical presentations of data collected during Phase I:

The average of interview responses or ranking values is shown. Each bar in a graph represents the calculated average of the corresponding data set. For example in Figure C.3, respondents were asked to rank the importance of four (4) factors affecting the use of I/D provisions; the average of 32 responses for "User Cost" is 2.2. Some of the graphs also show the upper and lower quartiles as an indication of the variability within the data set. Using Figure C.3 as an example, the lower quartile for "User Cost" is equal to 1.7 and the upper quartile is equal to 3.0; meaning that 25% of the rankings were less than 1.7, 50% of the rankings were between 1.7 and 3.0 and the remaining 25% of the rankings were greater than 3.0.

Agency Methods Used for Estimating Contract Duration

The primary method used by STAs to estimate project durations is nearly evenly split between historical experience (54%) and critical path method (46%) (Figure C.4). Written comments provided in the e-mail interview forms regarding the primary method used to estimate contract duration include the following:

- California—"Although CPMs are utilized during project development to estimate project duration in many cases, it is not standard practice for all projects. In any case, some

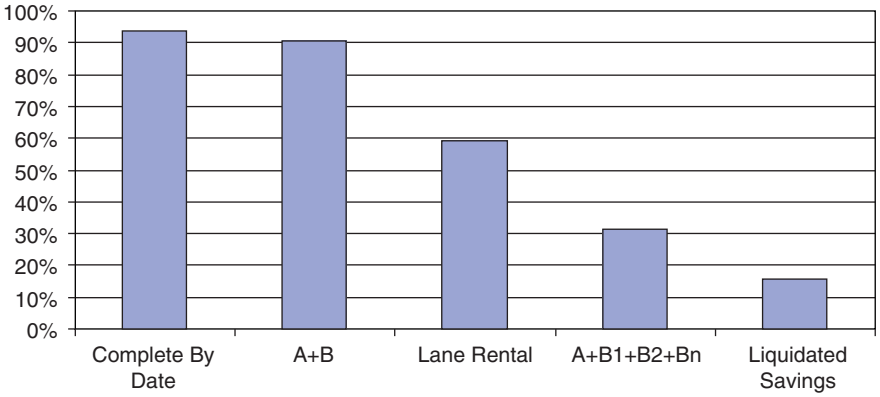

Figure C.1. Use of I/D provision types by STAs responding to the e-mail Interview form.

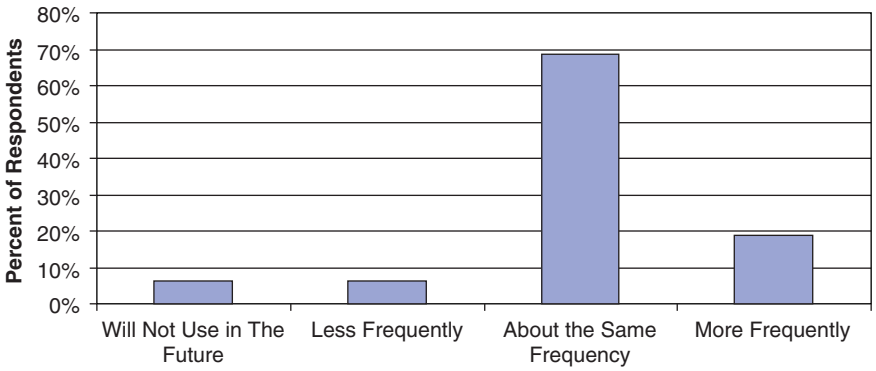

Figure C.2. STA plans to use I/D provisions in the future (n = 31).

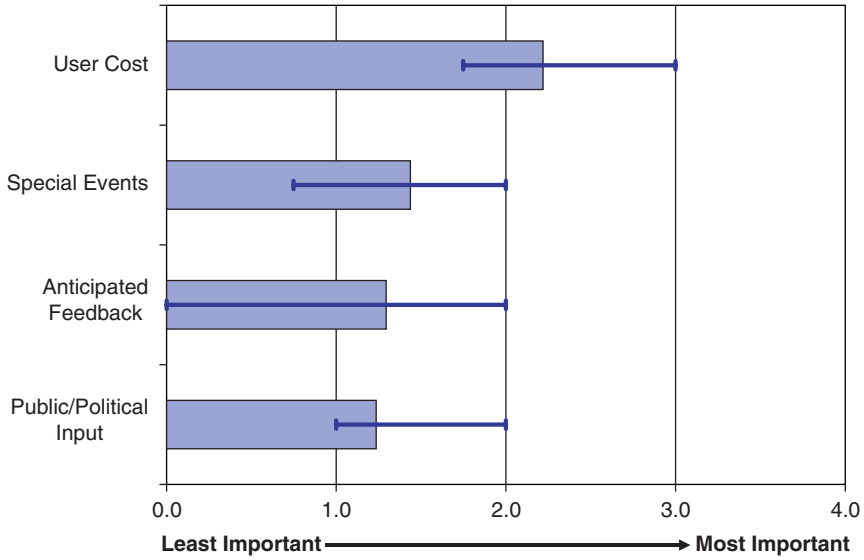

Figure C.3. Relative importance of factors affecting the use of I/D provision (n = 32).

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Figure C.4. Primary method used to estimate contract duration (n = 28).

type of schedule (e.g., bar chart) is prepared during project development."

- Tennessee—"A combination of a less detailed CPM of major items combined with historical experience."
- Minnesota—"We have used CPM on our larger complex projects."
- Texas—"Historical experience and Bar Chart (CPM)."

Based on the feedback from the e-mail interview form, STAs are not fully using CPM scheduling techniques. Accuracy of contract duration estimates has a significant impact on the effectiveness of I/D provisions. Implementing CPM scheduling entails more than just software training. Construction experience must be integrated with calculating durations and assigning logic. Sequencing schedule activities to avoid conflicts that are inherent in the plans requires a complete understanding of highway construction.

Contract Time Extensions

Almost one-third of the STA respondents indicated that contract time is not subject to adjustment for any reason. Contract time extensions for weather or utilities are allowed by over 40% of the STAs (Figure C.5). This e-mail interview question generated many comments in the "other" category. Some of these comments follow:

- California—"Our contracts generally provide for excusable and compensable delays to the contract completion date."
- Virginia—"unknowns not within the contractor's control"
- Michigan—"Fixed completion date with special provision for payment to accelerate but no additional time is allowed."
- Minnesota—"We are going to try a Locked Incentive Date specification based on Florida's No Excuse Bonus on one of our Metro projects next year."
- North Dakota—"The incentive date is a no-excuse date. We do allow the disincentive date to be moved for certain factors."

The manner in which time extensions are handled has a direct impact on the effectiveness of I/D provisions. This issue is related to what type of I/D provision is used and the specific language of a provision. STAs and contractors both need to understand how different elements or variables of common I/D provision types work together or, in some cases, do not work together.

California DOT and NYSDOT have documented comparisons between time extensions granted on I/D and non-I/D projects. NYSDOT's experience reveals that approximately 50% of all contracts grant time extensions while 42% of A+B contracts have adjustments to the B time. The most common reasons for time extensions were revisions to bridge related components (25%), utilities and drainage redesign (24%), overrun of pavement repair quantities (17%), added or revised lane closure restrictions (9%), additional pile quantities or revised piling design (6%) and delayed award (5%). California DOT's results are similar: 48% of A+B projects experienced time growth compared with 43% of non-I/D projects.

