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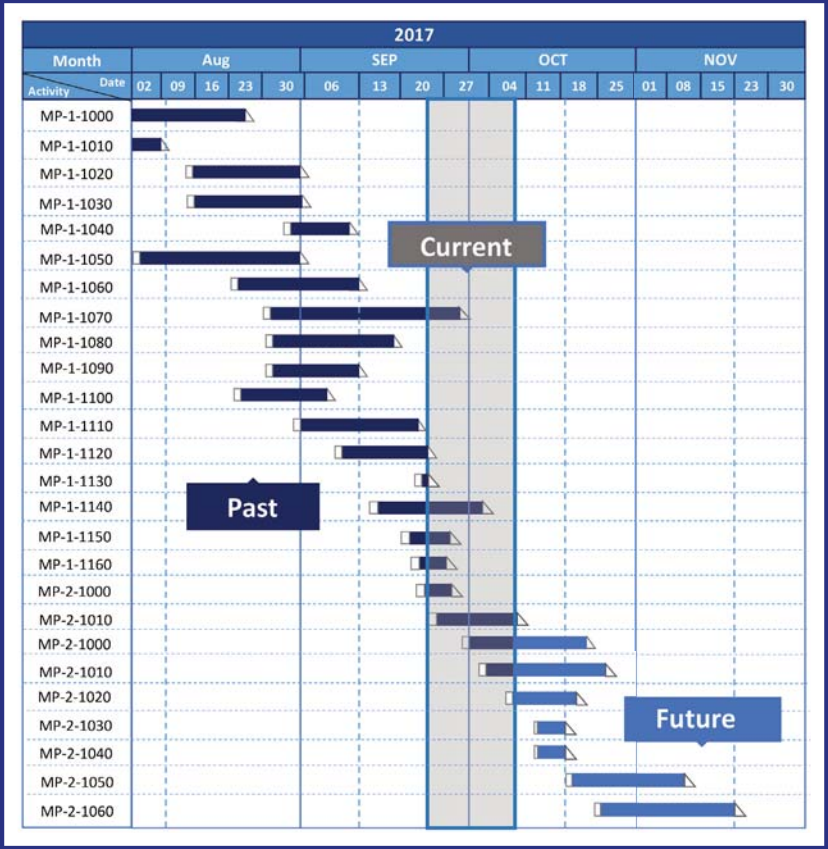
RESEARCH PROGRAM
INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

# Simplified Construction Scheduling for Field Personnel

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SPR-3907 • Report Number: FHWA/IN/JTRP-2016/28 • DOI: 10.5703/1288284316355

## RECOMMENDED CITATION

Khallaf, R., Yoon, S., Hastak, M., & Nantung, T. (2016). *Simplified construction scheduling for field personnel* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2016/28). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284316355

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## ACKNOWLEDGMENTS

This project was made possible by the sponsorship of the Joint Transportation Research Program (JTRP) and the Indiana Department of Transportation (INDOT). The authors would like to thank the study advisory committee for their valuable assistance and technical guidance in the course of performing this study.

## JOINT TRANSPORTATION RESEARCH PROGRAM

The Joint Transportation Research Program serves as a vehicle for INDOT collaboration with higher education institutions and industry in Indiana to facilitate innovation that results in continuous improvement in the planning, design, construction, operation, management and economic efficiency of the Indiana transportation infrastructure. https://engineering.purdue.edu/JTRP/index_html

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.

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Print ISBN: 978-1-62260-453-1
ePUB ISBN: 978-1-62260-454-8

TECHNICAL REPORT STANDARD TITLE PAGE

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| FHWA/IN/JTRP-2016/27 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Simplified Construction Scheduling for Field Personnel | May 2016 |
| | 6. Performing Organization Code |

| 7. Author(s) | 8. Performing Organization Report No. |
|---|---|
| Rana Khallaf, Soojin Yoon, Makarand Hastak, Tommy Nantung | FHWA/IN/JTRP-2016/27 |

| 9. Performing Organization Name and Address | 10. Work Unit No. |
|---|---|
| Joint Transportation Research Program<br>Purdue University<br>550 Stadium Mall Drive<br>West Lafayette, IN 47907-2051 | 11. Contract or Grant No.<br>SPR-3907 |

| 12. Sponsoring Agency Name and Address | 13. Type of Report and Period Covered |
|---|---|
| Indiana Department of Transportation<br>State Office Building<br>100 North Senate Avenue<br>Indianapolis, IN 46204 | Final Report |
| | 14. Sponsoring Agency Code |

**15. Supplementary Notes**
Prepared in cooperation with the Indiana Department of Transportation and Federal Highway Administration.

**16. Abstract**

The main purpose of this research is to determine the issues that INDOT faces with respect to schedule review/monitoring and determine the best practices by other DOTs in order to suggest improvements to INDOTs practices. Two questionnaire surveys and six interviews were conducted to gather this information. The two questionnaires were divided into four areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specs and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software. Results from these questionnaires were used to target five DOTs that showed good practices as well INDOT to gather more details about the common scheduling issues and their response to them.

Outcome of this research will (1) document current INDOT practices and challenges on tracking the projects in the field; (2) Identify scheduling methods and software packages used by other DOTs that would satisfy INDOT's project control needs (3) provide guidelines to make the tracking and analysis of scheduled milestones more effective and easy to implement for the field personnel.

According to the first survey that was distributed among INDOT personnel, some of the main issues they face include lack of contractor compliance in submitting schedules and following the scheduling specifications. Another issue is INDOT personnel's lack of training and experience using the scheduling techniques.

The second survey was distributed to all DOTs with thirty-five responses received. In order to enforce contractor compliance, DOTs have delayed and withheld payments. DOTs also train their employees in scheduling techniques to help them review contractors' submittals. They also meet with the contractor before construction starts and discuss the schedule requirements to ensure that both parties are on the same page.

Phone interviews were conducted with six DOTs in order to understand their means and methods. Some of the main items discovered were related to classification of projects (based on required level of scheduling), procedure requested by DOTs from contractors with regard to time impact analysis reports and how they handle weather shutdowns in their scheduling specifications.

In conclusion, the research found many suggestions that could be implemented by INDOT in order to revise/update their specifications and practices, increase contractor compliance and to simplify their scheduling and review processes.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| CPM scheduling, bar chart, scheduling specifications, schedule review, schedule monitoring, simplified scheduling | No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 62 | |

**Form DOT F 1700.7 (8-69)**

# EXECUTIVE SUMMARY

## SIMPLIFIED CONSTRUCTION SCHEDULING FOR FIELD PERSONNEL

### Introduction

Different scheduling methods have been developed over the years that require various levels of sophistication and knowledge to use them effectively. An appropriate method must be chosen depending on the project and the intended use. To determine the best scheduling practices for a project, the following should be considered: project risk, impact to traffic, environmental impact, likelihood of project delay, constraints to the schedule, and number of concurrent operations.

The most widely used scheduling methods are the bar chart (a simple graphical format) and Critical Path Method (CPM) scheduling, a more advanced method that utilizes software to schedule projects. The advantages of CPM scheduling are the ability to show a detailed project breakdown, utilize different calendars, perform cost and resource loading, track the critical path, and perform delay analysis and mitigation. Software choices include Microsoft Project and the more widely used and advanced Primavera. CPM schedules have many uses: monitoring project progress, tracking milestones, establishing delay responsibility and extent, revealing conflicts between different trades, and as tools for communication. However, CPM scheduling requires training, and small projects with straightforward activities often do not need a complicated scheduling method.

DOTs commonly request the following information from their contractors: baseline schedule depicting all the activities, duration, and sequence; updated schedule showing the current project progress; and a narrative report showing the status of milestones, description of the critical path and near-critical activities, calendars used, and possible future delays and mitigation plans. Most DOTs review contractor submittals for conformance to the specifications but do not perform an in-depth analysis for the details in the schedule itself since this responsibility falls on the contractor. The main purpose of this research was to investigate the Indiana Department of Transportation's (INDOT's) current scheduling methods as well as the best practices of other DOTs and consequently suggest a simplified guideline for use by field personnel to analyze schedule progress and propose other changes to scheduling methods and specifications. To accomplish this two questionnaire surveys and six telephone interviews were performed.

### Findings

The first survey gathered data from INDOT about the scheduling practices used for its projects. A total of 65 personnel participated in this survey, which was conducted from May 13 to June 11, 2016, and was divided into four areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specifications and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software. This first survey revealed the following:

- Contractors do not always follow the specifications or submit updated schedules in a timely manner.
- INDOT has seldom withheld payments to force contractors to comply with the scheduling specifications.
- INDOT requires either bar charts or CPM schedules from contractors. Bar charts are most commonly used, but they do not classify the scheduling needs depending on set project criteria.
- INDOT personnel lack the experience and training required to review CPM schedules.

The second survey gathered data from other state DOTs (Michigan, Texas, Vermont, Virginia, and Washington State) about the scheduling practices used for their projects. A total of 31 DOTs with 35 respondents participated in the survey. This second survey revealed the following:

- Contractors do not always follow the specifications or submit updated schedules in a timely manner.
- DOTs delay and withhold payments to force contractors to comply with the scheduling specifications.
- Both bar charts and CPM schedules are commonly used. The scheduling method is dependent on the type of project and magnitude of complexity.
- DOTs either accept or reject contractors' submitted baseline/updated schedules based on conformance to the specifications and do not approve the plans themselves.
- Contractors with employees trained in CPM are more timely with their schedule submittals, especially with regard to time impact analysis reports.
- The majority of the DOTs do not conduct a review of contractors' resources to ensure availability. However, some DOTs include a special provision for certain projects with costs higher than $20 million and for more complicated projects that would require the submittal of a resource-loaded schedule.

Phone interviews were conducted to verify some of the information gathered in the surveys as well as to collect more information about scheduling practices. The research team found that some DOTs have project classifications with respective required scheduling practices based on a set of criteria such as project complexity, number of bid items, and risks involved. Some also train their employees in scheduling techniques either by in-house personnel or outside training, while others have a scheduling engineer, especially for their larger projects.

### Implementation

Based on the analysis of the results of the surveys, phone interviews, and literature review conducted, this research team developed the following guidelines for INDOT to follow with regard to its scheduling practices:

1. Specification-related issues:
    - Enforce requirements in current specifications with a penalty for non-compliance.
    - Customize scheduling requirements by project type/number of bid items/project cost.
    - Create a template/checklist for reviewing projects.
    - Enforce compliance of new requirements.
    - Ensure that the contractor knows INDOT's scheduling expectations.
    - For larger and more complex projects, request a CPM schedule using Primavera.
    - Request a narrative for all projects that explains the basic assumptions made for the software, the sequence of work, and an explanation of the critical path.
2. INDOT (personnel)-related issues:
    - Provide customized training to INDOT field personnel to increase their knowledge in CPM scheduling.
    - Hire a scheduler to be involved in reviewing all CPM schedules and training INDOT field personnel.

Although it is recommended to train INDOT personnel in scheduling, they already have other tasks which are more critical to their job. Hence, a full-time scheduler is needed. Depending on the number and complexity of the projects, the number of schedulers can be determined. Some DOTs hire one scheduler per district.
- For large projects, hire a consulting firm to be responsible for the schedule review and delay analysis. Many DOTs rely on outside consultants since they do not have the resources or the required training to do the job.
- Use Citrix or WebPM for online access to Primavera on-site instead of having to download the software on every computer.

3. Contractor-related issues:
    - Create a separate pay item in the bid items list specifically for schedule submittals with a specific cost. This should include the baseline and updates. This would force the contractor to submit the baseline/updates on time or otherwise risk a delay in payment of the monthly invoice.
    - Conduct a scheduling meeting prior to the start of work with the contractor to discuss the scheduling requirements and expectations. A joint training can also be beneficial to get both sides on the same page.
    - Enforce penalties or withhold payments in response to contractor delays in schedule/update submission.
    - Create a timeline with the contractor for schedule and update submittal.
    - Ensure that the contractor has the required skill set to submit the required schedules by including a provision in the contract.
    - Schedule regular meetings with the contractor based on project complexity and size.

CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# 1. INTRODUCTION

## 1.1 Research Background and Need Statement

The main purpose of this research is to explore the problems with INDOT's current scheduling methods and explore the best practices by other DOTs. This study aims to propose guidelines to enhance and modify INDOT's techniques for schedule review/monitoring. The target is to investigate and suggest a project scheduling method that is simple to use and friendly to the construction personnel in the field. This will help the construction field personnel by providing standard checklists and guidelines for schedule review/monitoring that will help understand and track a project with the least effort. The CPM requirement in INDOT's (2011) Recurring Special Provision (108-C-215 Critical Path Method (CPM) Schedule) are found to be hard to implement in practice since analyzing a full-blown CPM is time consuming and requires more training for INDOT field personnel. Moreover, current scheduling techniques and accompanying software packages usually utilize complex interfaces that enhance the software capabilities but at the same time complicate its implementation by requiring too many inputs and rigorous updating procedures, which may be unnecessary for INDOT purposes. Furthermore, intrinsic uncertainties in construction execution almost always impose changes into the baseline schedule, which result in a need for variance analysis. Due to the reasons mentioned above, there is a need to research changes required in the scheduling or implementation technique/tool in order to overcome the implementation barriers.

## 1.2 Research Objectives

The objectives of the study are to:

- Identify INDOT scheduling needs and challenges
- Identify best practices implemented by other DOTs for scheduling and tracking progress
- Propose factors/indicators for analyzing schedules and progress control along with a guideline that simplifies the analysis for INDOT personnel

## 1.3 Project Scope

This research is a synthesis study that will explore the current scheduling methods and corresponding best practices and subsequently provide a simplified guideline that could be readily used by INDOT field personnel to analyze schedule progress. To achieve the above-mentioned objectives, this research project is divided into three steps that are discussed in the research methodology.

## 1.4 Research Methodology

This research divided into three steps in order to develop guidelines for INDOT regarding their scheduling. The first step looks at INDOT's current scheduling practices and the problems faced by INDOT personnel. The second step looks at the best practices undertaken by other DOTs in their scheduling practices. The third step proposes guidelines for INDOT to follow. The three steps in this research are explained in detail in this section.

Step 1: Identification of INDOT tracking/analysis state of practice plus documenting INDOT requirements from a scheduling method based on their challenges in the field.

- Review of all the current and past INDOT studies regarding scheduling
- INDOT scheduling needs and desired level of sophistication and ease of use from their project control practices
- INDOT issues and challenges in managing schedule progress on a project
- INDOT personnel skill set and its effect on managing schedule progress
- Required implementation procedures in current INDOT specifications:
    - Progress reporting periods
    - Updating actual schedule information and resource usage
    - Incorporation of subcontractors' schedule
    - Level of involvement of field personnel in the project planning and control
    - Float ownership
- Identifying parameters that can be used to classify INDOT projects into different categories of sophistication in regard to the scheduling method needed
- Identification of current practices in use by INDOT personnel for analyzing schedule variances and their effect on the project outcome
- Identification of the current procedure to manage and respond to claims arising from both parties

Step 2: Study of current scheduling methods/packages and corresponding best practices in use by other DOTs.

- A nationwide survey/questionnaire with a follow up interview will be conducted with other State DOTs to explore their scheduling specification/guidelines.
- The questionnaire and follow up interview will clarify the following:
    - Methods/software that are in their specifications and are required from the contractors for schedule reporting and analysis purposes
    - Utilization level of scheduling methods mentioned in their specification and their practicality in the field
    - Current issues/challenges they face with their current scheduling methods and their suggestions for resolving those issues
- Review of current popular planning and scheduling methods/software and corresponding best practices based on the information gathered from other DOTs. Some of the parameters that will be used as the basis of reviewing methods/software in this step are:
    - Implementation barriers
    - Organizational resistance issues
    - Limitations and shortcomings

- Best practices
- Tracking progress without resources versus tracking progress with resources
- Handling of floats

Step 3: Proposing a simple to use guideline based on the best practices and state of the art planning and scheduling techniques that would satisfy INDOT needs identified in Steps 1 & 2.

- Classification of scheduling techniques/software based on what other DOTs are using as a scheduling package/ technique to make the schedule tracking and analysis more accessible to their field personnel.
- Propose a set of functionalities that satisfy INDOT needs from a planning and scheduling method (Criterion I).
- Identify ease of implementation that makes the planning and scheduling method readily accessible to INDOT field personnel (Criterion II).
- Summarizing and categorizing the best scheduling practices that satisfy both Criteria I & II.