Cost growth was also examined by NYSDOT and California DOT. When adjusted for two outliers, NYSDOT's comparison between 98 A+B contracts and 2,636 normal contracts showed the average cost growth of A+B contracts to be within ½% of the other contracts. Again, California DOT's results are similar for cost growth. Average cost growth for A+B projects was 24% and non-I/D project average cost growth was 26%.

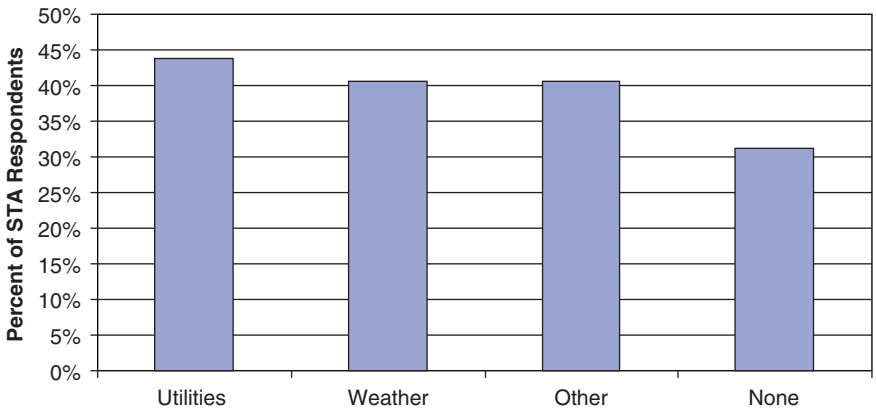

Figure C.5. Allowable causes for contract time extensions on I/D projects (n = 28).

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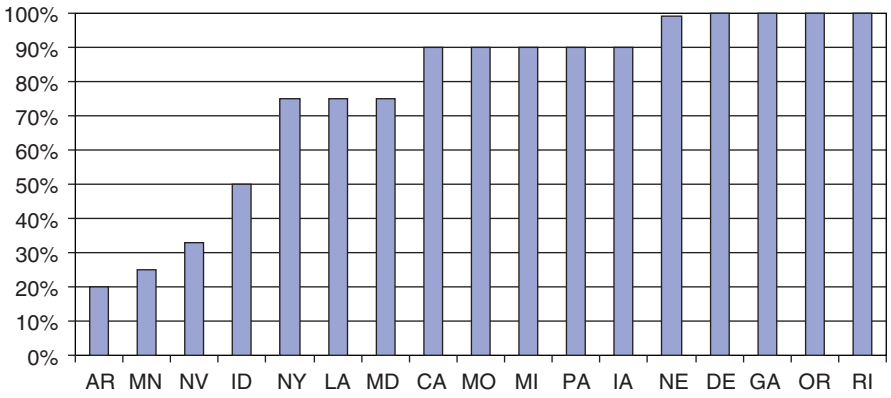

Figure C.6. Percent of projects earning maximum incentive by state (last 2 fiscal years) (n = 17).

Incentives Earned

Three-fourths of the respondents indicated that I/D projects typically resulted in the contractor earning significant incentives. None of the STAs indicated that I/D projects typically resulted in disincentive charges to the contractor nor did they indicate that projects finished late with reduced disincentive charges.

This response is further validated by Figure C.6 and the fact that 13 of 17 STAs stated that at least 75% of all I/D projects in their state over the last 2 fiscal years had resulted in the contractor earning the maximum incentive allowed.

Budgeting for I/Ds

The majority of STAs budget for I/Ds in some manner, with only one-fourth of the responding STAs indicating they do not specifically budget for I/Ds (Figure C.7). This budgeting question also generated some comments worth noting:

- California—"Included in estimate as Supplemental Work."
- Michigan—"A determination to use an I/D provision is usually made at the later stages of the design process. Therefore, the cost is usually budgeted for at that time. MDOT is presently in the process of trying to identify these I/D projects during the scoping phase and to include the amount in the original programmed project amount so as to eliminate funding transfers. This will help stabilize our program delivery."
- Delaware—"It's been overlooked."
- Ontario, Canada—"Budgeting for incentives is inconsistent."

Projects that will include I/D provisions should be identified early in the project development phase. This is not only a best practice with respect to budgeting needs, but it also allows project design to accommodate accelerated construction.

I/D Impacts on Quality

Based on the perceptions and experiences of the e-mail interview respondents, time-related I/D provisions do not negatively impact the project quality to any great degree. Only 5 of the 32 STAs have experienced quality deficiencies that they attribute to project acceleration from I/D provisions (Figure C.8).

MNDOT reports anecdotal evidence from some of its field staff who believed that the quality of work was reduced on A+B and lane rental projects. According to a study performed by the Kentucky Transportation Center, quality is not negatively impacted by time-related I/D provisions. This study

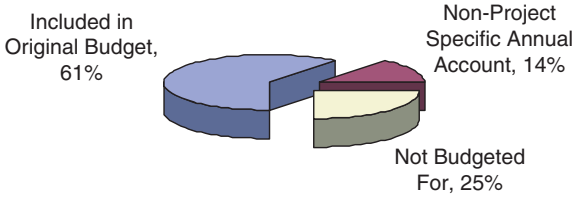

Figure C.7. I/D budgeting (n = 28).

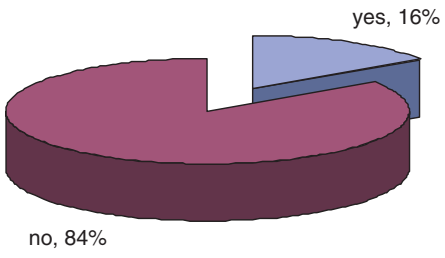

Figure C.8. I/D impacts on quality (n = 32).

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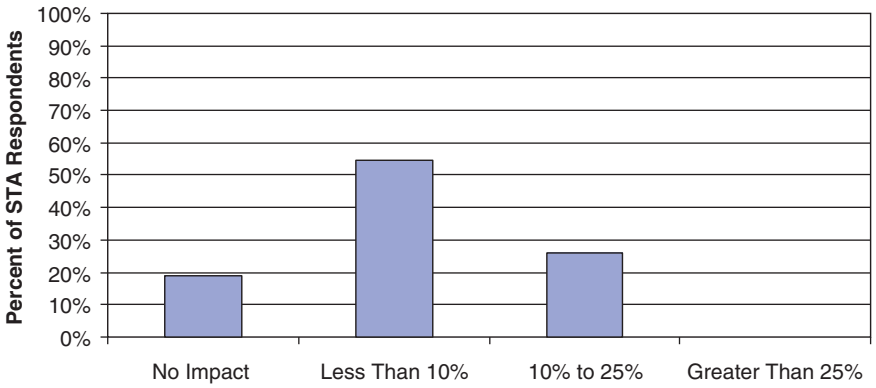

Figure C.9. I/D provision impacts on cost (n = 25).

compared asphalt pavement characteristics for 26 I/D projects and 25 non-I/D projects. Material quality incentives were earned on 80% of the I/D projects while 56% of the non-I/D projects earned a material quality incentive.

I/D Impacts on Cost

In contrast to the subject of I/D impacts on quality, a large majority of STA respondents believe that I/D provisions impact the cost of a project. Over 80% felt that project costs increased as a result of time-related I/D provisions. Of those who indicated that costs were increased, two-thirds felt that the cost increase was less than 10%. The remaining one-third felt that costs were increased from 10% to 25%. The cost impacts of time-related I/D provisions are summarized by the following statements and are also illustrated in Figure C.9:

- 19% of the STAs felt that cost was not impacted
- 55% of the STAs felt that cost increased less than 10%
- 26% of the STAs felt that cost increased between 10% and 25%

A comparison of contractor bid prices by Strong et al. (*16*) shows that the average initial bid for A+B projects is 7.5% higher per mile than for non-I/D projects.