### 1.5 Expected Outcomes

- Comparison chart documenting the current planning and scheduling methods used by INDOT and other DOTs.
- Minimum criteria for the core functionality that INDOT requires from its scheduling method and software package.
- Simplicity level criteria that makes the planning and scheduling method readily accessible to INDOT field personnel.
- A guideline incorporating best practices and implementation according to the results of synthesis study. The proposed methods will take into consideration that INDOT projects need different levels of sophistication from their scheduling methods in different projects. The proposed guideline goal is to enhance/simplify both the bar chart and CPM schedule guidelines currently used by INDOT.
- The proposed methodology will enable the field personal to qualitatively analyze the contractor's progress in terms of time and cost.

### 1.6 Report Organization

This report is divided into six (6) chapters. Chapter 1 presents the research background and problem statement and subsequently explains the research needs as well as the work scope and objectives. An extensive literature review is presented in Chapter 2 covering the current scheduling techniques in use, tools available and INDOT's scheduling requirements. Chapter 3 describes the data collection from surveys 1 and 2 as well as the phone interview conducted to obtain a deeper understanding of the current scheduling practices. The results of the surveys and phone interview are illustrated in Chapter 4. Chapter 5 illustrates the guidelines and recommendations obtained from the research study. Chapter 6 presents an overall summary and conclusion for the surveys, interviews, and the study. Also recommendations and limitations are covered in Chapter 6. Survey 1 questions and results are illustrated in Appendix A. Survey 2 questions and results are illustrated in Appendix B. The phone interview questions are illustrated in Appendix C.

## 2. LITERATURE REVIEW

### 2.1 Introduction

The need for scheduling practices is evident in all construction projects. Scheduling is an important tool used to plan and monitor projects. INDOT manages more than 5300 bridges, 8700 small structures and 28000 lane miles and invests more than $1 billion yearly in construction projects in Indiana (in.gov). This multitude of projects necessitates the availability of a sound and feasible scheduling practice in order to best track all projects. INDOT currently employs bar charts and CPM schedules in some of its current projects. However, there are some issues with current INDOT scheduling methodologies and enforcement methods, which drove the need for this research.

There are several techniques available for scheduling projects but the most popular techniques are bar chart and CPM scheduling. The following sections describe bar chart and CPM scheduling methods, narratives, commonly used tools and finally current scheduling methods employed by INDOT and by other DOTs.

### 2.2 Bar Charts

A bar chart is a visual tool that displays the operations in a project. It is a basic form of scheduling and is usually used for small projects that do not require much tracking or those with shorter durations such as a few months. A bar chart shows the breakdown of the project into several activities with their durations. They are drawn as bars on a timeline showing the sequence of the main activities. This breakdown can be detailed or general depending on the schedule requirements. It can be shown in an excel spreadsheet or simply as a list depending on the contractor's methods. It is a simple method that lacks the details required for more complex projects hence its use has been decreasing over the years. However, some people prefer it due to its simplicity, ease of use and that it does not require a high budget (Galloway, 2006;Rowings, Harmelink, & Rahbar, 1993).

There are many drawbacks to bar charts since they are a very simple method. These drawbacks include:

- Does not show relationships
- Does not show a detailed breakdown of the project
- Does not show resources
- Does not show cost
- Does not show calendars or shutdowns due to weather
- Cannot be updated to show project progress

### 2.3 CPM Schedules

CPM or Critical Path Method scheduling is the second most popular scheduling technique. It was developed

after the bar chart but has spread widely since its introduction. It is more advanced than the bar chart and has been increasing in use especially on larger and more complex projects. Tavakoli and Riachi (1990) created an online survey targeting the top 400 engineering companies (from Engineering News Record-ENR). They found that about 92% of the 121 companies that responded use CPM scheduling. They also compared this number to a previous study by Davis (1974) where the percentage of CPM users was 90%. The most recent survey performed was by Kelleher (2004) which showed that 98% of the companies use CPM, which is higher than the 92% found by Tavakoli and Riachi (1990) and the 90% found by Davis (1974). These three studies emphasize the increased use of CPM by the top 400 contractors. The most common CPM scheduling software used include Primavera P3, P6 and Suretrak and Microsoft Project.

DOTs usually request the following items to be present in the baseline (NYSDOT, 2015):

- Project operations, shown as activities
- Sequencing of activities that mirrors the actual intended plan
- Project milestones
- Materials and equipment
- Submittals
- Traffic control plans
- Activities assigned to other parties
- Inspection activities

DOTs review the received schedules in order to send a "soft approval" to the contractor. This means that the DOT only reviews the schedule for conformance to the specifications and looks at format and constraints to make sure that there are no anomalies in the schedule (Clough, Sears, & Sears, 2000; Henschel & Hildreth, 2007; Hildreth, 2006a). An approval, however, does not mean that the owner has reviewed the activities, their sequencing or any other schedule details since this is the sole responsibility of the contractor.

CPM schedules can be effectively used for the following (Cashman & Tayam, 2010; Galloway, 2006; Hildreth & Munoz, 2005; Kelleher, 2004; Mubarak, 2005; VDOT, 2012):

- Monitoring project progress
- Showing project milestones
- Establishing the correct amount of time to accept for project extension
- Analyzing effects of change orders
- Establishing delay responsibility
- Verifying actual start and finish dates of activities on-site
- Projecting the expected finish date and any possible delays
- Revealing conflicts between different trades
- Revealing problems due to activity concurrency or lack of available resources
- Communication
- Project control
- Coordination between different activities or resources (such as equipment and labor)
- Creating a look-ahead schedule
- Tracking submittals
- Reduce risks through detailed planning
- Efficient utilization of resources

Advantages of CPM schedules:

- Can show a detailed breakdown of the project
- Enables resource and cost loading
- Can show different layouts and filters
- Can utilize multiple calendars
- Can perform crashing of projects to reduce their time
- Can identify the paths that can be taken to accelerate a project to be completed prior to its due date or identify the shortest possible time or the least possible cost that is needed to complete a task (Stelth, 2009)

According to Jaafari (1984), the problem with CPM schedules is not in the method itself but in the way it is applied. Hence a better and more educated use of CPM would lead to better schedules that represent the real project and are manageable. Training is required in order to increase the knowledge and aptitude of a scheduler in order to better manage projects.

Disadvantages of CPM schedules (Galloway, 2006; Henschel & Hildreth, 2007; Wickwire, Driscoll, Hurlbut, & Groff, 2003):

- Can be manipulated by the scheduler to show non-critical activities as critical or vice versa in order to benefit from the float on activities that are delayed or to draw attention away from delays caused by them
- CPM schedules are as good as the scheduler creating them. If the scheduler is an expert, he/she will be able to utilize the software effectively to show the correct sequence of work and critical path. If the scheduler is not capable, however, then the end product will closely resemble a bar chart and will not be as effective
- Construction managers are usually not very well-informed about the software
- The cost of using them is higher than bar charts
- Must be updated regularly to reflect the actual status
- Requires trained personnel
- Float abuse

According to Tavakoli and Riachi (1990), the main reason behind the failure of CPM usage is lack of support from field personnel. Factors that affect the success of CPM schedules are (Galloway, 2006; Jaafari, 1984; McCullough, 1999):

- Correct estimation of labor productivity
- Correct addition of buffers between activities especially those under different trades
- Experience (or lack of) of the scheduler
- Correct update estimates in the schedule
- Well-maintained schedules that depict any changes that occurred

Many DOTs request the submission of three main items: preliminary schedule, baseline schedule and updates (Hildreth, 2006b). The preliminary schedule serves as an initial schedule that summarizes the project. It is

usually a small schedule and is not detailed since it only serves as an introduction. It can provide more detail for a specific duration such as the first 60 or 90 days of the project. The next submittal is the baseline schedule that serves as the detailed plan for the entire project. The final type of submittal is the update that is usually requested on a monthly basis to monitor the progress of the work.

Prior to starting work, a scheduling conference should take place with the presence of representatives from the contractor and owner's side. This conference should be held to discuss the future plan for the submittals. The contractor should also submit a preliminary schedule, especially for larger projects. This schedule usually shows a detailed breakdown of the first month or sometimes more depending on the project size.

*Critical Path*

The critical path is the sequence of critical activities in the project. These activities drive the project and determine the project completion date. It is important to track the critical path throughout all the project stages and monitor the changes that occur. Any delay to the critical path will affect the entire project and the completion date; hence to control the project, the critical path must be controlled. Another list of activities, the "near-critical" activities also need to be monitored. These can be defined differently based on the project and the person looking at it. They are defined as activities with a small float that could be critical if any delays occur. In order to reduce delays, the critical and near-critical activities need to be monitored in order to create mitigation plans for them early on.

*Updated Schedule*

In order to monitor the progress in projects and perform sound delay analysis, the baseline must be updated at regular intervals (Hegazy, Elbeltagi, & Zhang, 2005; Winter, 2011). The updates must be based on the actual progress on-site and reflect any changes that have occurred in the plan (Mubarak, 2005). Figure 2.1 shows the sources of information that are converted to information to be used to create the updates. Some of these sources include meeting minutes, change order data and daily reports. These are then converted to actual start and finish dates for the activities, delays and cost or resource data if they were included in the schedule.

*Delays*

The majority of construction projects suffer from time overrun. When this happens, the contractor seeks to get an extension of time in response to the delay. In order to prove his entitlement, the contractor usually submits a narrative explaining the delay, reasons behind it, affected activities and the critical path before and after the delay to justify his claim. The contractor also supplements this with his analysis that is performed using the CPM schedule. According to a survey by Galloway (2006), over 67% of the respondents indicated that using CPM schedules reduced the number of claims in their projects. Data about activity updates is usually important for the performance of a delay analysis (Hegazy et al., 2005). There are different methods of assessing the delay caused by a certain event such as as-built, as-impacted, contemporaneous, window

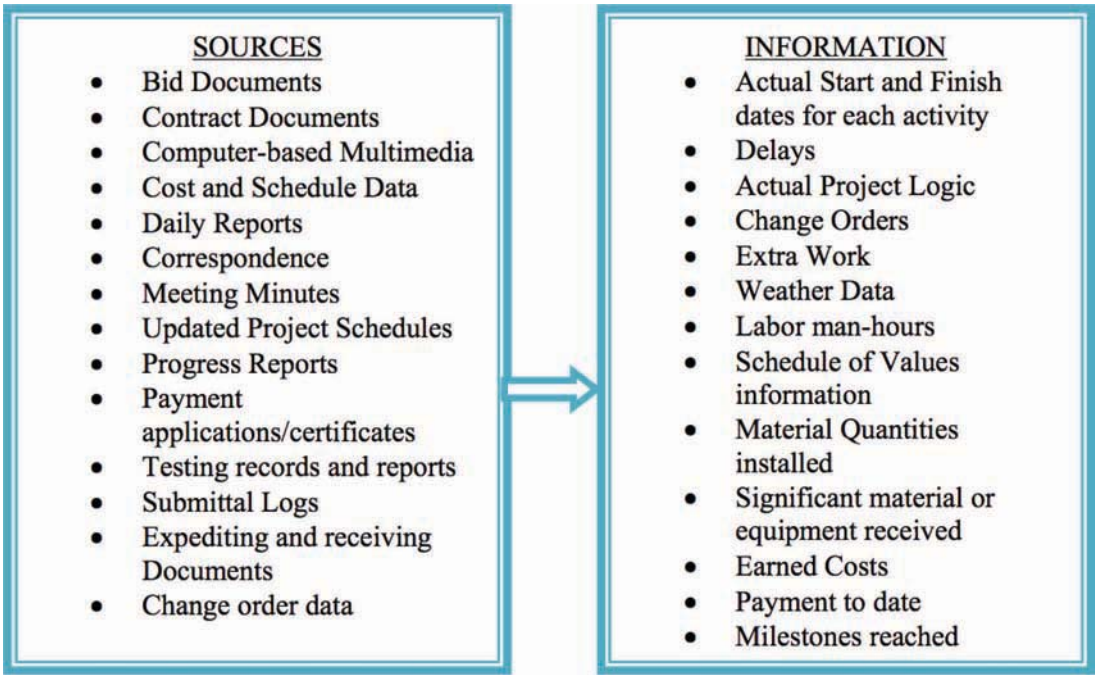


**Figure 2.1** Information used in creating updates (redrawn from Knoke & Jentzen, 1996).

analysis, time-impact analysis and collapsed as-built (Arcuri & Hildreth, 2007; Galloway, 2006; Mbabazi, Hegazy, & Saccomanno, 2005; McCullough, 1999). However, the most widely used is the Time Impact Analysis method. This method uses the update prior to the delay event occurring. The delay is broken down into a number of activities with the duration and logic, called a fragnet. The delay fragnet is inserted into the update and a comparative analysis of the schedule before and after the insertion of the delay is conducted. The difference in duration between both updates is usually the time extension to be requested by the contractor. It is important to regularly update the schedule in order to capture the correct progress of work since this schedule would be used for any delay analysis. When performing a delay analysis, the schedule should not be changed, but should be maintained as it is. The only step required is to add the delay event. Changing the schedule in any way might affect the critical path and distort actual consequences of the delay. It is important for the owner to review the time impact analysis report submitted by the contractor thoroughly to check on any changes the contractor might have made that could make the analysis biased to his favor. In his report, the contractor must also include a mitigation plan and recovery process for the delay.

*Linear Projects*

Linear projects such as roadways, tunnels, pipelines or railways consist of repeated sections of work. These projects can be represented visually by drawing the repeated sets of activities on an axis showing the time (Gronevelt & Mattila, 1999). The activities are represented as lines, with the production rate as the slope. Linear projects can be scheduled using CPM scheduling techniques (Jaafari 1984). Software such as Primavera P6 would make this task easier since the user can create one set of activities and copy them (including their information such as duration, relationships and cost) and paste them multiple times. They can then change each activity's data as needed. This method helps keep the schedule consistent. There are some methods that have been developed specifically for linear projects such as the Line of Balance (LOB) technique. According to Arditi (1986), in a survey of 200 contractors, none of them used the LOB technique. One problem with the LOB technique is that it assumes that the output rate is constant and uses it to schedule the project (Rowings et al., 1993). Another problem is that there is no software that employs this method; hence the calculations need to be performed manually (Rowings et al., 1993).

*Classifying Projects*

In order to extract the most benefit from schedules and avoid extra work, projects need to be classified into certain categories with each category requiring a certain amount of detail in the schedule. Criteria for classifying projects includes the inherent risk, size of the project and complexity. Complexity depends on many factors such as:

- Project risk
- Impact to traffic
- Environmental impact
- Likelihood of project delay
- Constraints to the schedule
- Number of concurrent operations

Rowings et al. (1993) suggested a classification based on five project criteria: "size, complexity, repetition, timing and variability." Project size was divided into three classes: less than $1 million, $1–5 million and more than $5 million. Complexity ranged from simple projects that required one contractor to more complex projects such as highways to the highest complexity which involved multiple contractors and had high traffic flow. Project timing was divided into three classes: less than six (6) months, 6–12 months and more than 12 months. The last classification, variability, dealt with duration and resource availability where the lowest level consisted of one-season projects and the highest level had longer duration and limited resources. Since each of these classifications was divided into three, the lowest level would require a simple bar chart, the middle classification would require linear scheduling and the highest classification would require a CPM schedule (Rowings et al., 1993).

### 2.4 Narrative

A narrative is a document containing a description of the project and the scheduling method used. It can contain general project information such as phasing and milestones as well as more detailed schedule-related information such as:

- Project milestones
- Sequencing of activities
- Description of the critical path
- Description of near-critical activities
- Weather shutdowns
- Calendars used in the project
- Possible delays in the future and mitigation plans
- Problematic areas/activities in the project
- Previous delays and if they have been contained or are still on-going
- Information about cost/resource loading
- Settings used (for CPM schedules)

Narratives are useful tools when properly used. They can save time and effort if they portray enough information about the project since they are written by the scheduler and discuss his/her creation of the schedule. A narrative makes schedule review/monitoring easier since it extracts some of the important information pertaining to the schedule and summarizes it in a document. It provides the framework for the entire schedule (Hildreth & Munoz, 2005).
A sample narrative would contain the following sections:

**I:** Introduction
**II:** Basis and Assumptions

**III:** Current Critical Path
**IV:** Progress & Modification Methodology
**V:** Problem Areas
**VI:** Notes

And the following appendices:

**A:** Required Schedule Reports
**B:** Schedule Calculation Report
**C:** Critical Activities Report
**D:** Progressed Activities Report

Schedule revisions are usually requested due to: change orders, delays to the project, changes in the logic or other activity information or due to acceleration/deceleration (Galloway, 2006).