I/D Impacts on Agency Staffing

Impacts on agency human resources during the project development phase appear to be negligible, because only two STAs indicated that this was a concern. However, this is not the case for impacts on agency human resources during the construction phase of the project. Seventy percent of the respondents feel that agency staff requirements are impacted by time-related I/D provisions. The most common strategies for coping with this impact are represented in Figure C.10.

Recommendations for agency staffing issues on I/D projects identified by Petring and Helgeson include the following:

- Limit project managers to oversight of one A+B project at a time and avoiding consecutive assignments on A+B projects.
- Train project managers regarding limitations on agency personnel work hour limitations.

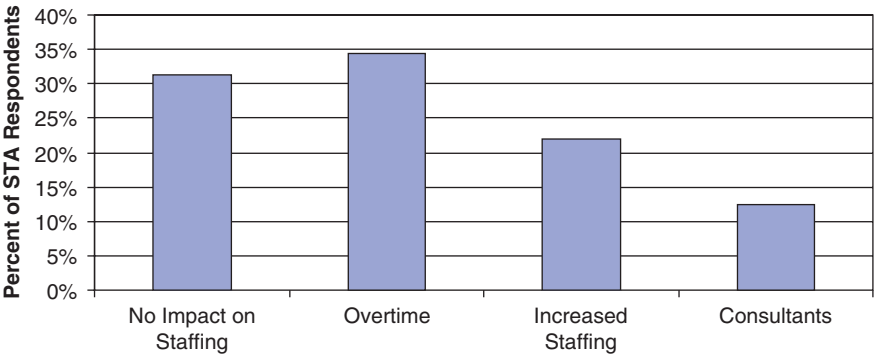

Figure C.10. Strategies for addressing impacts on agency staffing (n = 32).

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- Staff A+B projects with a resident engineer and two project managers (day shift and night shift).
- Provide team building training.
- Empower project personnel to encourage "ownership" of the project.

Results of In-Depth Interviews

Findings of the in-depth investigations are based on results of the ranking forms that were completed by 42 construction professionals. The purpose of the ranking form is to have some way to quantify the experiences and perceptions of the interviewee experts.

In-Depth Investigation Ranking Forms

Ranking forms were completed by 42 interviewees. The interviewees are classified into four groups: agency administration, agency field, contractor administration, and contractor field. The distribution of interviewees is shown in Figure C.11.

These on-site in-depth interviews took place in six different states. The experience level with different types of I/D provisions varies by group. Interview participants had the most experience with A+B and complete-by-date I/D provisions. The groups had less experience with lane rental, multiple I/D for interim milestones, and liquidated savings I/D provisions. Figure C.12 shows the number of projects by I/D provision type, and interview group. Except for liquidated savings, every group had experience with each I/D provision types identified in the ranking form. The one exception was the contractor field group, which indicated that none of them had actually completed a project under a liquidated savings I/D provision.

One section of the ranking form asked interviewees to contrast projects of similar scope and size that used time-related I/D provisions with non-I/D projects and rate their level of agreement or disagreement with a specific statement. Rankings for these statements were given on a scale from 1 through 5 as shown in Table C.1.

This section of the ranking form included 19 statements to rate. The average ranking for all statements was calculated and then sorted in ascending order. An initial analysis of the results looks at the four statements that generated the lowest level of agreement (respondents disagree with the interview statement) and the four statements that resulted in the highest level of agreement. Segregating the average results this way gives an indication of what issues the interviewees feel most strongly about, either in agreement or disagreement. Figure C.13 shows the results of this analysis graphically.

From Figure C.13, it can be inferred that on average, the interviewees felt most strongly about the following items:

1. The contractor works longer hours on I/D projects.
2. Contractors schedule their work better on I/D projects.
3. Staffing of I/D projects requires experienced personnel.
4. Innovation occurs more often on I/D projects.
5. Safety compromises do not occur more often on I/D projects.
6. Time extensions that impact incentive payments are not granted too often.
7. The quality of the design (plan errors/omissions) is not better on I/D projects.
8. The process of calculating time charges does not favor the contractor more than the agency.

This same set of 19 rankings was further analyzed to reveal which four statements had the highest level of relative difference when comparing the rankings of agency personnel with contractor personnel (Figure C.14).

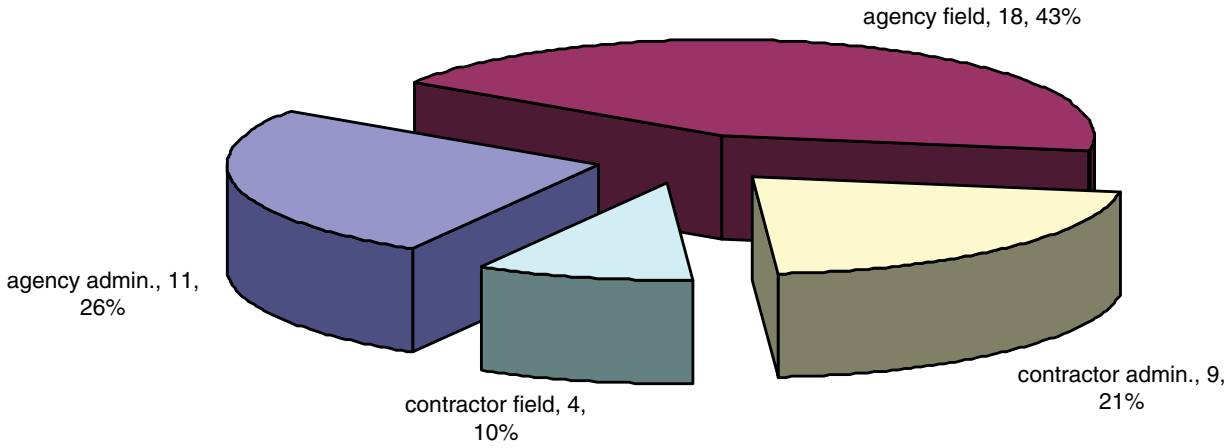

Figure C.11. Distribution of on-site interviewees by group (n = 42).