### 2.5 Commonly Used Tools

There are several tools available for scheduling practices which can either be forms, checklists or commercial software. The evolution of scheduling techniques and accompanying software packages is heading towards more complex interfaces that enable users to perform more sophisticated analysis but require special training. These new features enhance the software capabilities but at the same time complicate its implementation by requiring too many inputs and rigorous updating procedures, which may be unnecessary for INDOT purposes. Furthermore, performing probabilistic or what-if analysis demands more sophisticated knowledge of the interworking of the software and its underlying scheduling method. Commercial software ranges from the more complex software such as Primavera (P3, P6, Suretrak, Contractor) to the simpler tools such as Microsoft Project and Microsoft Excel. The choice of which software to use depends on the project size, complexity and the required items to show. Below is a brief explanation of the main software used in scheduling.

*Microsoft Excel*

Microsoft excel can be used to show the project activities and bar chart showing the dates and duration as well. It is usually used for small projects with short durations which are not too complex and do not require a lot of details to be presented.

*Microsoft Project*

A step higher in the complexity would be the Microsoft Project software. It is generally used for projects of higher complexity or where more details need to be presented. In addition to the duration and dates, it can also show relationships between activities. Another important item is that it can show the critical path which is useful to track the project. Cost and resource loading can also be performed. An advantage of Microsoft Project is its lower cost, compared to Primavera software (Winter, 2011). It also has built-in graphs and reports that could be easily used. However, it is not a very easy tool when it comes to updating or performing delay analysis (Winter, 2011).

*Primavera*

The highest level of complexity would bring us to the Primavera software that is a product of Oracle. There are various types of commercial packages available from Primavera depending on the required level of usage. Primavera is the most widely used software in creating a CPM schedule. In a survey analysis by Galloway (2006), 65% of the contractors indicated that they prefer Primavera software while only 22% indicated they prefer Microsoft Project.

### 2.6 Schedule Review

The process of schedule review varies from one state to another. There are three basic levels: receive, review and approve. The "receive" status only indicates that the contractor has submitted a schedule but no review has been done. The "review" status means that the schedule has been reviewed only for conformance to the requirements to the specifications. The final status, "approve," indicates that a higher level of review was made for the reasonableness of the schedule as well as its conformance to the specifications. According to (Hildreth, 2006a), seven (7) agencies indicated that the schedules are "received," 19 agencies replied that the schedules will either be "reviewed" or "approved," 12 agencies indicated that "approval" does not mean validation of the contractor's plans. Many DOTs do not approve so that they aren't held liable for the schedule. This is discussed in a later section.

It is important to create a standard for review/approval of schedules for the following reasons (Hildreth, 2006a; Wickwire et al., 2003):

- Check how reasonable the contractor's schedule is
- Coordinate between contractors or schedules
- Check for incorrect or ambitious plans
- Review owner-related operations in the schedule

### 2.7 INDOT Scheduling Requirements

Standard scheduling requirements were developed in the specifications in order to apply them to INDOT's construction projects. The current scheduling specifications were reviewed and surveys sent out to INDOT personnel and to other DOTs in order to find the shortcomings in the current specifications and propose changes based on the best practices observed.

INDOT projects are either short-term projects with duration of a few months and thus do not require schedules or are longer projects with specific scheduling requirements which are not always conformed to by the contractors. The following is extracted from INDOT's (2011) schedule specifications (108-C-215):

*"2. The Contractor shall furnish the Engineer with a bar graph type schedule which shows the* ***estimated times*** *required to prosecute the* ***major or critical items*** *of work for acceptance*

3. *Exemptions (no need for bar graph) are:*

   - *the contract has less than 60 calendar days completion time*
   - *less than 35 work days*
   - *less than 60 days between the date of the notice to proceed and the calendar completion date*

4. *This schedule:*

   - *Shall incorporate all contract requirements regarding the order of performance of work and each activity.*
   - *Shall graphically show the calendar time for which each activity is scheduled for work*
   - *May be used as the basis for establishing major construction operations and as a* ***check on the progress*** *of the work.*
   - *Sufficient materials, equipment, and labor shall be provided to guarantee the completion of the project in accordance with the plans and specifications within the specified completion time."*

According to INDOT's 2014 Standard Specifications (108.04—Prosecution of the Work), the contractor shall furnish the INDOT engineer with a bar graph type schedule which shows the estimated times required to prosecute the major or critical items of work for acceptance at the pre-construction conference. This schedule should incorporate all contract requirements regarding the order of performance of work and each activity.

INDOT's (2011) Recurring Special Provision (108-C-215 Critical Path Method (CPM) Schedule) is a more detailed guideline that is used for more complex projects requiring a CPM schedule. According to this document, each CPM schedule submittal shall include a letter of transmittal identifying the schedule submittal and contents and a narrative report in accordance. Contractors should also submit an electronic file of the schedule in Primavera (XER) format that is completely compatible with and may be directly imported into Primavera Contractor 5.0 without any loss or modification of data or need for any conversion or other software. The first CPM schedule submittal will be the baseline and should be submitted at preconstruction conference. Information obtained from the baseline CPM schedule and subsequent monthly updates are used as a basis for compensation, disputes/claims and time adjustments by INDOT engineers.

### 2.8 Other DOT Scheduling Requirements

According to Michigan DOT (Gronevelt & Mattila, 1999), the purpose of scheduling requirements include:

- Ensuring that the contractor has created a reasonable plan for the project
- Ensure the availability of a tracking method to follow-up on the progress of the project
- Ensure the availability of a documentation method in order to show the initial project plan and any time extensions awarded

Every DOT has its own standard practices, specifications and requested documents from the contractor pertaining to scheduling. Some of the main points seen in other DOTs are discussed below.

TxDOT specifications request a preliminary schedule for the first 90 days, a baseline schedule, monthly updates and also a "notice of potential time impact" in case of a time extension (TxDOT, 2004). TxDOT has four levels of scheduling: level one which does not require schedules for small projects such as maintenance activities, level two which requires a bar chart schedule, level three (3) which requires basic CPM scheduling and level four (4) which requires advanced CPM scheduling and necessitates the use of Primavera software (Gronevelt & Mattila, 1999). Level four (4) also requires activities to have a duration less than twenty days and include coding for the type and location of the activity (Gronevelt & Mattila, 1999). TxDOT also requires the submission of a preliminary schedule describing the first 60 days of the work and the submission of the baseline schedule within 35 days (Gronevelt & Mattila, 1999).

MDOT's Final Report (Gronevelt & Mattila, 1999) stated that TxDOT requires biweekly updates and enforce a fine of $100 per day for the delayed submittals. In order to monitor progress, some DOTs use milestones. These are dates that signify the start or completion of a certain event. This event can be bound by the contractual agreement and have liquidated damage in case of its delay such as the contract completion or it can be a preferred date (Hildreth, 2006b). Two-week lookahead schedules are also requested by several DOTs to track progress and anticipate activities that would start/finish within the specified duration.

NYSDOT specifications has specific requirements for the activities to be included in the schedules such as:

> *"(a) milestone events; (b) seasonal weather limitations (c) the procurement and fabrication of materials, plant and equipment; (d) the order in which the Contractor proposes to complete activities; (e) temporary structures or systems; (f) major construction or work zone traffic control stages; (g) activities assigned to Utilities, railroads and other parties; (h) activities assigned to the Department and other State or municipal entities; (i) sampling and testing of materials; (j) settlement, surcharge or cure periods; (k) punch list work, and (l) inspection activities assigned to the Department, including final inspection"* (NYSDOT, 2015).

Washington state DOT specifications consist of two types of schedules: type A which can be a bar chart, CPM or any other method and type B which must be a CPM (WsDOT, 2016). WsDOT also requests weekly look ahead schedules and updates in case of a delay, extension or a change in the sequence of work (WsDOT, 2016). WsDOT also delineates in its specifications the presence of a bid item named "Type B Progress Schedule" that is a lump sum amount (WsDOT, 2016).

Delaware DOT utilizes a database of production rates for the creation of schedules and also adds adverse weather delays to the schedule. Pennsylvania DOT, on the other hand, does not keep a record of the production rates but plans a scheduling meeting with DOT,

TABLE 2.1
**Calendar and adverse weather (Hildreth, 2005).**

| DOT | Procedure |
|---|---|
| Arkansas | 150 working days per year |
| Idaho | Different inclement weather days per month |
| Indiana | Different inclement weather days per month (specifications; 101.02) |
| Missouri | Different inclement weather days per month for each type of project and region |
| Nebraska | Different inclement weather days per month |
| Pennsylvania | Does not give special consideration to weather |
| Tennessee | 150 working days per year |
| Washington | Average number of working days per month |

design and utility personnel in order to decide on activity duration and relationships (Hildreth, 2005).

In order to calculate contract durations, some DOTs have created a number of templates for each type of project containing activities for the contractor to fill in the duration required to complete each of them. These DOTs include Texas and Kentucky (Hildreth, 2005). Other DOTs rely on the contractor to provide the schedule consisting of activities, durations, and relationships.

Many DOTs train their personnel in scheduling techniques to keep them up-to-date and make their review of contractors' schedules easy. This training can either be by in-house professionals or outside consultants such as the National Highway Institute (NHI). The NHI provides a course on Critical Path Method (CPM) Scheduling titles "Use of Critical Path Method for Estimating, Scheduling, and Timely Completion (Course #13049)" (Trauner Consulting, n.d.). This course provides training on schedule understanding, control and monitor. Some states also have District Engineers who are responsible for all the work related to schedules and time impact analysis review. These engineers are also sometimes responsible for training and supporting the field personnel.

A nation-wide survey by Rowings et al. (1993) that was sent to 50 state DOTs to gather their scheduling practices found that 47% of the 36 states that responded did not use schedule specifications, 27% used different specifications for different projects, 20% said they only use one specification for all their projects and finally, 7% mentioned other undocumented methods. Since then, there has been a rise in the number of DOTs that use scheduling specifications and the details they employ (as presented later in this study). The study by Rowings et al. (1993) also indicated that 40% of the respondents request CPM from the contractors, 35% request bar chart, 5% request narrative, 5% request progress curve while the remaining 15% do not request any scheduling from the contractor (Rowings et al., 1993). This study will present the progress of the state DOTs in requesting scheduling methods from the contractor from the previous study in 1993. Another important point that Rowings et al. (1993) presented is that 33% of DOTs responded that updates are performed only when the project is ten to sixty days behind schedule or more than 20% of the duration, 33% do not update the schedule, 7% perform quarterly updates, 13% perform monthly updates and the remaining 13% only update as requested.

An important aspect to look at is the inclusion of inclement weather days in schedules. Some DOTs input these days as shutdown days in the calendar while others include it in the affected activities' duration. Table 2.1 shows how some DOTs define inclement weather in their specifications.

## 3. DATA COLLECTION

### 3.1 Survey 1

The main purpose of this survey was to gather data from Indiana State Department of Transportation (INDOT) about the scheduling practices used for their projects. In order to perform this, an online questionnaire was created consisting of 11 questions targeted to gather data about INDOT's scheduling needs, practices and problems. The survey questionnaire was provided to INDOT field personnel to gather their responses. It was conducted from May 13th to June 11th with a total of 65 field personnel who responded to the survey. The questions included in the survey are listed in Appendix A. All the questions were prepared to collect data to satisfy the study objectives and were reviewed by the Study Advisory Committee (SAC) members. It was then distributed to the field personnel. Figure 3.1 shows the breakdown of the questionnaire into four areas and the number of questions in each area. The first question is not included in the figure because it asked about the respondent's name, position and contact information.

As seen in Figure 3.1, there are 11 questions in the survey targeted to address the survey objectives discussed previously. The survey was divided into four (4) areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specs and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software.

As mentioned earlier, 65 INDOT field personnel responded to the questionnaire through the web-based survey tool, SurveyMonkey. The questions in the survey are discussed in this chapter, the survey is shown in Appendix A and the results of the analysis are discussed in chapter 4.

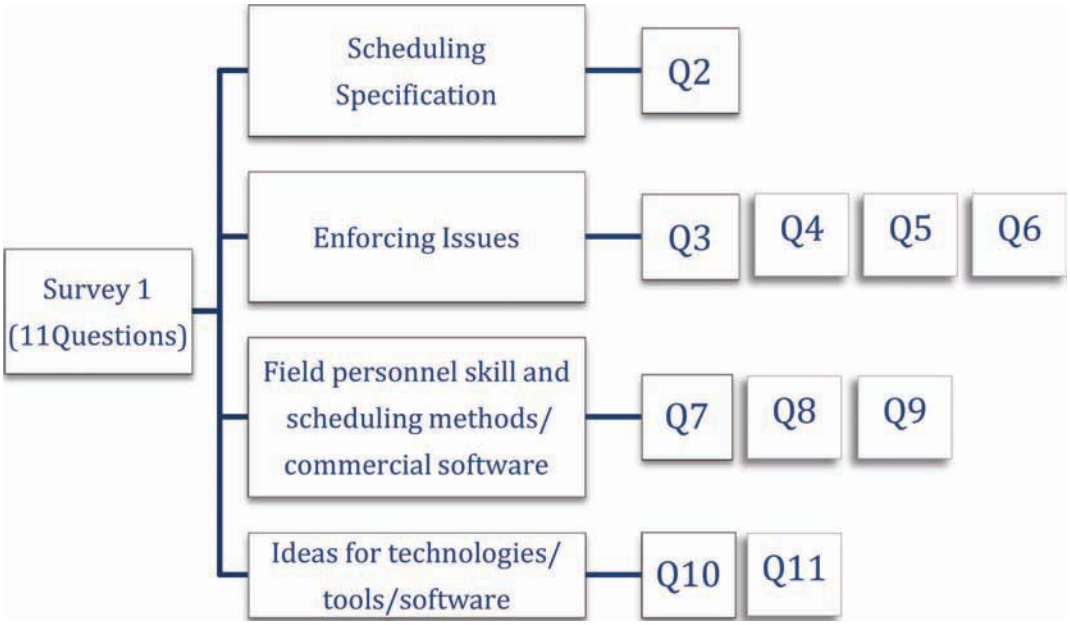


**Figure 3.1** Breakdown of survey 1 questions.

### 3.2 Survey 2

The main purpose of this survey was to gather data from other state Department of Transportations (DOTs) about the scheduling practices used for their projects. In order to perform this, an online questionnaire was created targeted to gather data about the DOTs' scheduling needs, practices and problems. A total of 31 states with 35 people responded to this survey. The questions included in the survey are listed in Appendix B. All the questions were prepared to collect data to satisfy the study objectives and were reviewed by the Study Advisory Committee (SAC) members. It was then distributed to other DOTs. There were 14 questions in the survey targeted to address the above survey objectives. The survey was divided into four (4) areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specs and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software.

This nationwide survey was conducted for three months from June to September in 2015. A total of thirty-five DOTs responded to this survey. The various positions of the participants for survey 2 are presented in Table 3.1. Additionally Table 3.2 shows the DOTs and the transportation agencies that participated in this survey. The discussion of the survey results is presented in chapter 4.

TABLE 3.1
**Positions of the participants for survey 2.**

| Position of the Participants | No. |
|---|---|
| Project Manager | 2 |
| Field Engineering | 2 |
| Construction Engineer | 20 |
| Research & Technology transfer and TAM | 1 |
| Deputy Chief Engineer | 1 |
| Materials Manager | 1 |
| Construction & Materials Liaison Engineer | 1 |
| Construction and Materials Liaison Engineer | 1 |
| Head of RSS | 1 |
| Transportation Engineer III/Team Leader | 1 |
| Bureau Chief | 1 |
| Total | 32 |

### 3.3 Phone Interviews

Phone interviews were planned for INDOT and for other DOTs as well. One engineer was chosen from INDOT who had responded to both survey 1 and 2 in order to verify some information about INDOT's scheduling practices and level of understanding of scheduling. Regarding the other DOTs, the results collected from 31 DOTs with 35 people in survey 2 were analyzed in order to select a number of DOTs to interview. The responses drew attention to certain DOTs whose practices were varied in complexity and effectiveness. Some DOTs had very good practices that seem to work well; hence they were targeted in order to better understand their practices and how they enforce them. Other DOTs provided interesting responses about the importance (or lack of) of scheduling practices and how they tracked progress. We decided to interview six (6) DOTs whose knowledge would be a beneficial addition to the research (including INDOT to better understand their problems). Table 3.3 shows the list of selected interviewees' position and agency.

These six individuals were interviewed over the phone to discuss our questions with them. Chapter 4 presents the analysis of the interviews and Appendix C shows the questionnaire for each DOT.