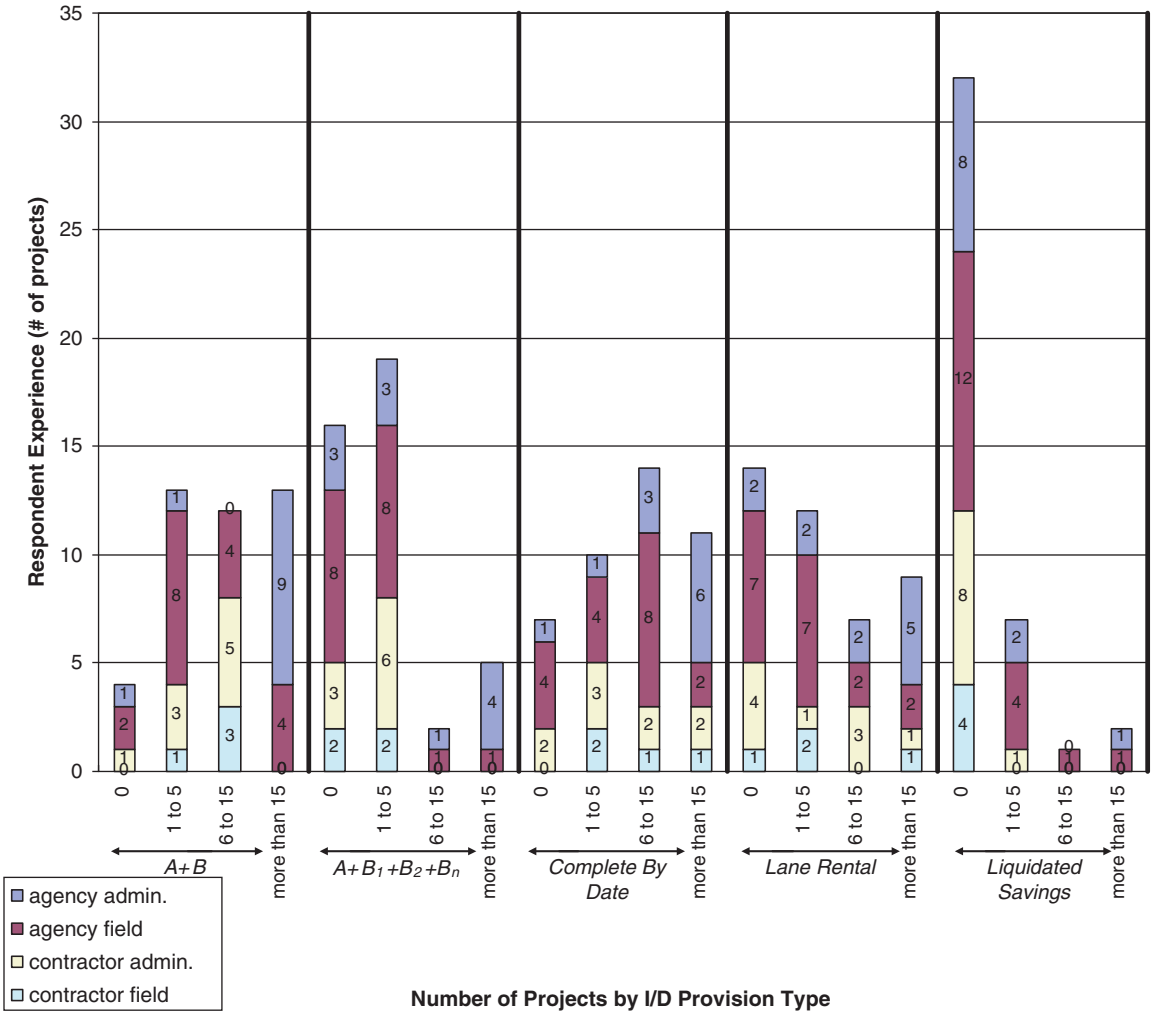

Figure C.12. Interviewees' experience by I/D type and group (n = 42).

As shown in Figure C.14, items that had the largest relative difference between average contractor and average agency rankings are provided as follows:

1. Contractors believe that the decision making process regarding contract changes is handled differently on I/D projects, while agency personnel believe that this process is similar for I/D and non-I/D projects.
2. Both agencies and contractors agree that I/D projects require experienced personnel, but the contractors agree at a higher level.
3. Contractors and agencies both agree that innovation occurs more often on I/D projects, but the contractors agree at a higher level.
4. Agencies and contractors also agree that time extensions affecting incentive payments are granted too often, however the agencies agree to a higher level.

Table C.1. Ranking form scale (compare and contrast I/D projects with non-I/D projects).

Ranking	Description
1	strongly disagree
2	moderately disagree
3	neutral
4	moderately agree
5	strongly agree

I/D Provision Impacts on Project Factors

In-depth Interviewees were asked to rank the degree to which time-related I/D provisions impact seven different project factors. The project factors considered were construction time, project cost, project quality, safety, innovation, contract administration and project staffing. Nine ranking levels were used in this section of the ranking form (Table C.2).

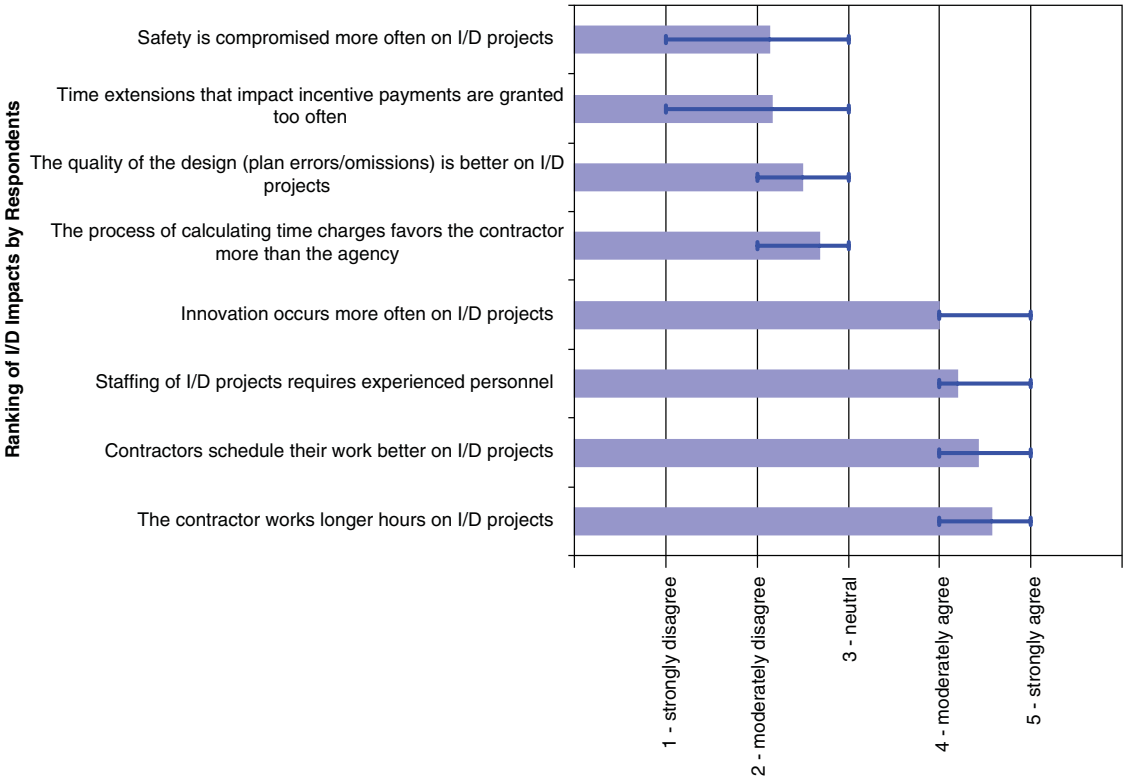

Figure C.13. Items with the lowest or highest level of agreement (I/D provision impacts): average and upper and lower quartiles (n = 42).

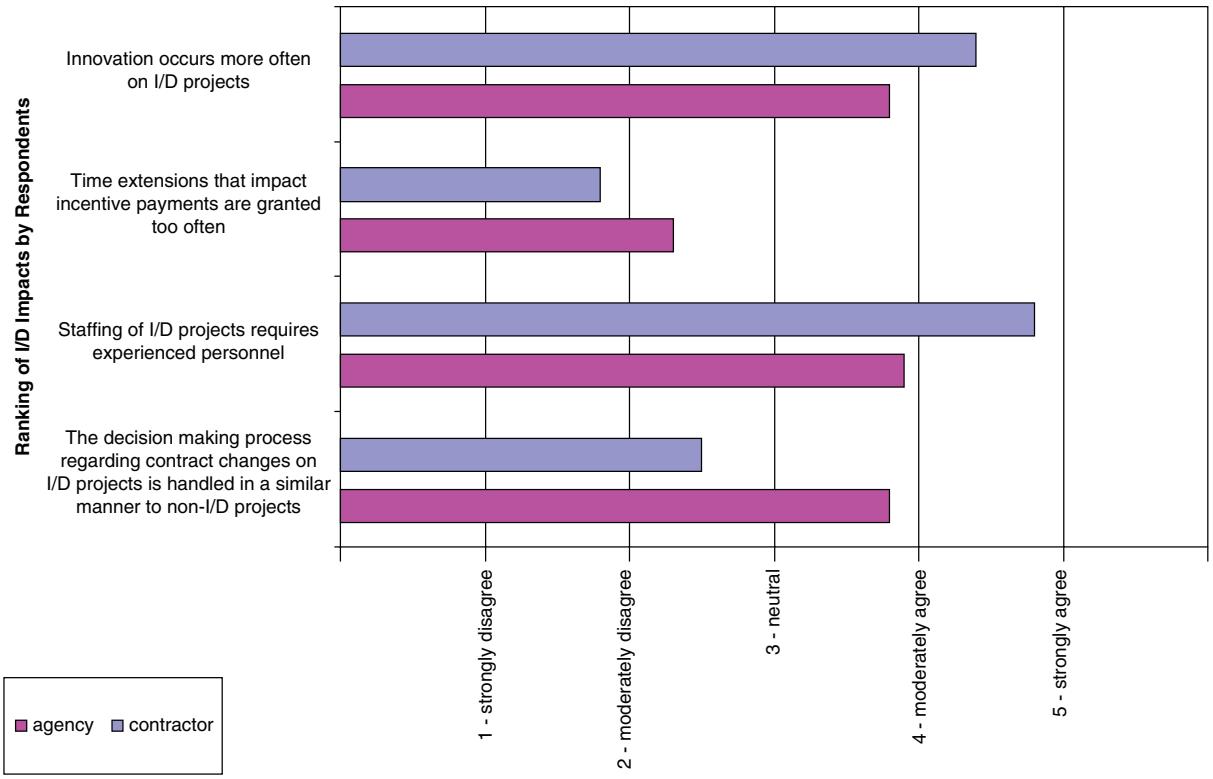

Figure C.14. Differences between contractor and agency perceptions: I/D projects contrasted with non-I/D projects (n = 42).

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Table C.2. Ranking levels for I/D impacts on project factors.

Rank	I/D Degree of Impact on Project Factors
5	significant beneficial impact
4	considerable beneficial impact
3	moderate beneficial impact
2	slight beneficial impact
1 or -1	neutral impact
-2	slight detrimental impact
-3	moderate detrimental impact
-4	considerable detrimental impact
-5	significant detrimental impact

Time-Related I/D Provision Impacts on Construction Time

On average the rankings from the expert interviewees indicate that time-related I/D provisions have a moderate beneficial impact on construction time (Figure C.15). The contractor field group results were evenly split between beneficial impact and detrimental impact. Of the 41 rankings, 37 indicated a beneficial impact, 1 ranked the impact of I/Ds on construction time as neutral, and 3 ranked it as detrimental. Of the 3 detrimental rankings, 2 came from the contractor field group and the other came from the agency field group. Even though there is not a majority among the contractor field group regarding the impact of I/Ds on construction time, there is an overwhelming consensus from the other groups that time-related I/Ds are beneficial at reducing construction durations.

Time-Related I/D Provision Impacts on Project Cost

Based on the rankings of 41 construction professionals having considerable experience with time-related I/D provisions, the impact on project cost is negligible (Figure C.16).

Time-Related I/D Provision Impacts on Project Quality

Overall rankings reveal that project quality is unaffected by I/Ds (Figure C.17). However, the contractor field group had a majority that ranked I/D impacts on project quality as slightly detrimental. One probable explanation for the difference between this group's ranking and the other group's is the manner in which quality is defined. Agency and contractor administration personnel measure quality almost exclusively from a specification perspective; however, contractor field personnel have a personal connection to the construction

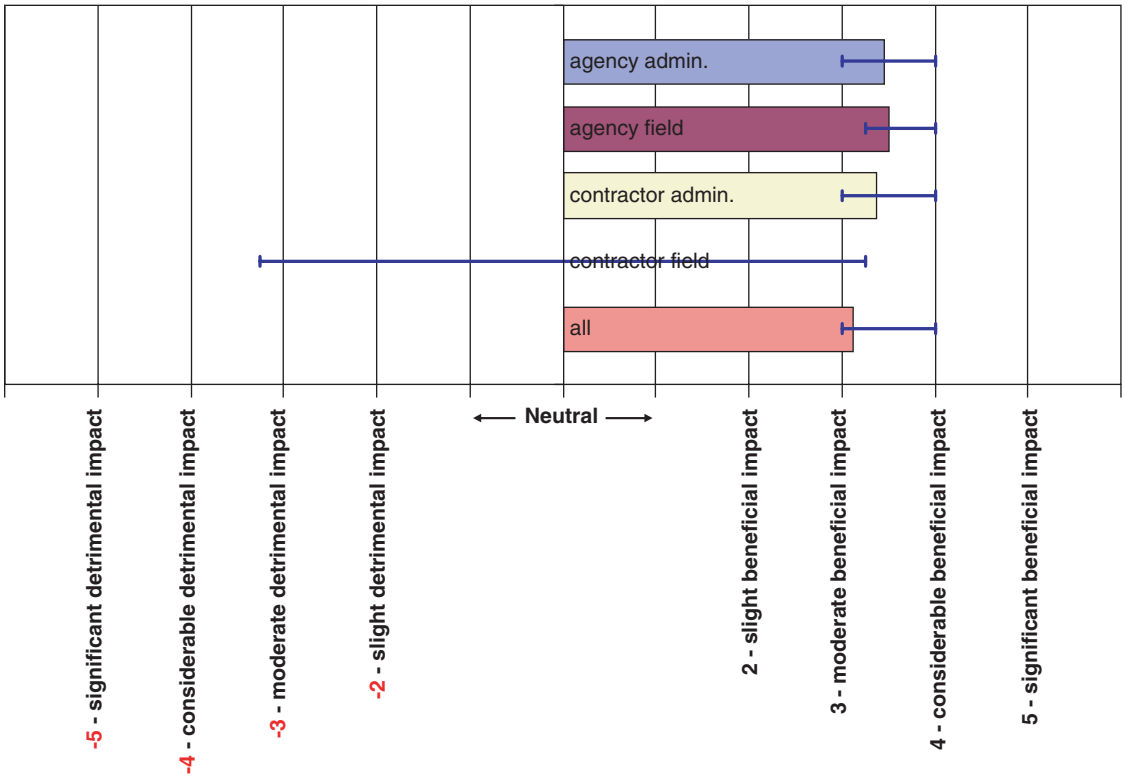

Figure C.15. I/D impact on construction time: average and upper and lower quartiles (n = 41).