TABLE 3.2
**List of DOTs that participated in the survey.**

| | |
|---|---|
| 1 | Virginia Department of Transportation |
| 2 | Vermont Agency of Transportation |
| 3 | Alaska Department of Transportation and Public Facilities |
| 4 | District Department of Transportation |
| 5 | Idaho Transportation Department |
| 6 | Georgia Department of Transportation |
| 7 | Missouri Department of Transportation |
| 8 | South Carolina Department of Transportation |
| 9 | Missouri DOT |
| 10 | MassDOT |
| 11 | Kentucky Trans Cabinet |
| 12 | Oregon Department of Transportation |
| 13 | TxDOT |
| 14 | Oregon DOT |
| 15 | ODOT |
| 16 | Mississippi DOT |
| 17 | Wyoming DOT |
| 18 | MoDOT |
| 19 | UDOT |
| 20 | Montana |
| 21 | WVDOT |
| 22 | Kansas DOT |
| 23 | Illinois DOT |
| 24 | NHDOT |
| 25 | Michigan DOT |
| 26 | INDOT |
| 27 | NJDOT |
| 28 | AR Highway & Transportation Department |
| 29 | NDDOT |
| 30 | WSDOT |
| 31 | INDOT |

TABLE 3.3
**List of DOTs and position titles.**

| Position Title | Agency |
|---|---|
| Field Engineer | INDOT |
| Assistant State Construction Engineer | Virginia DOT |
| Director of Construction & Materials | Vermont DOT |
| State Roadway Construction Engineer | WSDOT |
| Construction Section Director | TxDOT |
| Construction Operations Engineer | Michigan DOT |

### 3.4 Summary

This chapter discussed the data collection process for surveys 1 and 2 as well as the phone interviews conducted. Survey 1 was conducted to gather data from Indiana State Department of Transportation (INDOT) about the scheduling practices used for their projects and 65 responses were received from INDOT personnel. Survey 2 was conducted to gather data from other state Department of Transportations (DOTs) about the scheduling practices used for their projects. A total of 31 DOTs with 35 people responded to this survey. Both surveys were divided into four (4) areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specs and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software. Phone interviews were also conducted for INDOT and for 5 other DOTs in order to verify some of the information received in the responses and to gather more information about methods to improve INDOT's scheduling techniques. Chapter 4 will discuss the results collected from these three steps in detail.

## 4. ANALYSIS

### 4.1 Survey 1

The aim of the first survey was to gather information about INDOT personnel's current scheduling practices, their needs, areas of improvement and possible changes to be made. The survey was made available online through Survey Monkey and 65 responses were received. This section describes the responses received for each question.

The first question addressed the issues and challenges in implementing the current specifications, which can be summarized as follows:

- Specifications are vague in some areas and very extent in others
- Contractors' reluctance to update master schedules
- Lack of personnel training on CPM schedules
- Lack of AE/PE/PS training in interpreting specifications
- Lack of a change log as specifications are updated
- Specifications do not specify well enough the detail necessary or milestones sought in the schedules
- More accurate narratives needed
- Lack of understanding of the PE/PS and Contractors in utilizing a CPM schedule to communicate, coordinate, mitigate risk, manage change and document change

The second question aimed at calculating the percentage of contractor compliance to submitting updated schedules. Results showed that contractors do not comply in more than 50% of the cases as shown in Figure 4.1. This can be attributed to lack of penalty on the contractor if they do not submit, and this varies according to the contractor assigned to the project.

The third question asked whether contractors always followed INDOT scheduling specifications. Responses (Figure 4.2) indicate that contractors do not follow INDOT's scheduling specifications almost 70% of the time. Comments on this question include that this depends on the experience level of the contractor and INDOT follow-up with them. Some of the responses include:

- Yes to this … things happen and depending on your contractor's experience level, things can easily be forgotten. Part of my job is to make sure that scheduling issues or submittal deadlines that do not meet our spec do not cause any job issues. I try to prod the contractor along and stay proactive. I feel that doing that is part of my job though, in an ideal world, it wouldn't have to be.

The fourth question addresses suggestions for changes to current bid documents to increase the contractor's

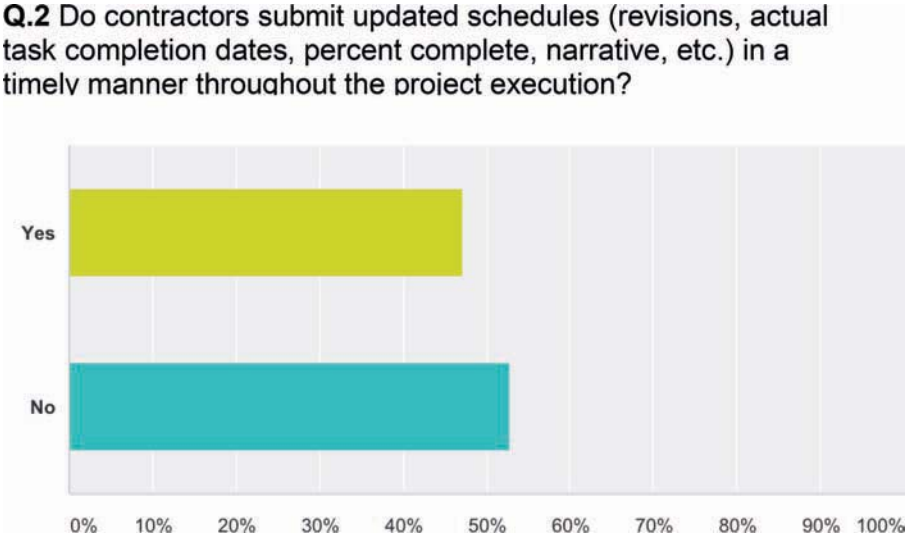


**Figure 4.1** Responses for question 2.

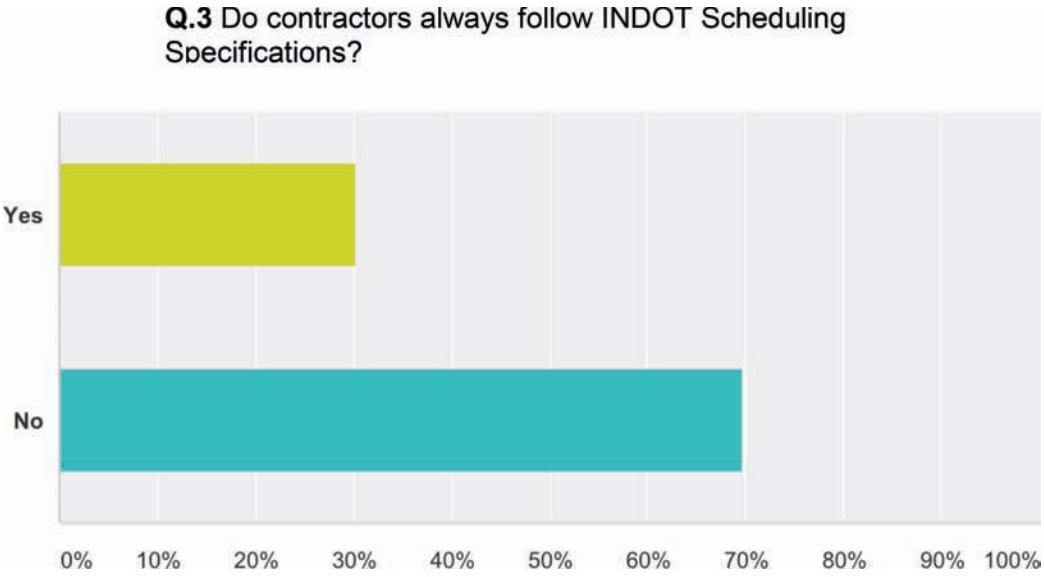


**Figure 4.2** Responses for question 3.

compliance to scheduling specifications. These suggestions include:

- Enforcing timeframes for every phase and milestones for the important events
- Enforce the submittal of a schedule before a pre-construction meeting
- Enforce a penalty for late schedule submittals

The fifth question addresses current methods of ensuring that contractors comply with the scheduling specifications. Suggestions for these methods include:

- Discussing specifications at the preconstruction meeting
- Biweekly progress meetings
- Constant reminders/requests to the contractor
- Withhold payment on items
- Frequent communication with the contractor
- Documenting requests
- Threaten contractor using the CR-2 (Report on contractor's performance of contract used by INDOT)

The sixth question addresses the frequency of meetings with the contractor and shows that about 80% of the respondents meet at least once a month with the contractor as seen in Figure 4.3. Respondents stated that for larger contracts INDOT usually meets the contractor on a biweekly basis at least although sometimes these meetings are informal.

Responses to question 7 show that bar charts are the most used scheduling method, with 70% of the responses followed by 20% for CPM schedules. Although INDOT has been pushing to transition to CPM schedules, this is not fully in effect yet. Figure 4.4 presents the responses to question 7. According to the respondents,

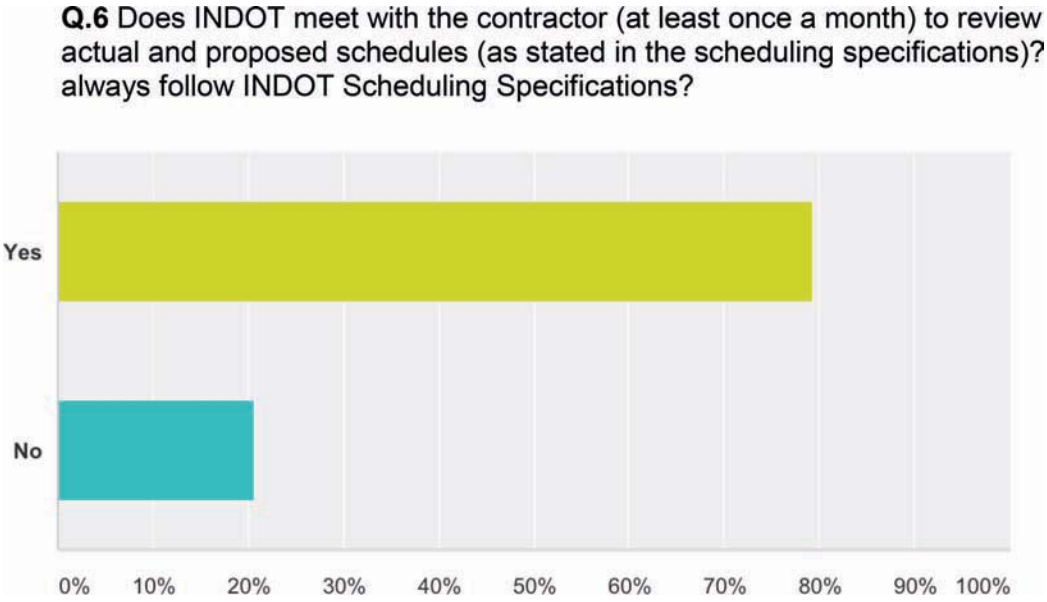


**Figure 4.3** Responses for question 6.

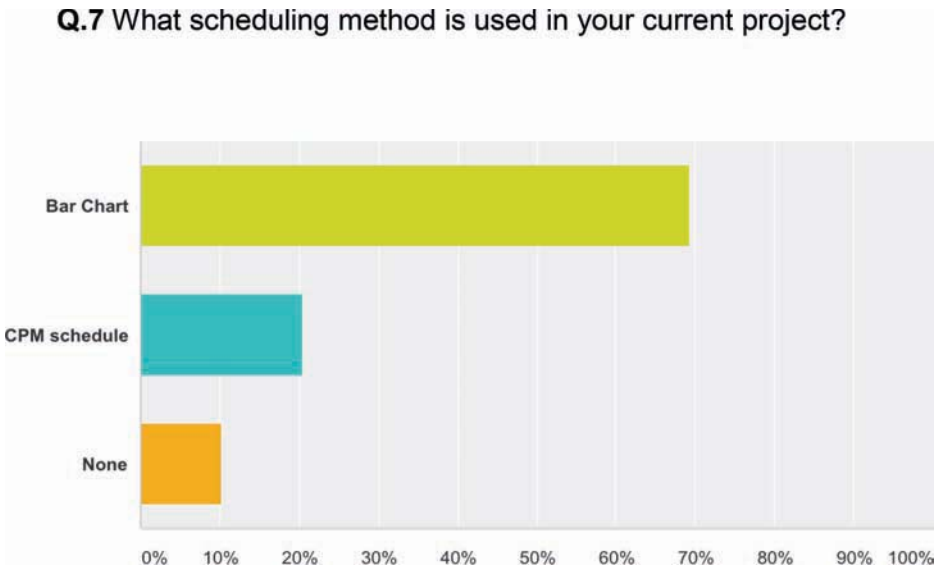


**Figure 4.4** Responses for question 7.

there are other varying methods that the contractors use to show their schedule such as:

- Excel spreadsheet
- Few lines in e-mail
- Biweekly meetings
- Simply a list of operations with dates accompanying the operation
- Weekly updates
- Chart with weekly summaries
- Over-all schedule is presented at Pre-Con; contractor prepares a 2-week schedule for each weekly meeting
- Regular schedule for time allowed
- The projects may use either bar chart or CPM
- Bar chart most common, some cpm

Question 8 addresses INDOT's schedule review. Figure 4.5 shows the percentage of use of each of the options by the respondents. Other methods of schedule review mentioned are reviewing schedule delays and comparing the schedule received to the verbal discussions or weekly meetings.

Question 9 addresses the issue of evaluating the contractor's resources before project commencement. As seen in Figure 4.6, almost 80% of the respondents answered that they do not evaluate the contractor's resources. Comments include that contractors' bidding for a project and their approval is taken to mean that they can perform the job with adequate resources and that respondents do not usually have the time to

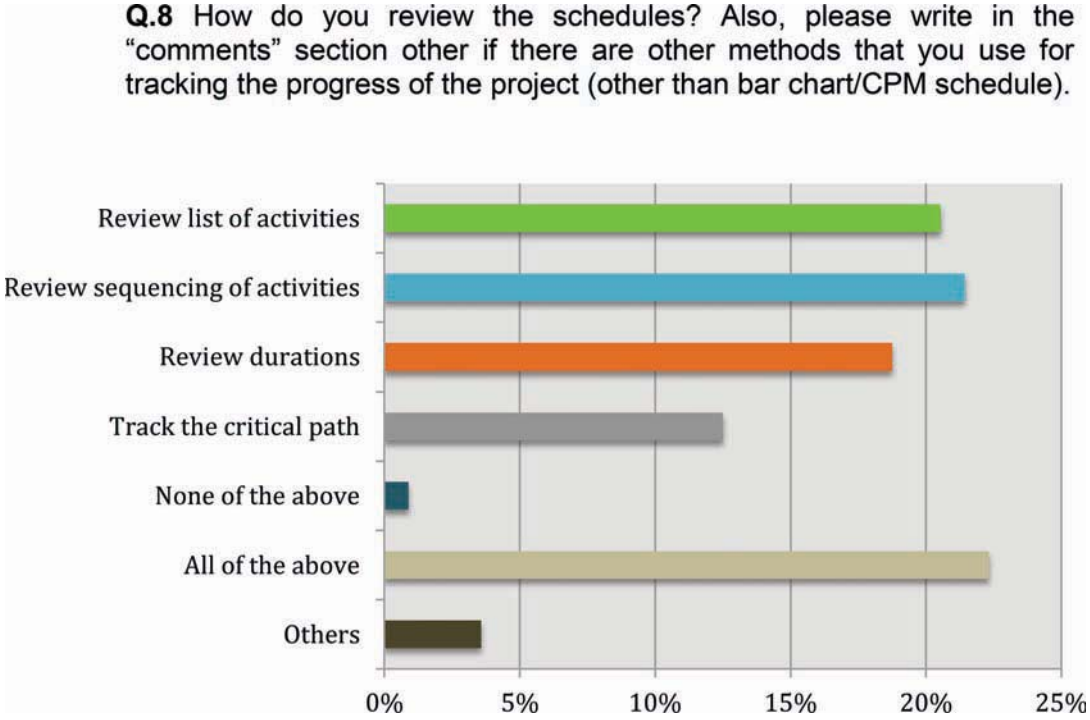


**Figure 4.5** Responses for question 8.

perform a detailed analysis, they only look for obvious irregularities. Figure 4.6 presents the responses to question 9.

Question 10 addresses proposed amendments to the current bar chart/CPM schedule in order to make the review more effective. Figure 4.7 shows the respondents' answers. Other suggestions include providing the critical path for the project and training personnel to improve their level of understanding.

The final question, question 11 addresses the flaws in the current narrative in order to modify it. Figure 4.8 shows the respondents answers to this question. Other problems with the narrative are that it would only be useful for larger projects and is not necessary for smaller ones.