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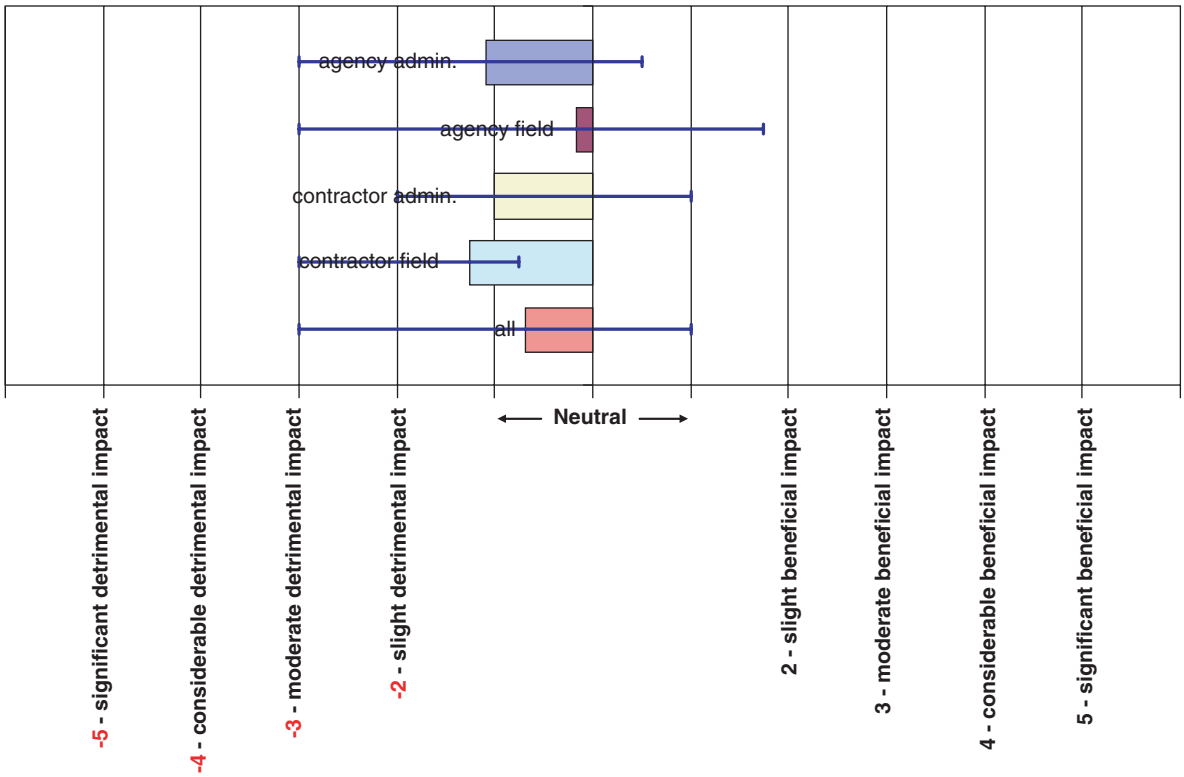

Figure C.16. I/D impact on project cost: average and upper and lower quartiles (n = 41).

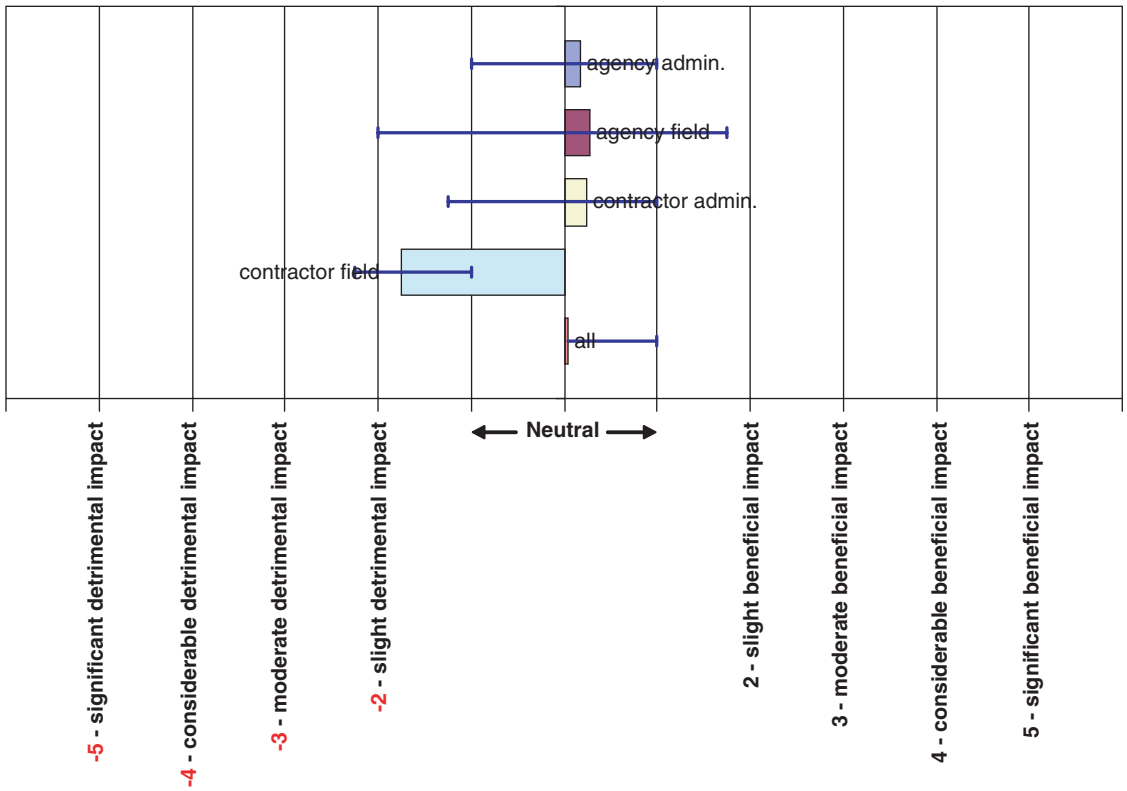

Figure C.17. I/D impacts on project quality: average and upper and lower quartiles (n = 41).

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project. Their reputation is attached to that project. There are perceived levels of quality beyond a specified pass or fail level. Contractor field personnel are intimately aware of all the hidden blemishes on a project that go unnoticed by the untrained eye. Even though these blemishes meet or exceed specification, the contractor field group may perceive that time-related I/Ds increase the frequency of these aesthetic or less than perfect project features.

Time-Related I/D Provision Impacts on Safety

According to the average ranking, safety is not compromised to a measurable degree by I/Ds (Figure C.18). Although all four contractor field responses were technically on the detrimental side of the scale, the difference between neutral on the detrimental side of the scale and neutral on the beneficial side of the scale cannot be discerned. In hindsight, it would have been preferable to designate zero as the only choice for ranking an I/D impact as neutral. A review of the ranking data of all 41 responses shows that the median and mode ranking values are both equal to one.

A publication from 1987 on I/D contracting reported an eight-fold increase in work-related accidents compared with a non-I/D project. However, the fact that I/D provision use has continued and grown suggests that accident rates of this magnitude are not the norm.

Time-Related I/D Provision Impacts on Innovation

All interview groups concur that I/Ds impact innovation in a beneficial manner (Figure C.19). The contractor administration group views the impact as slightly beneficial, and the contractor field group ranks the impact as considerable. On average the impact of time-related I/D provisions on innovation is moderately beneficial.

Time-Related I/D Provision Impacts on Contract Administration

The average ranking of the interview groups indicates that I/Ds do not affect contract administration in any appreciable way (Figure C.20). However, this is another area where the contractor field group ranked the impact differently than the other groups. Based on feedback that was received during the Q&A interview sessions, it is likely that the contractor field group identifies the agencies prompt resolution of issues on I/D projects as a beneficial impact with respect to contract administration.

Time-Related I/D Provision Impacts on Project Staffing

Contractor administration and field group rankings indicate that these groups perceive a slight to moderate beneficial

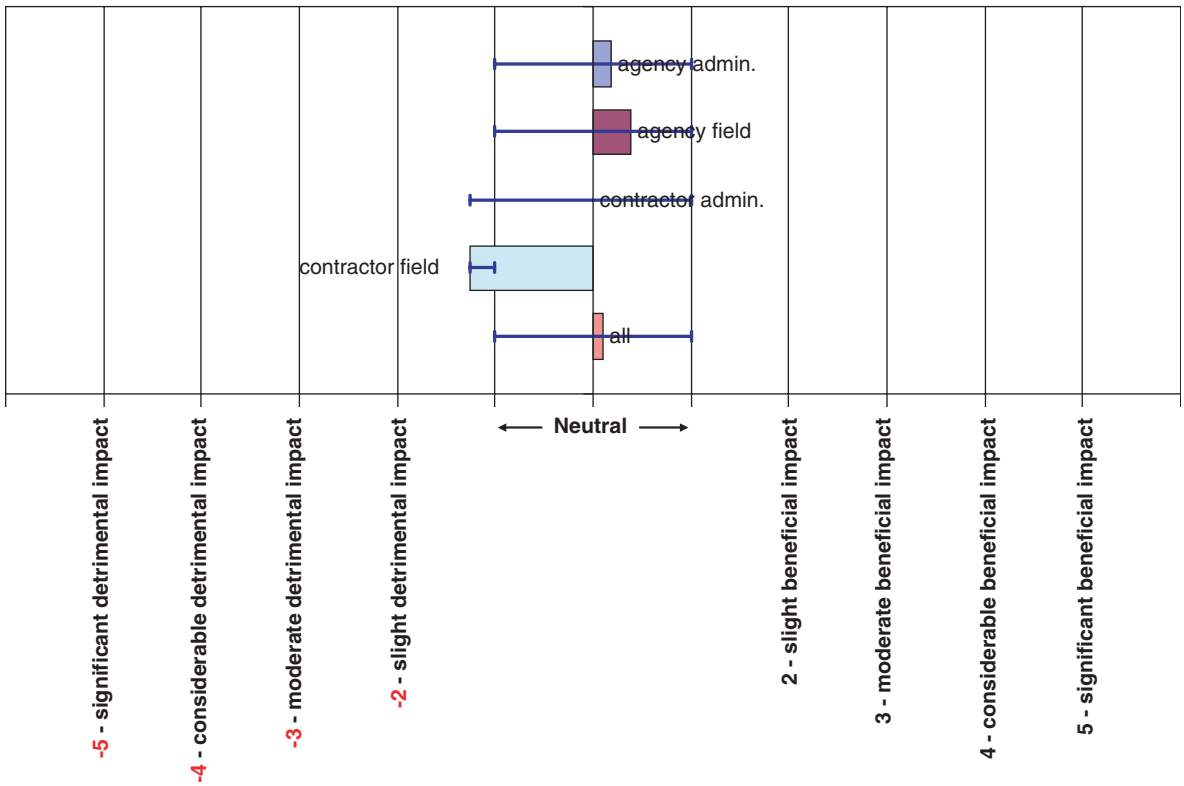

Figure C.18. I/D impacts on safety: average and upper and lower quartiles (n = 41).

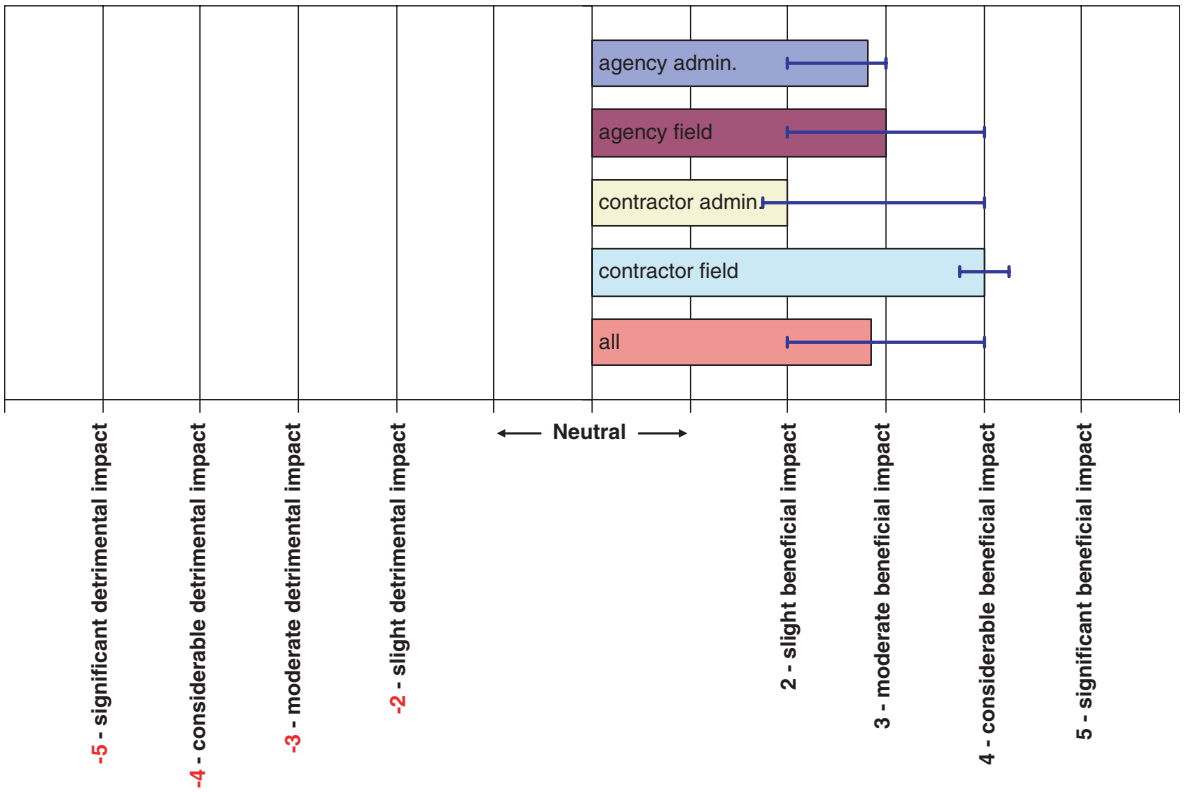

Figure C.19. I/D impacts on innovation: average and upper and lower quartiles (n = 41).