### 4.2 Summary of Survey 1

The main purpose of the first survey was to explore the current issues for scheduling specifications faced by INDOT to serve as a basis for exploring alternatives to solve these issues. The target for this survey was INDOT field personnel only. The first survey focused on the four main issues: (a) scheduling requirements; (b) enforcing issues; (c) field personnel skill set and understanding of the specs and scheduling methods/commercial software; and (d) ideas for scheduling technologies/tools/software. Sixty-five (65) INDOT personnel responded to the survey. Table 4.1 shows the summary of the first survey. Some of the problems INDOT face are that contractors do not always follow the specifications and they also do not submit updated schedules in a timely manner as requested. In order to enforce this, INDOT has withheld payments to force contractors to comply with the scheduling specifications but only in rare occasions. For the scheduling method, bar chart is the most commonly used with CPM scheduling being enforced. There is no differentiation or classification for different types of projects in terms of required schedule submittals. INDOT personnel lack the experience and training required to review schedules hence it is highly recommended to conduct training to enhance their knowledge.

### 4.3 Survey 2

The second survey was distributed nationwide to all DOTs across the country to explore the current state of the practice in scheduling application. The survey identified the methods and standard specifications of scheduling used by other state DOTs. The survey focused on four areas: (1) scheduling specifications, (2) enforcing issues, (3) field personnel skill set and understanding of the specs and scheduling methods/commercial software, and (4) ideas for scheduling technologies/tools/software. A total of 31 states DOTs with 35 people responded to the survey.

The first question was about the current state of scheduling and the issues in implementing the scheduling requirements. Nineteen (19) states (70.4%) responded that contractors' lack of cooperation in following the requirements is the main challenge, followed by untrained PE/PS (Project Engineer/Project Supervisor) in understanding requirements as the main issue by sixteen (16) states (59.3%). Also many states wrote comments for their current situation and issues faced regarding the

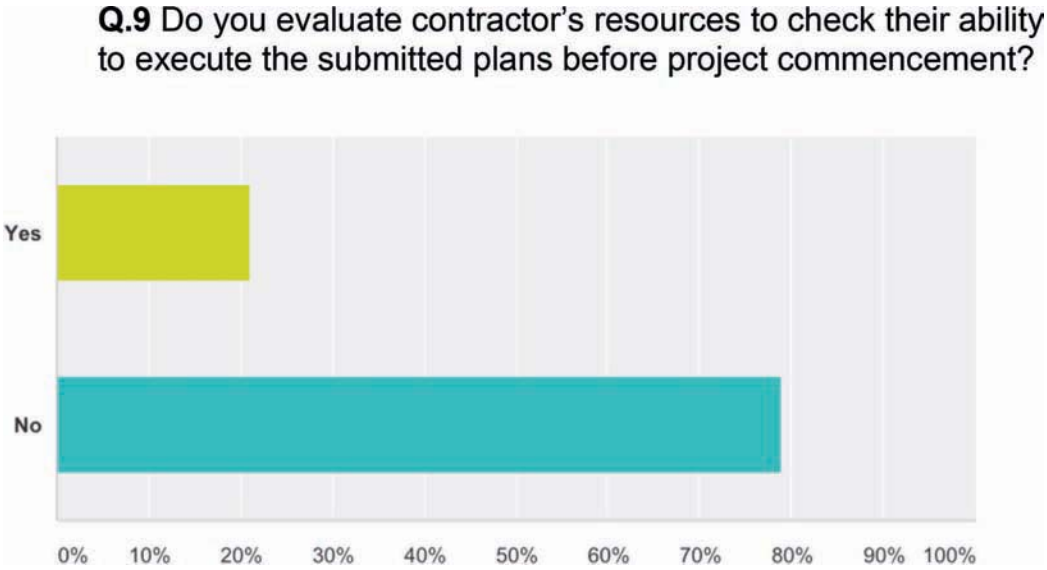


**Figure 4.6** Responses for question 9.

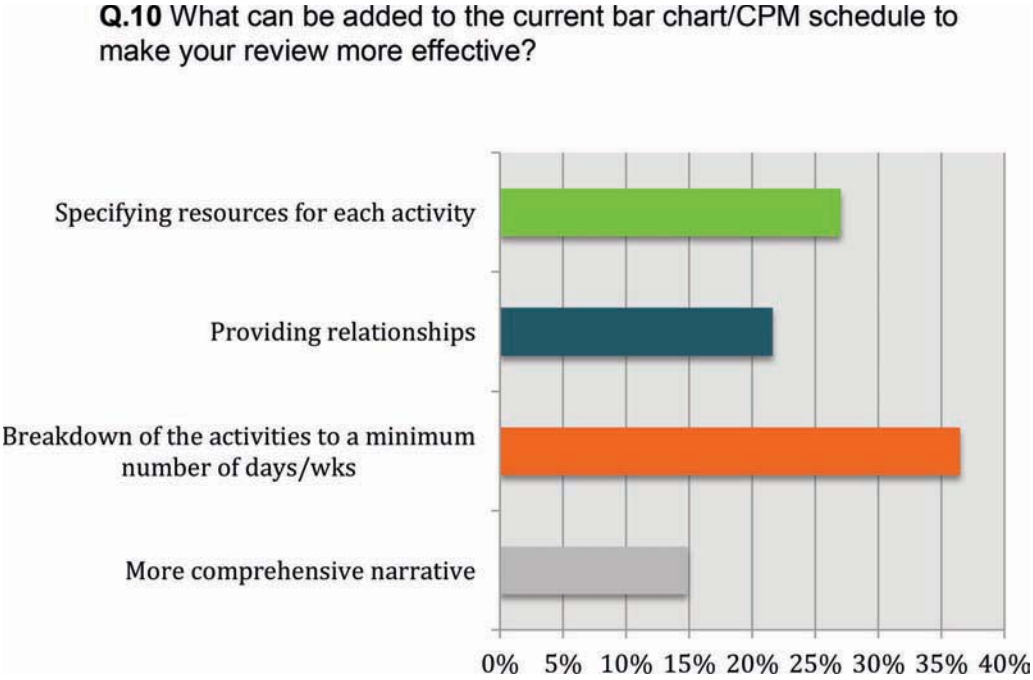


**Figure 4.7** Responses for question 10.

scheduling requirements. According to the comments, contractors tend to be reluctant to follow schedules since there are no repercussions if the contractor does not submit a schedule. Also a number of states have revised their scheduling specification to deal with such issues. Figure 4.9 shows the result of question 1 and some comments provided by the respondents. The detailed list of all survey 2 questions is available in Appendix B.

Several comments were provided:

- Schedules are not a priority. They are rarely being used to justify time extensions. DOT folks scrutinize schedules too much. There are no repercussions when the contractor does not submit schedules.
- Contractors reluctance to update approved schedules
- Unwillingness to enforce the specification. Our scheduling requirements are out of date.
- We are in the process of hiring a scheduling position to help us revise our specifications.
- We have three (3) levels of schedule from a basic bar chart to a detailed CPM using Primavera.
- Contractors' lack of training in scheduling

The second question examined the frequency of the updates required from the contractor. It was observed that the highest percentage was for monthly updates (18),

The final question, question 11 addresses the flaws in the current narrative in order to modify it. Figure 4.8 shows the respondents answers to this question. Other problems with the narrative are that it would only be useful for larger projects and is not necessary for smaller ones.

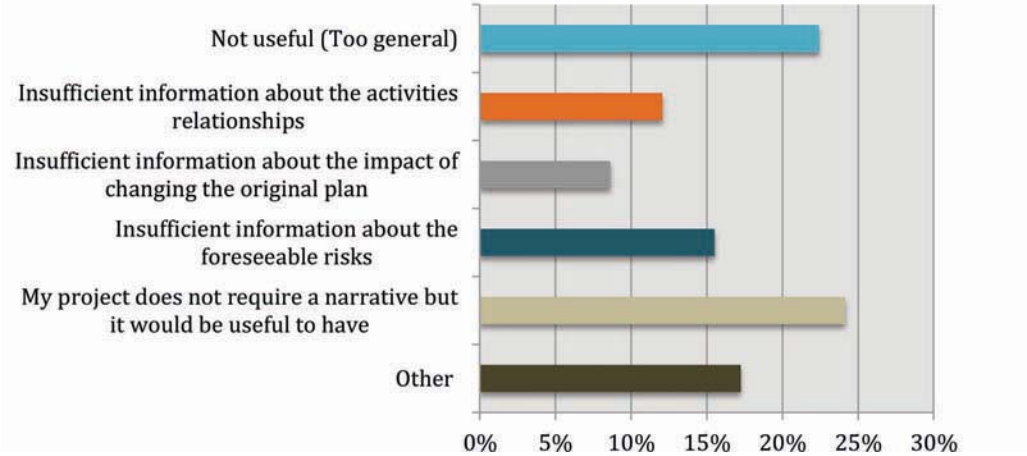


**Figure 4.8** Responses for question 11.

TABLE 4.1
**Summary of the first survey.**

| | |
|---|---|
| **Scheduling specification** | The current issues:<br>• Specifications are vague in some areas and very extent in others<br>• Contractors' reluctance to update master schedules<br>• Lack of personnel training on CPM schedules<br>With regards to updating schedules, contractors do not comply in more than 50% of the cases |
| **Enforcing issues** | Contractors do not follow INDOT's scheduling specifications almost 70% of the time; this can depend on the experience level of the contractor and INDOT follow-up with them<br>Proposals for changes to current bid documents to increase the contractor's compliance:<br>• Enforce timeframes for every phase and milestones for the important events<br>• Enforce the submittal of a schedule before a pre-construction meeting<br>• Enforce a penalty for late schedule submittals |
| **Field personnel skill set and understanding of the specs and scheduling methods/software** | Some methods that the contractors use to show their schedule include:<br>• Excel spreadsheet<br>• Few lines in e-mail.<br>• Biweekly meetings<br>• Simply a list of operations with dates accompanying the operation<br>• Bar chart most common, some CPM<br>80% of the respondents mentioned that they do not evaluate the contractor's resources |
| **Ideas for technologies/tools/software** | Suggestions for making the scheduling review more effective:<br>• More comprehensive narrative<br>• Breakdown of the activities to a minimum number of days/weeks (to track down progress more effectively)<br>• Providing relationships<br>• Specifying resources for each activity |

followed by others (10), weekly updates, and finally biweekly updates based on 29 responses. As can be seen from the responses to question 2 shown in Figure 4.10, DOTs have different requirements for the frequency of the requested schedule updates. Some DOTs had specific requirements such as Michigan DOT that request that the contractor must update the progress schedule within 14 calendar days of several predefined events while other states indicated that progress schedules are requested only if necessary. However, it can be seen that the most common requirement is a monthly update.

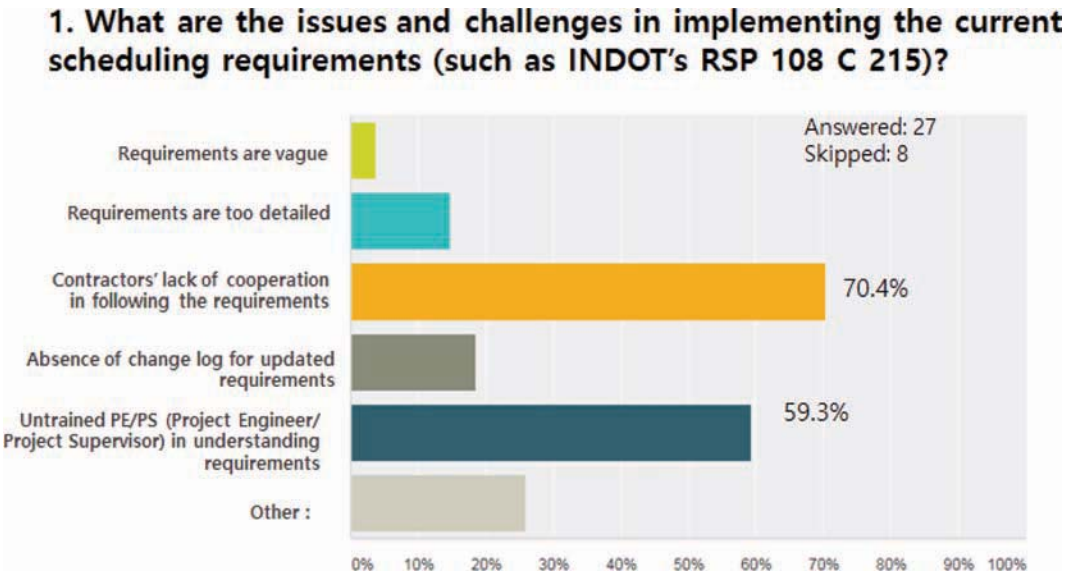


**Figure 4.9** Current state of the application of scheduling requirement.

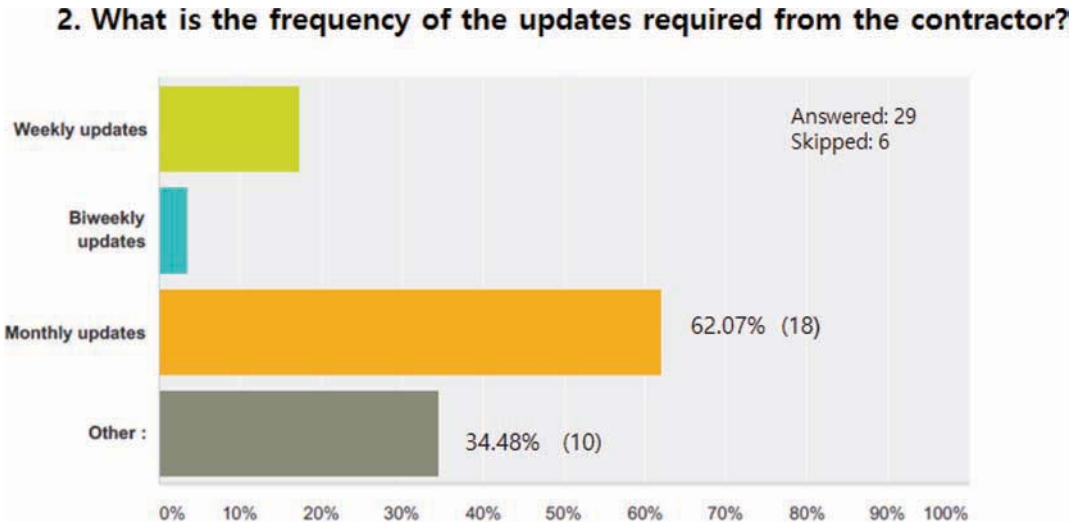


**Figure 4.10** Frequency of the updates of the schedule.

Several comments were provided:

- Specification has an "as-needed" to supplement monthly submissions if necessary.
- As needed when there are impacts to the projects that affect the contractors' progress.
- 3-week look ahead works best.
- Depends on the size of the project. Updates are provided weekly, biweekly, monthly.
- A revised schedule is required when the work falls two weeks behind schedule.
- Updated when the contractor falls 10% behind schedule.
- Bi-monthly (every two month)
- The Contractor must update the progress schedule within 14 calendar days of several predefined events.
- The RSP 108-C-215 (Recurring Special Provisions) requires monthly but without the RSP it is only provided when requested.
- Contract change, contract delay, work falls behind more than 10 working days.

Question 3 examined the requirement of the resource-loaded schedules from the contractor. Twenty states (71.4% out of 28 who responded) responded that they do not request resource-loaded schedules from the contractor, while the remaining eight respondents (28.6%) said that they request it. The general comments for this issue are that the requirement of the resource-loaded schedule varies depending on the size of the project. Some DOTs request resource-loaded schedules for projects higher than a certain dollar amount such as projects over $20 million as well as for highly complicated projects. Figure 4.11 illustrates the result of question 3 and shows some of the comments received.