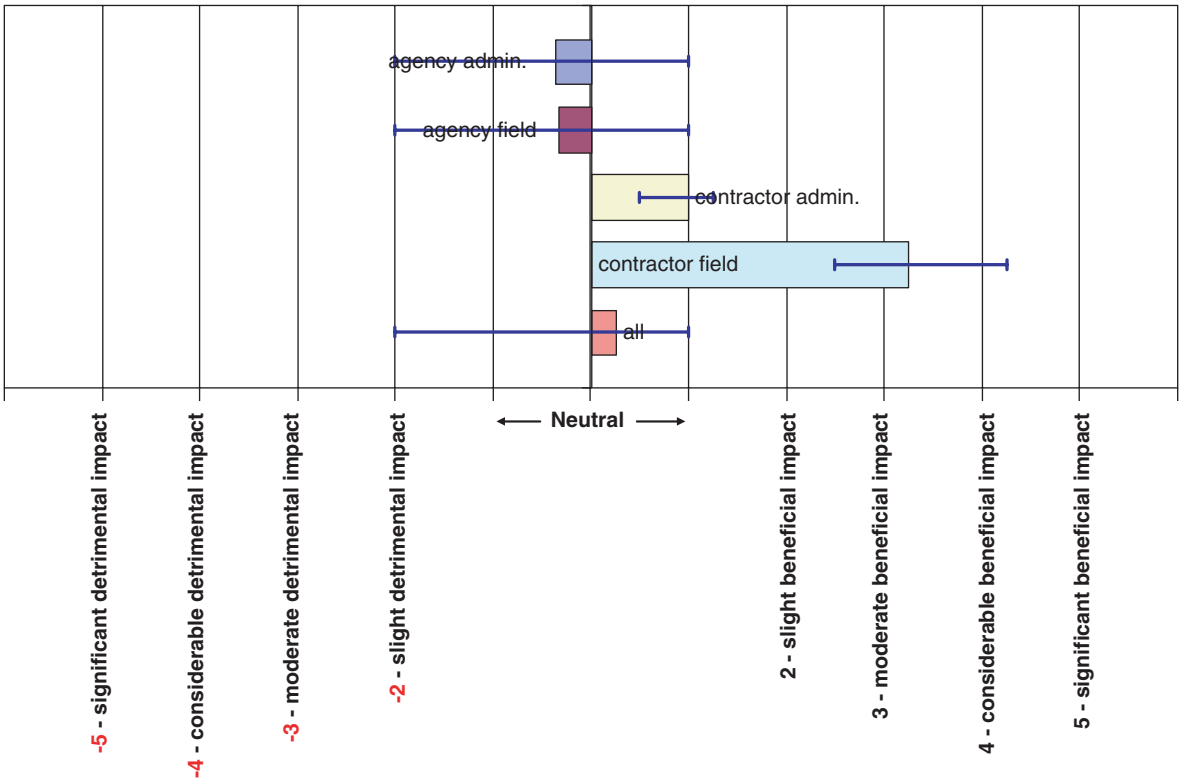

Figure C.20. I/D impacts on contract administration: average and upper and lower quartiles (n = 41).

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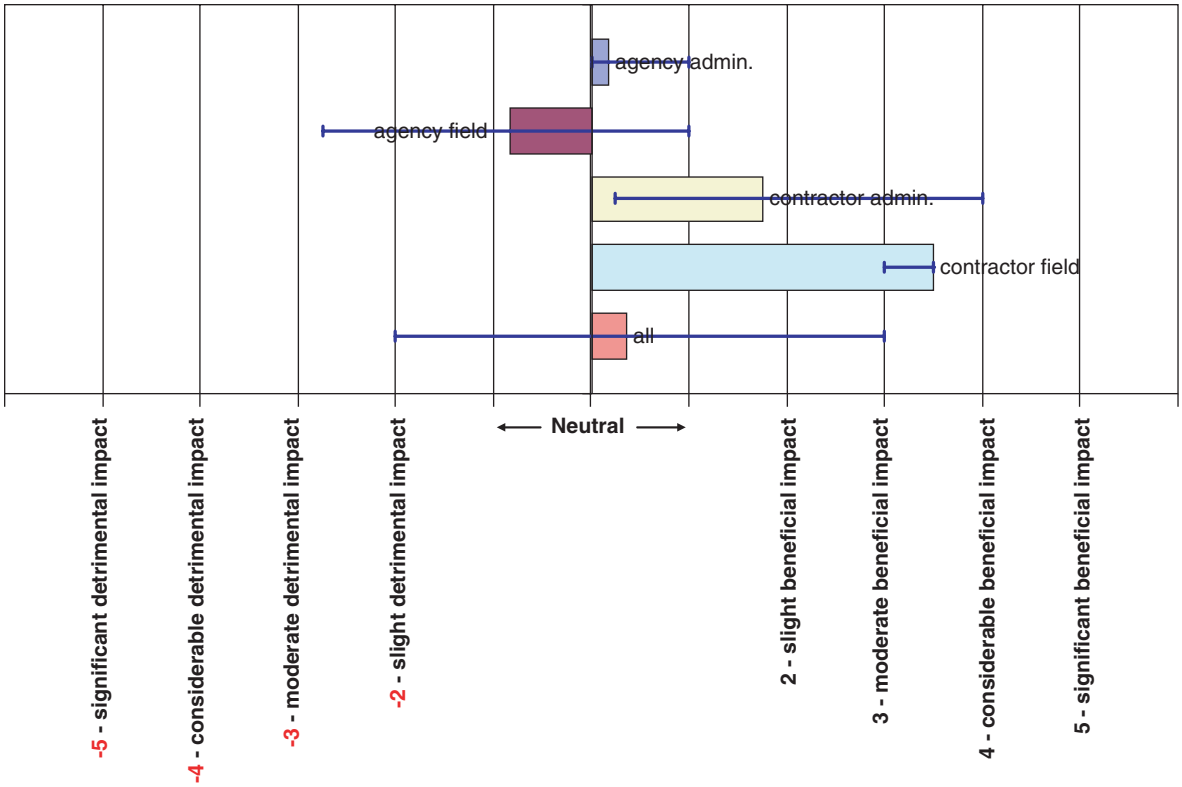

Figure C.21. I/D impacts on project staffing: average and upper and lower quartiles (n = 41).

impact on project staffing (Figure C.21). This is in contrast to the agency groups, which perceived a neutral impact on project staffing. Based on the notes from in-depth Q&A sessions and the research team's experience, this difference between the contractor and agency perceptions is a factor of (1) contractors placing their most experienced people on the jobs where there is higher exposure to risk and (2) the agencies not having the same flexibility in shifting personnel assignments.

Overall Effectiveness of I/D Provisions by Type

In the last section of the in-depth ranking form, the interviewees were asked to rate the different types of I/D provisions with respect to their effectiveness at reducing construction time (Figure C.22). The scale ranged from 1 (highly ineffective) through 5 (highly effective). According to the in-depth interviewee's experiences, A+B with multiple milestones ($A+B_1+B_2+B_n$) is the most effective at reducing construction time. A+B, complete-by-date and liquidated savings I/D provisions are also considered effective at accelerating construction. Lane Rental provisions were not deemed effective for reducing construction time.

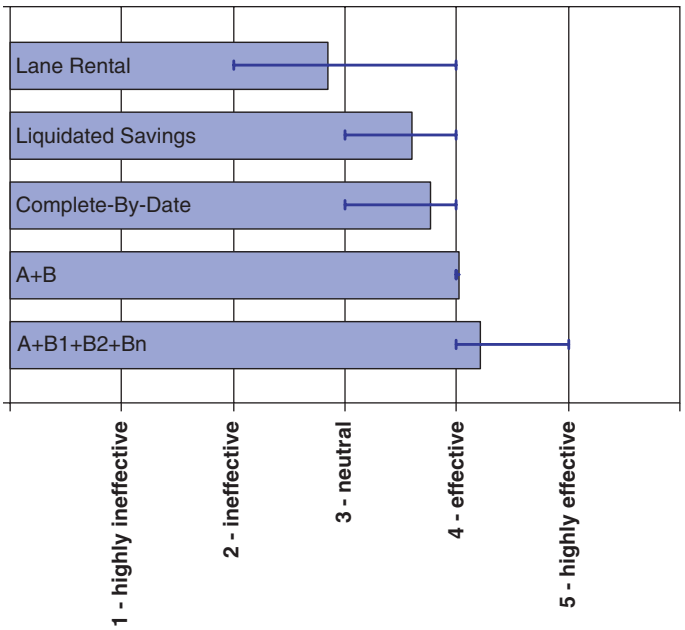

Figure C.22. Effectiveness of I/D provision types for reducing construction time: average and upper and lower quartiles (n = 42).

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Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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