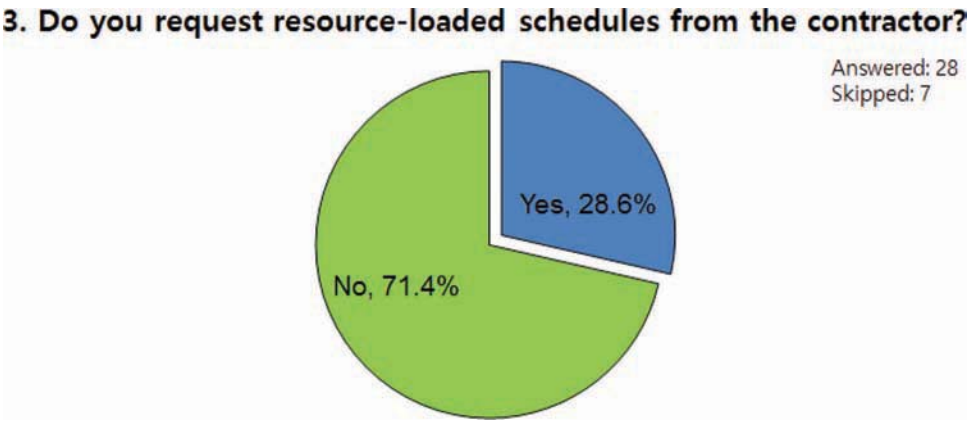


**Figure 4.11** Percentage of DOTs requesting resource-loaded schedules.

Several comments were provided:

- Our spec is new and implementation needs to be incremental; resource loading would be phase 2.
- Only on projects over $20 million, complex projects and special provision projects (four states).
- The contractor is responsible for the means and methods (which includes resources for the project). This information is only used if the contractor is required compensation for damages and we are confirming that they brought the equipment and crews they committed to bring to the project.
- DOT spec requires the schedule activity to be "verifiable by manpower and equipment allocations…" but I've not seen that information submitted with their bar chart type schedules.
- Major resources: Major resources are defined as crews and equipment that constrain the contractor from pursuing available work.
- Schedules require a detailed narrative report along with the schedule.

The next question (question 4) aimed at identifying the contractors' actual practice in submitting updated schedule. Fifteen states (60% out of 25 who answered) indicated that contractors do not submit updated schedules (revisions, actual task completion dates, percent complete, narrative, etc.) in a timely manner throughout the project execution while, the remaining 10 states (40%) answered that they do. The main comment for this question was that it depends on the nature of the project. Also the reasons for not submitting updated schedules in a timely manner were that (1) the issue is typically a problem with contactors—the project engineer is always pushing to get an updated schedule from the contractor that is accurate; (2) only if a monetary penalty is enforced, contractors follow; (3) and they are not as compliant as DOT would like. Figure 4.12 shows the results of question 4.

Several comments were provided:

- Yes and no. They are supposed to according to the contract (three states)
- Contractors are very poor at submitting schedules and that strategy seems to work to their advantage. It depends on the nature of the project.
- Only if a monetary penalty is enforced if they do not.
- IDOT does not require task completion and percent complete from the contractor.
- For the most part. Our issue lies with getting an accurate schedule that meets the specification requirements.
- Only required when projects fall 10% behind schedule.
- This seems to be task completed by request.
- They are not as compliant as we would like. Additionally it may not make sense to update the schedule in a month if little to no activity took place.
- We are experiencing issues getting bi-monthly updates.
- Typically, MDOT has to request updates. Everyone gets busy and updates may be overlooked.
- Yes and no. Contractors with a trained CPM employee are very timely, especially when it comes to time impacts, whereas companies without a CPM "expert" are not timely with their updates.
- This is typically a problem with contactors. The project engineer is always pushing to get an updated schedule from the contractor that is accurate.

Question 5 examined whether contractors always follow scheduling requirements or not. The majority of the respondents replied that contractors "mostly follow" (55.6%), "neutral" (18.5%), "sometimes" (18.5%), and finally "always follow" (7.4%). All the percentages are based on the 27 people who responded this question. As can be seen in the comments in Figure 4.13, it can be seen that some DOT scheduling requirements are not very detailed; hence the contractor is not expected to provide much information while other DOTs say that this depends on the level of the project and contractor's level of expertise.

Several comments were provided:

- The reviews find deficiencies and the owner require corrections
- Most of the large contractors do but the smaller contractors have a tendency not to.
- Work in progress.
- Some smaller contractors on smaller jobs don't think the schedule is beneficial and some of DOTs' resident engineers think the same so those schedules may not follow requirements as close as they should.
- We usually struggle to get a valid baseline schedule that meets all of our requirements.
- The only scheduling requirements are milestones.

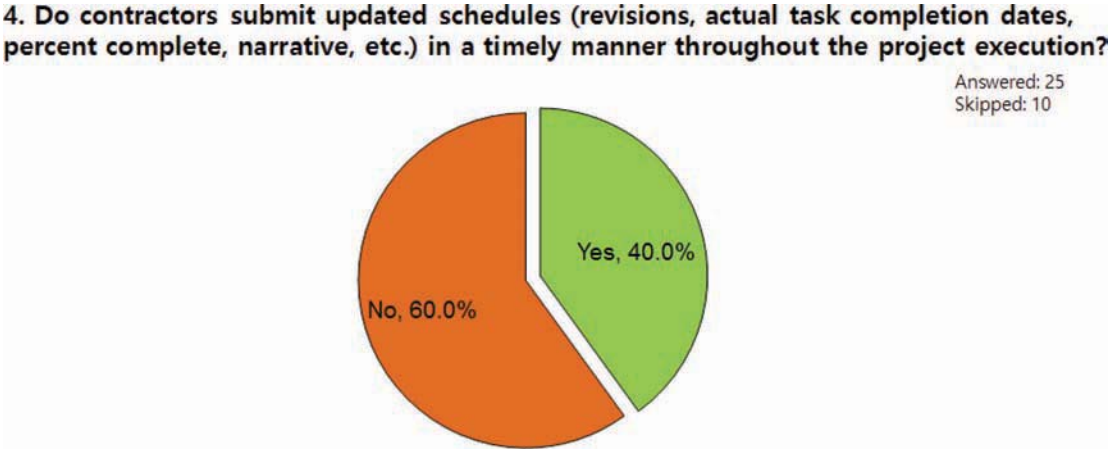


**Figure 4.12** Communication between contractors and DOTs for scheduling specification (1).

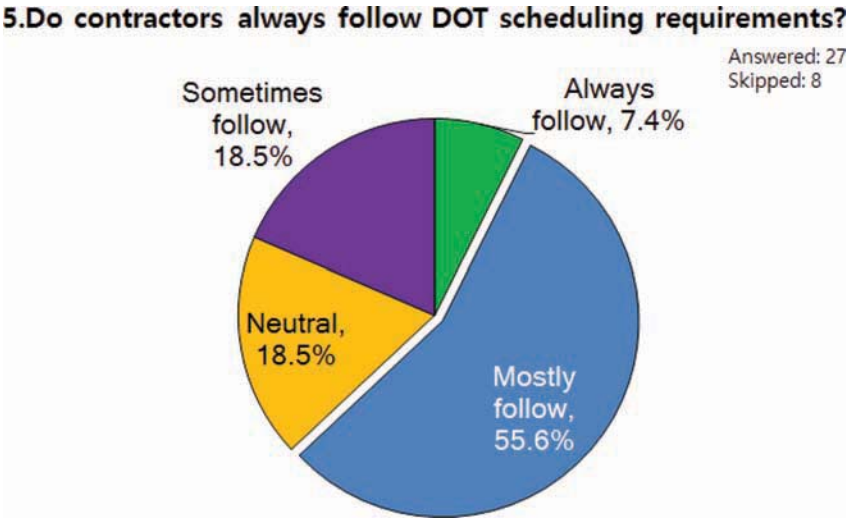


**Figure 4.13** Communication between contractors and DOTs for scheduling specification (2).

- Our current requirements on scheduling do not force the contractor to provide much information.
- They follow as directed. If we don't direct on certain scheduling issues they simply will not submit. It becomes a scheduling comfort zone.

Question 6 dealt with the enforcing of the scheduling specifications. As can be seen from Figure 4.14, a total of 20 respondents (74.1% out of 27 who answered) answered that DOTs have delayed or withheld payments to ensure that contractors comply with the scheduling specifications. Eight (8) states (29.6%) indicated that DOTs have enforced the use of CPM schedules for their projects to deal with this issue. Several additional comments were provided such as "depending on the severity, we sometimes withhold pay, and sometimes we issue an order record which hurts the contractor's performance rating" and "just keep asking for the revised schedule."

The following questions, 7 and 8 were about scheduling method(s) as shown in Figure 4.15 and Figure 4.16. Critical Path Method (CPM) has been commonly used in 23 states (88.5% out of 26 who answered) followed by bar chart in 18 states (69.2% out of 26 who answered). Additionally, written narrative and historical progress curves were mentioned in the comments. With regards to question 8 that asked respondents to rank the scheduling methods based on effectiveness, CPM was ranked in the first place as the most effective method. According to the comments, most notably many DOTs use a narrative for simple projects, then bar charts and CPM schedules as projects become progressively more complex. The responses to these questions greatly depended on the type of project and magnitude of complexity. Also, the responses were ranked differently for different types of projects.

The result of question 9, shown in Figure 4.17, revealed that 22 states (84.6%) review and approve the contractor's submitted baseline/updated schedule. Many DOTs also left comments that the action taken is of acceptance or rejection rather than approval. This is because approving the submittals would mean their agreement on the contractors' plans, which would make them partly responsible for it. Another notable comment is that training and experience are needed to

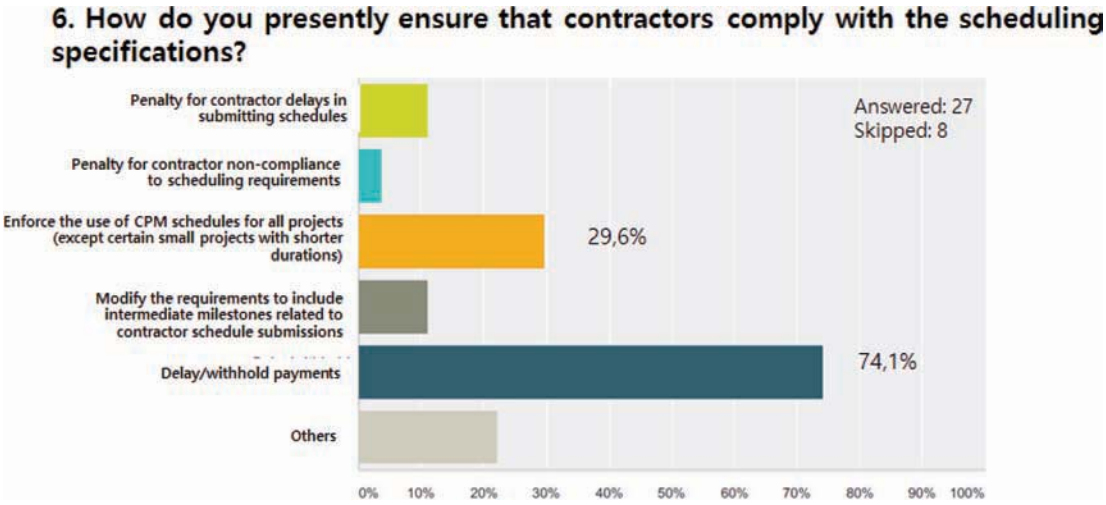


**Figure 4.14** Enforcing issue for the scheduling specifications.

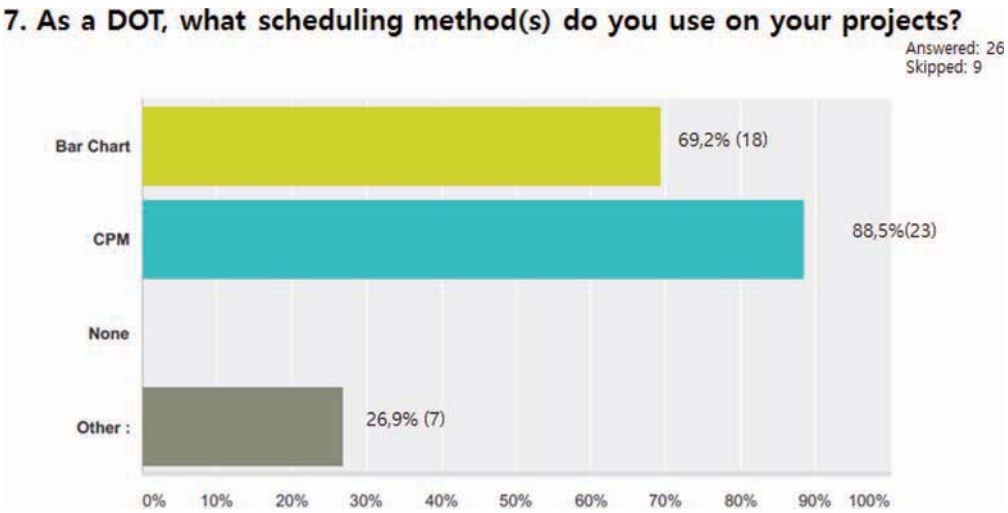


**Figure 4.15** Scheduling method.

review of baseline/updated schedules, which the DOT personnel do not have.

Several comments were provided:

- We review for specification compliance and reasonableness
- Actually we accept or reject; the term approve is not used.
- If we do not have in house expertise, it is performed by an independent consultant.
- Getting approved baseline schedules is always a problem due to disagreements on the overall logic and then getting the resource loading.
- We "accept" the schedules. We do not approve them since it is the contractors work plan and not ours. This keeps us from being held liable for approving something we did not create or develop.
- We review, with a soft approval.
- The district construction engineer signs the progress schedule as approved if the schedule appears reasonable and uses all the contract time.
- We review for contract compliance and completeness and then we accept for documentation. We do not approve.
- Preliminary, baseline and updates are reviewed.
- Spec states: The Engineer will approve or reject the updated progress schedule in writing within 14 calendar days of the contractors' submittal.
- First, a preliminary schedule is submitted and approved, while the detailed, baseline schedule is being developed.
- Within 10 business days of receipt of a baseline schedule and within 5 business days of an updated or revised schedule, the Department is required to respond in writing.

Question 10 was about the frequency of the regular meeting with the contractors to review proposed and actual schedules. As can be seen from Figure 4.18, the frequency of the regular meeting depends on the schedule type and project complexity. Many of respondents answered that they do not hold regular meetings but only meet with contractors as necessary to discuss scheduling issues.

Several comments were provided:

- It is part of the project meetings; frequency depends on the project.

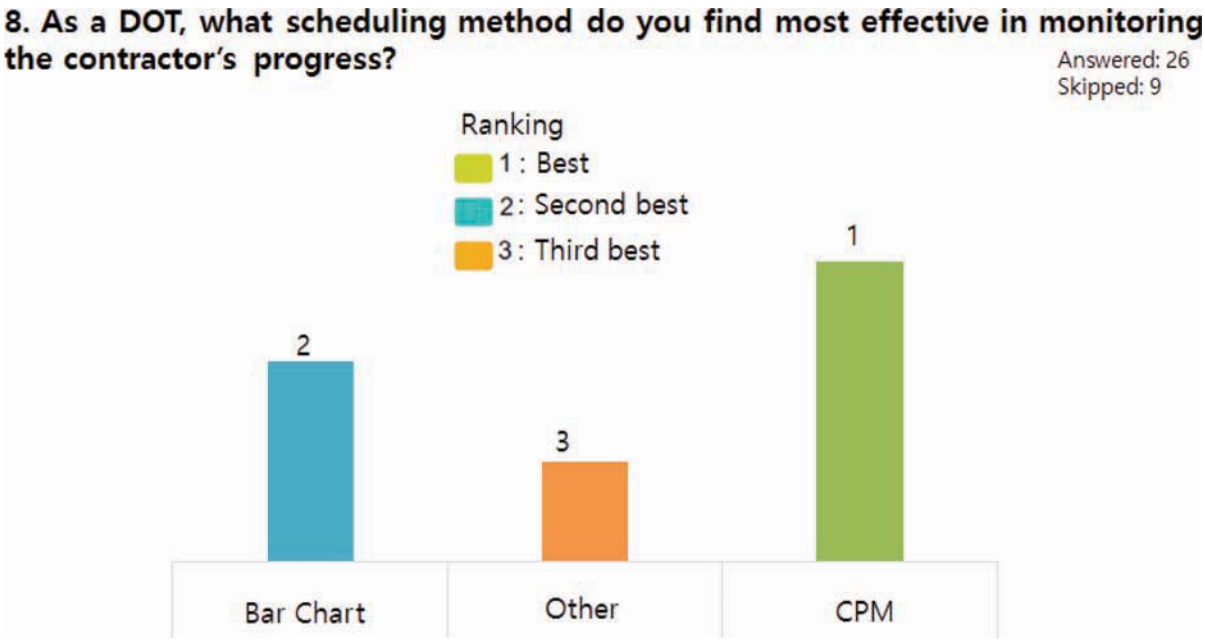


**Figure 4.16** Effective scheduling method.

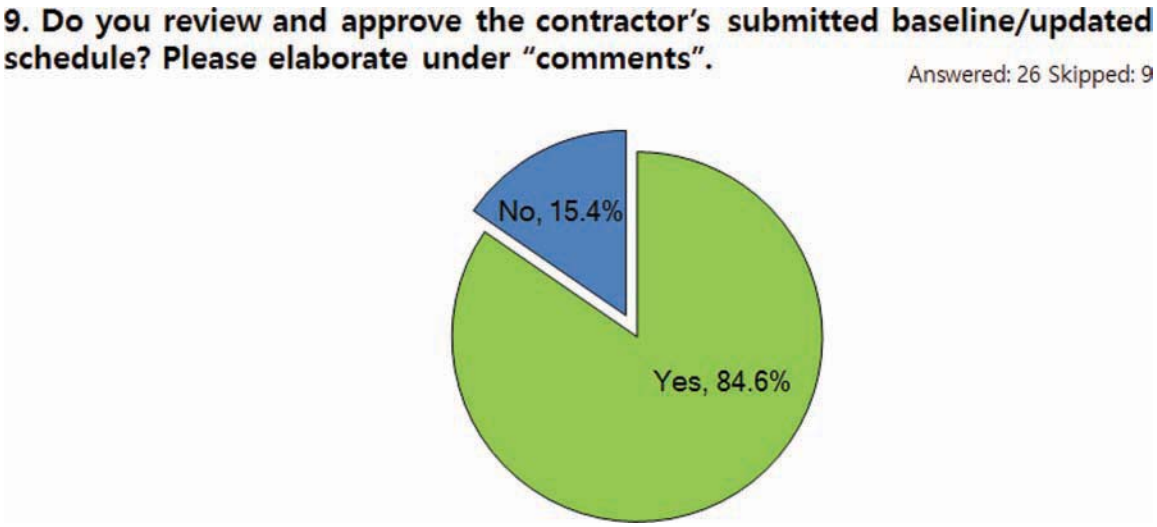


**Figure 4.17** Review and approval for the updated baseline.

- Varies based on schedule type and project complexity.
- No, it's usually discussed as a part of the general project meeting (may be as often as one per week), if one is conducted.
- We mostly look at the two-week schedule but occasionally look at the overall schedule.
- This really depends on the type of work. A paving project for example doesn't need much regular review but rebuilds on Interstate and within city boundaries requires more attention to the nuances of the schedule.
- Minimum once per month, some projects have them weekly.
- We do not have progress meetings for small projects. Large reconstruction projects will have progress meetings every 1–2 weeks.
- The Resident Engineer schedules meetings as necessary. Likely once a month as schedules and pay applications are due.
- For CPM schedule, we do require month updates. For other projects depending on circumstances we may hold weekly meetings.
- We do not hold regular meetings but we do meet as necessary to discuss scheduling issues.

From question 11 "Do you review the schedule to establish delay responsibility prior to awarding time extensions on a project?," it was observed that 12 states review the schedule to establish delay responsibility prior to awarding time extensions on a project while two (2) states do not review it. According to the comments, time extensions are not granted unless the delay is on the critical path. The contractor is responsible for incorporating delays caused by the DOT in the schedule in the correct monthly update for the creation

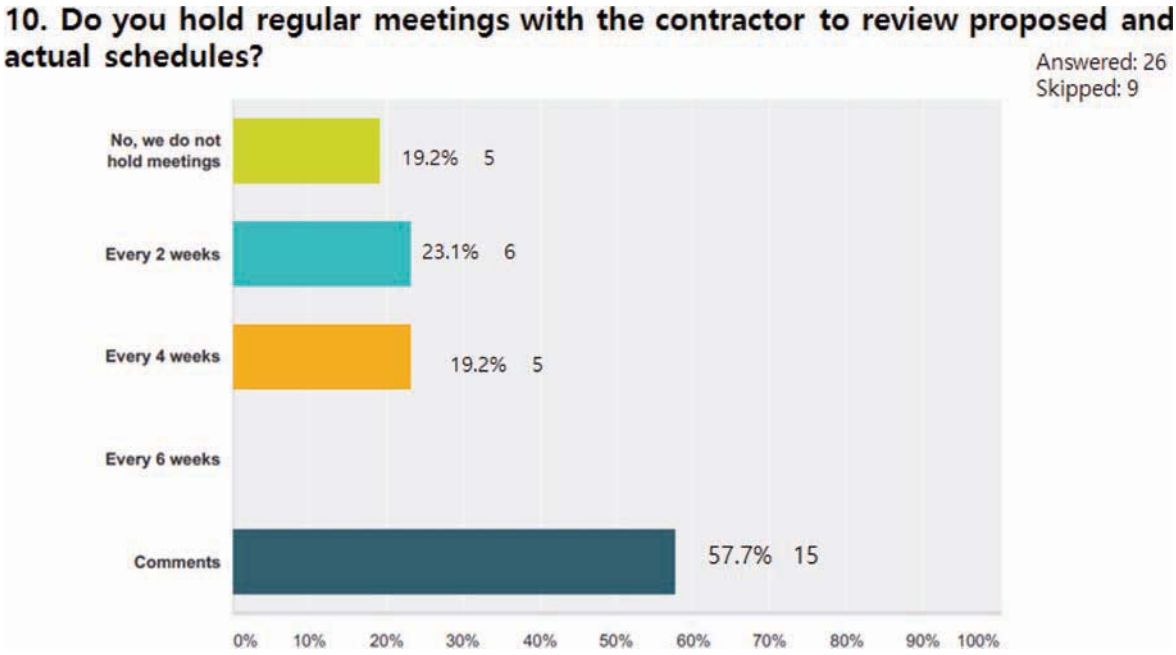


**Figure 4.18** Frequency of the meeting with contractors to review proposed and actual schedules.

of a time impact analysis report. However, contractors do not always update the schedule frequently nor do they perform a correct analysis. Therefore, it is important to enforce the submittal of updates and for the DOT to perform a sound review of whether the delay was on the critical path before establishing delay responsibility. Figure 4.19 shows the results of question 11.

Several comments were provided:

- Time extensions are not granted unless it is on the critical path.
- They are required to submit a time entitlement analysis with requests for time extensions.
- Time is expressly addressed in the change order process.
- Contractor progress is always evaluated when considered a request for extension of time.
- I'm not sure how many Resident Engineer's review the schedule. If they do, they will check whether the delay was on the critical path.
- Activities not on the critical path are less likely to be awarded a time extension for a delay.
- We look at the schedule to determine the cause of delay.
- Yes I do, but this is a difficult task to do without regular updates and contractor would have to admit to their own delays.
- We have begun to do this on oversight CPM contracts. We have however not updated our Specs to allow this to occur statewide.
- Yes, we try to do this but it can be very complicated, we are hiring staff to help with this endeavor.
- Yes, the contractor is responsible for incorporating DOT time impacts on schedule after monthly update for analysis. However, contractors rarely insert delays caused by their actions/inactions.
- The contractor is required to submit a notice of intent to file a claim and a request for time extension documenting the delay. Documentation must also include a time impact analysis for the Department's review prior to consideration.

Question 12 was about the presence/absence of personnel training with regards to scheduling techniques. It was an open-ended question for the type and frequency of the training program provided by the DOTs. Several types of scheduling training programs were mentioned (see Figure 4.20): CPM Training (specifically Primavera WebAccess), National Highway Institution course (NHI), internal training and consultant provided webinars on occasion. A number of DOTs said that they do not have any training programs.

Next question, number 13 asked about the review of the availability of contractor's resources. 16 respondents (61.5% out of 26 who responded) do not perform any review for the availability of contractor's resources, seven (7) respondents (26.9% out of 26 who responded) hold weekly meetings with the contractor to review resources, while two (2) states review the resource-loaded schedule. The reasons for not ensuring the availability of contractor's resources were that (1) it is very tough to enforce, (2) availability of contractor resources is a risk assigned to the contractor, and (3) it is difficult for DOT to dispute and disprove. Figure 4.21 shows the results of this question.

Several comments were provided:

- We do not programmatically assess contractor resources.
- Availability of contractor resources is a risk assigned to the contractor.
- Very tough one to enforce.
- I'm not a part of the weekly meetings, but since we don't require resource loaded schedules if any resource discussions occur, they would likely be at the weekly meetings.

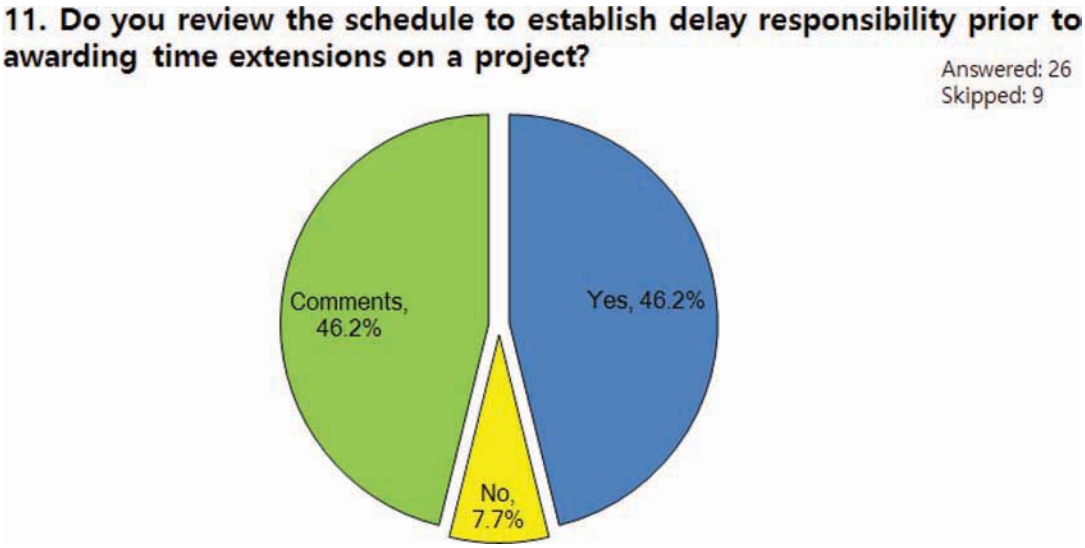


**Figure 4.19** Review and approval for the updated baseline.

- This seems to be a frequent problem. Contractors tend to be over optimistic about their available resources. However, it is difficult for DOT to dispute & disprove.

The last question, number 14 was about the requirement of a narrative. Twenty-six people responded the question and nine people skipped the question. The percentages in Figure 4.22 were based on the 26 people who answered the question. Majority of the DOTs require: general information about the project and sequence of work (53.8%), followed by information about delays that occurred, reason and mitigation strategies (50%), detailed information about the project including sequencing of work areas/activities and description of critical path (42.3%) and finally information about foreseeable risks (42.3%). Additionally, a narrative has been used to identify time extensions requested by the contractor. Figure 4.22 shows the results of question 14.

Several comments were provided:

- We have several schedule specifications, requirements vary based on project complexity.
- A narrative is requested as "good" practice, seldom occurs.
- Typically do not request a narrative but a few select projects have included a narrative requirement.
- After the baseline has been established, the contractor only needs to summarize major changes to the schedule. If the contractor is requesting a time extension, the contractor will submit a detailed narrative.
- The level of detail depends upon which type of schedule is specified. For example, type A schedules (bar charts) require progress reports sufficient to describe the past progress, anticipated activates and stage work. A description of current and expected changes or delay factors and any corrective actions.

### 4.4 Summary of Survey 2

The main purpose of the second survey was to explore the current issues for scheduling specifications faced by DOTs and exploring the alternatives for these issues. The target for the second survey was the state Department of Transportations (DOTs) and other transportation agencies in the U.S. The second survey focused on the four main issues: (a) scheduling requirements; (b) enforcing issues; (c) field personnel skill set and understanding of the specs and scheduling methods/commercial software; and (d) ideas for scheduling technologies/tools/software. Thirty-one (31) DOTs with 35 people responded to the survey. Table 4.2 shows the summary of the second survey. Many of the DOTs suffer from common issues such as lack of contractor compliance to the scheduling specifications. Contractors do not submit updated schedules in a timely manner as requested by the DOT. In order to enforce this, DOTs have delayed and withheld payments to force contractors to comply with the scheduling specifications. For the scheduling method, CPM and bar chart have been commonly used. However, the scheduling method is chosen depending on the type of project and magnitude of complexity. With regards to the issue of review and approval of the contractor's submitted baseline/updated schedule, DOTs said they either accept or reject the submittals based on conformance to the specifications and they do not approve the plan itself. This is a recent change that DOTs made in their specifications so that they are not responsible for the contractors' schedules. Previously, some DOTs reviewed and approved contractors' schedule (as presented in Chapter 2 in the survey by Hildreth, 2006a).

Contractors with trained CPM employee were found to be very timely, especially when it comes to time impact analysis reports. Therefore, a solid training program is necessary for both DOTs field engineers and contractors. With regards to review of contractors' resources, majority of the DOTs do not conduct any review to ensure the availability. However, some DOTs include a special provision for certain projects with a cost higher than $20 million and for more complicated

**12. What type of Scheduling training is provided to your DOT personnel (such as PE/PS-Project Engineer or Project Supervisor) and how frequently?**

Answered: 26
Skipped: 9

| |
|---|
| 1. We rely on NHI and internal training for scheduling and Primavera. |
| 2. We provided training as part of new spec implementation and designated a champion as the go-to person for support. |
| 3. New hire base training w/refreshers as needed. |
| 4. External training as needed. |
| 5. CPM training (specifically Primavera WebAccess) was developed in-house and provided to resident engineers in 2009. It has not been repeated. |
| 6. We have developed a project controls group in the headquarters office that includes outside consultant staff. They have been working with the district offices to provide schedule training. |
| 7. Very limited. Mostly on-the-job training (two states). |
| 8. We have a curriculum (four separate course) for schedulers. The curriculum progressively gets more involved in analysis. Schedulers only take the courses they need to perform their duties. |
| 9. I've attended non-DOT schedule training I recall through NHI or FHWA I don't recall specifically. |
| 10. Primavera P6. At least once per year (two states). |
| 11. We have had vendor provided training. We have also provided refresher training at our annual construction school. We also have engaged a consultant to assist field people with CPM related questions. |
| 12. As of right now we do not have any training. |
| 13. NHI, CPM training; once in last 3–4 years; resident engineers & district construction engineers. |
| 14. Consultant provided webinars on occasion. |

**Figure 4.20** Training programs in scheduling.

projects that would require the submittal of a resource-loaded schedule.

### 4.5 Analysis of Phone Interviews

Based on the survey results received from INDOT (survey 1) and all other DOTs (survey 2), follow-up phone interviews were conducted. The telephone interviews were conducted between October and December 2015. The purpose of the phone interview was to collect more detailed information about other states' scheduling practices that could be recommended for use by INDOT. From INDOT, the interviewee that was chosen had responded to both surveys 1 and 2, hence his input was required to clarify some points about INDOT's performance. This was also performed as a pilot to test the questions we prepared for the other DOTs.

The main common questions asked were about the current status of the scheduling specifications, classification of the projects, requirements from the contractor in terms of submittals and level of detail, weather shutdown and calendar information and finally how they handle time extensions. Other DOT-specific questions were also asked depending on their individual responses to the second questionnaire. Therefore, the following Table 4.3 indicates the targeted DOTs as well as the interviewee position. The DOTs interviewed are: Michigan, Texas, Vermont, Virginia and Washington State as well INDOT.

There were some common questions that were asked to all DOTs, including:

1. What are the State DOTs requirements from contractors (in terms of details)?

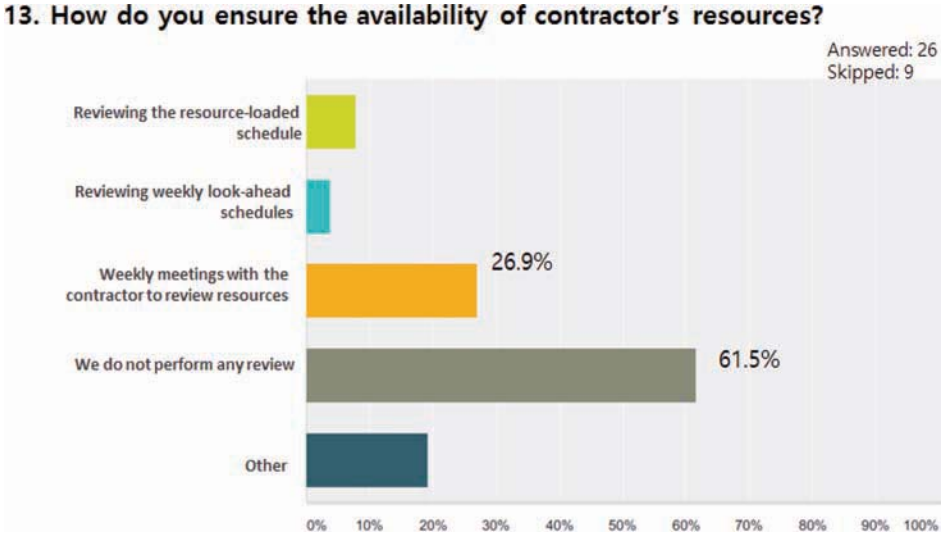


**Figure 4.21** Availability of contractor's resources.

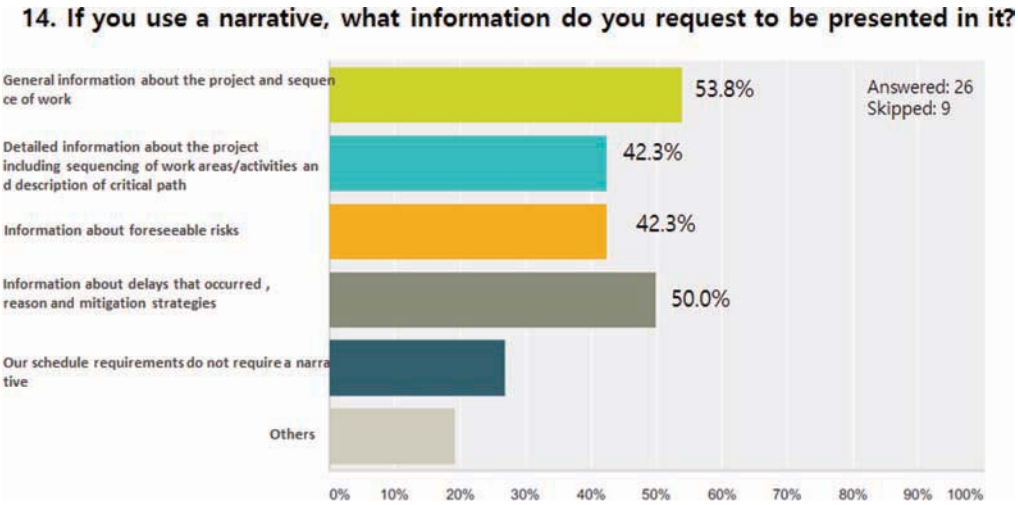


**Figure 4.22** Requirement of narrative.

2. Can they live with simplified scheduling?
3. Do they think simplified scheduling is enough to control the progress of the project?
4. Do they make any difference between pavement, bridge, and other projects in terms of scheduling?
5. What items do they control the most? (Soil work, paving works, etc.)
6. How do they handle critical path, weather, climate, etc.?

Other state-specific questions are available in Appendix C. The telephone interviews were conducted between October and November 2015. Figures 4.23 through 4.28 present the results of the interview with each DOT.

TABLE 4.2
**Summary of the second survey.**

| | |
|---|---|
| **Scheduling specifications** | The current issues:<br>• Contractors do not submit updated schedules in a timely manner throughout the project execution<br>• Training issue<br>The contracts update progress schedule monthly (18 states); other states said that it is provided only as requested or in case of a contractual change, contract delay, or if work falls behind<br>• 11 states hold regular meetings with the contractor to review proposed and actual schedules<br>• 5 states do not hold regular meeting to review proposed and actual schedules<br>• Majority of DOTs have meetings as necessary to discuss scheduling issues<br>16 states have not performed any review to ensure the availability of contractor's resources; seven states hold weekly meetings with the contractor to review resources |
| **Scheduling technologies/tools/software** | The most commonly used the scheduling method is CPM (23 states) followed by bar chart (18 states); a number of DOTs have used several levels of scheduling methods based on the projects<br>CPM (26 states) is selected to find most effective followed by bar chart in monitoring the contractor's progress; the other method: Schedule narrative and historical progress curves |
| **Field personnel skill and training methods/ commercial software** | CPM Training (specifically Primavera WebAccess)<br>NHI and internal training<br>Mostly on-the-job training<br>Consultant provided webinars on occasion |
| **Enforcing issue** | 20 states have used the method of delay/withhold payments for contractors to comply with the scheduling specifications<br>20 states indicated that they don't request resource-loaded schedules from the contractor—only on projects over $20 million, complex projects and special provision projects (4 states) |

TABLE 4.3
**List of DOTs.**

| Position Title | Agency |
|---|---|
| Field Engineer | INDOT |
| Assistant State Construction Engineer | Virginia DOT |
| Director of Construction & Materials | Vermont DOT |
| State Roadway Construction Engineer | WSDOT |
| Construction Section Director | TxDOT |
| Construction Operations Engineer | Michigan DOT |

| DOT | Michigan DOT | |
|---|---|---|
| Position | Construction Operations Engineer | |
| From survey | **Questions** | **Comments** |
| | Issues and challenges in implementing the current scheduling requirements | Our scheduling requirements are out of date. We are in the process of hiring a scheduling position to help us revise our specifications. |
| | The frequency of the updates required from the contractor | The Contractor must update the progress schedule within 14 calendar days of several predefined events. |
| | Do you request resource-loaded schedules from the contractor? | We are considering this. |
| | As a DOT, what scheduling method(s) do you use on your projects? | We also have a form for contractor schedules and bar charts, charts and linear schedules can be submitted. |
| | As a DOT, what scheduling method do you find most effective in monitoring the contractor's progress? | The response to this question greatly depends on the type of project and magnitude of complexity. The responses are ranked differently for different types of projects. |
| | Do you review the schedule to establish delay responsibility prior to awarding time extensions on a project? | Yes, we try to do this but it can be very complicated, we are hiring staff to help with this endeavor. |

*Interview*

| | Questions | | Answers |
|---|---|---|---|
| **Current scheduling specifications** | Q1 | Current status of the scheduling specifications | MDOT's specifications are outdated. The current specification was written in 2001 and briefly amended later.<br>The spec does not help MDOT personnel to force the contractors to follow the requirements. Therefore, contractors do not submit the updated schedule in a timely manner.<br>We hire a consultant to help us update the new scheduling specifications. |
| **Current scheduling methods** | Q2 | What method is used by MDOT? | MDOT uses critical path method for network scheduling and simple bar chart. But our basic spec is form-1130 (based on simple narratives).<br>CPM is only applied in complicated projects. |
| | | | How do you divide the projects into basic form and CPM?<br>As requested by engineers, the scheduling methods vary. |
| | Q3 | After establishing the new specifications, do you force all contracts to use CPM? | MDOT is going to have CPM approach mainly but we are using different methods (Microsoft access, simple narratives, and bar chart) according to the projects. |
| **Criteria for classifying projects** | Q4 | What are the criteria considered in project scheduling? | MDOT is in the primary phase at this time to update the specifications. We are looking at the criteria to classify the projects.<br>Complexity-Simplicity/CPM-Bar chart/Urban-rural/the number of pay items will be considered. |
| | Q5 | Do you differentiate between pavement, bridge, and other projects in terms of scheduling? | We do not differentiate between them. All projects are treated the same in scheduling. However, MDOT will consider the scheduling for project types differently later on. |

**Figure 4.23** SPR-3907 phone interview with Michigan DOT.

| | | | |
|---|---|---|---|
| **Claim and resource-loaded schedule** | Q6 | Do you see a trend between the number of claims and certain types of the projects? | There is no trend among different project types with respect to claims. Most of the claims are from Interstate highway projects which are larger and have more activities and pay items (type A project: metro area) |
| | Q7 | What would you consider when you request resource-loaded schedules from the contractor? | MDOT does not evaluate the resource-loaded schedules since we don't have the expertise to check the resource-loaded schedules in specific.<br>MDOT evaluates the logical constraints. |
| **Delay issue** | Q8 | How do you review the schedule to establish delay responsibility? | MDOT does not have expertise in the area of delay analysis. However, we are working on the new specifications and bringing on consultants to help us analyze the scheduling and delay claims. |
| | Q9 | How do you deal with the weather? | Our spec includes rain days: four and half days per a month can be delayed. Our construction period is from mid-April to mid-November. In general, 2~2.5 days per month are delayed due to weather.<br>Such delays are not included in the baseline.<br>Contractors don't block weather delays in their schedules. |
| **Training issue** | Q10 | Do you have training programs for scheduling? | MDOT does not have a specific training program. We have brought in the NHI for a course once in the last two years.<br>We expect to establish training programs. |
| | | | Which levels for the training program do you expect? (A basic level of training program that every engineer can take or high level of the program to grow the expertise in the scheduling)<br>MDOT needs both training levels. |
| **Improvement** | Q11 | In order to simplify the scheduling method and improve contractor compliance, what should be improved? | An overall upgrade is needed. |

**Figure 4.23** continued

| DOT | Virginia DOT | |
|---|---|---|
| Position | Assistant Sate Construction Engineer | |
| From survey | **Questions** | **Comment** |
| | Issues and challenges in implementing the current scheduling requirements | VDOT uses a narrative for simple projects, then bar charts and CPM schedules as projects become progressively more complex. |
| | What type of schedule training is used? | VDOT relies on National Highway Institute (NHI) and internal training for scheduling and Primavera. |
| | If you use a narrative, what information do you request to be presented in it? | VDOT has several schedule specifications, requirements vary based on project complexity. |

*Interview*

| | Questions | | Answers |
|---|---|---|---|
| **Current scheduling specifications** | Q1 | Current status of the scheduling specifications | VDOT's specifications are detailed and consist of a classification for projects and their corresponding scheduling requirements. |
| **Current scheduling methods** | Q2 | What method is used by VDOT? | MDOT use critical path method for scheduling projects (category 1–5) while category M only requires a table of the list of activities. VDOT also requests a narrative for each project as well as an Earnings report that is a standardized sheet provided by VDOT. |
| **Criteria for classifying projects** | Q3 | What criteria do you use to classify projects for scheduling requirements? | VDOT uses a classification method based on two criteria: project complexity and risks. Projects are classified into six categories as follows:<br>*Category M*: the lowest category in projects, which are more flexible, simple, with a duration of one construction season. Scheduling requirements for this type are: a narrative describing the sequence of work in a tabular format and 2-week look ahead schedules.<br>*Category 1*: the next level up in the classification for simple projects with a duration of one construction season that have a fixed completion date (based on VDOT's internal schedule) and a cost of $1 million or less. Scheduling requirements for this type are: a narrative describing the overall plan, a schedule (either bar chart or cpm) and an earnings report (excel sheet template provided by VDOT).<br>*Category 2*: the next level up in the classification for more complex projects with a duration of one to two construction seasons and a cost between $1–3 million. Scheduling requirements for this type are: a narrative describing the overall plan, a schedule (either bar chart or cpm) and an earnings report (excel sheet template provided by VDOT).<br>*Category 3*: this is the first level that requires a CPM schedule. It is for moderately complex projects with a duration of 2–3 seasons and consists of multiple crews in multiple locations. They are usually medium to large projects with a low risk level and a limited number of concurrent activities. Examples include intersection |

**Figure 4.24** SPR-3907 phone interview with Virginia DOT.

| | | | |
|---|---|---|---|
| | | | improvement projects with multiple widening, bridge construction and bridge span replacements. A preliminary schedule is submitted within the first 60 days consisting of the detailed plan for that duration. A narrative, CPM schedule, Primavera file, updates and earnings report are required for the final submission.<br>*Category 4*: this category is for medium to large and more complex projects with higher risks that are three (3) or more construction seasons. They usually have more constraints, multiple concurrent work and a cost of $10–75 million. They often have substantial traffic impacts or environmental issues such as major urban widening, multiple tunneling, rural/urban new construction or reconstruction. A preliminary schedule for the first 90 days is required for this category as well as an earning schedule based on the baseline, monthly look ahead schedules and monthly updates. The main difference between category 3 and 4 is that 4 requires a cost-loaded schedule. The majority of the projects fall under this category.<br>*Category 5*: this category is reserved for very large and complex projects that require a project management team with a project scheduler available on-site. The difference between category four (4) and five (5) is the complexity and level of risk. Category 5 requires resource loading. Contract time determination is used to also see the number of concurrent operations, which affects the complexity of the project. |
| | Q4 | Do you differentiate between pavement, bridge, and other project types in terms of scheduling? | The difference is in the project complexity and size. VDOT uses a 6-tier classification in order to make this distinction. |
| **Specifications and recommen-dations** | Q5 | How do you handle critical path, climate and weather? | VDOT includes weather in their CDS (contract determination schedule). Specifications state that there is no time extension for normal weather, only for extraordinary conditions. There is no standard number of weather delay days in the specifications; it is based on the contractor's decision as how many days is necessary. The risk and responsibility are on the contractor depending on how many days he can justify. Some contractors include the adverse weather days in the calendar while others add it to activity durations. In the case of a delay, a schedule impact analysis is submitted. The narrative describes the issue, why and how the critical path was impacted and what specific activities were impacted as well. The specifications require one of two methods: contemporaneous analysis or time impact analysis. The contemporaneous method is an observational method used to determine variations between updates and the window can be 2–3 update cycles where the differences between both updates are observed. The time impact analysis method is a model approach where the delayed event is inserted in the schedule (before the occurrence of the event) and a forward-looking approach is taken to look at the |

**Figure 4.24** continued

| | | | |
|---|---|---|---|
| | | | possible outcome of a change. This method is used to deal with potential issues or when we're not too far ahead. |
| | Q6 | What would you recommend in terms of training and simplifying the scheduling methods? | Develop modules for training and train personnel for specific areas and they can train others. However, this is not very effective since they have their original responsibilities so they get distracted from scheduling since it is a side-job. Another method that is more effective is to hire consultants instead. These consultants will be available especially for larger and more complex projects. They can help assist DOT personnel onsite with their scheduling. Also, DOT personnel should have a basic familiarity with scheduling. Another effective thing is to hold a joint training between DOT staff and contractor staff to assert the requirements before the project starts. This has helped VDOT with the scheduling since the contractors now know what to expect and what to submit. This can also be enforced through a scheduling conference held before scheduling the work.<br>To make the schedule more efficient, breaking down categories to get an adequate level schedule in projects. You can also eliminate potential cost on lower categories by not asking for CPM schedules for them. |

**Figure 4.24** continued

| DOT | Washington State DOT | |
|---|---|---|
| Position | State Roadway Construction Engineer | |
| From survey | **Questions** | **Comment** |
| | Issues and challenges in implementing the current scheduling requirements | We have three (3) levels of schedule from a basic bar chart to a detailed CPM using Primavera |
| | Do you request resource-loaded schedules from the contractor? | We have used a resource-loaded schedule by a special provision to a contract on a few select projects. |
| | What type of scheduling training is provided to your DOT personnel? | External training as needed. |

*Interview*

| | **Questions** | **Answers** |
|---|---|---|
| **Current scheduling specifications** | Current status of the scheduling specifications | WsDOT updates its specifications every 2 years. The latest specifications were just reviewed so the 2016 version is available. There are three (3) types of schedules: Type A, B and C. Type A is the most basic requiring either a bar chart, cpm or any other method the contractor chooses. A critical path must be identified regardless of the method used. More complex projects require Type B or Type C which are explained in the special provisions. Type C is for the most complicated jobs such as an interchange project that takes a couple of years, where there is demolition and paving and building of bridges with simultaneous activities occurring and environmental restrictions such as in-water work where there is salmon or where bald eagles are spotted out so the schedule needs to work around that. Project engineer (lead engineer with a staff of employees signing multiple jobs) makes the decision of which type of schedule is needed (A, B or C). WsDOT has six regions and each region has a staff that prepares contracts so the region staff, including the project engineer decide which schedule is needed.<br>Classification: A is default but B is the most commonly used and C is for the most complex projects. WsDOT also receives two-week lookahead schedule every week. |
| | What are the issues and challenges in implementing the current scheduling specification? | One main issue is in forcing contractors to initially submit the schedule. Another problem is that schedules aren't always reasonable, sometimes they show activities that aren't critical as critical and vice versa. This problem is with a few contractors only because many of them submit reasonable schedules. |
| **Current scheduling specifications** | How do you review contractor's submittal? | We review the general order of work. If the project engineer does not approve, it can be returned to the contractor and work can be suspended. |
| | When do you require resource-loading? | Not very often, only on design-build jobs to know how much it will cost and how much work will be done. |
| **Current scheduling methods** | What scheduling method | Type A: depends on what contractor wants to submit. Bar chart or CPM are accepted.<br>Type B: CPM schedule does WSDOT use?Type C: Primavera is used |

**Figure 4.25** SPR-3907 phone interview with Washington State DOT.

| | | |
|---|---|---|
| **Current scheduling methods** | **What external training do you use?** | **Construction trainers for topics in construction.** |
| | What are the field engineer's roles in project scheduling? (Review/approve) | Project engineering staff reviews the baseline and updates. |
| **Specifications and recommendations** | How do you handle critical path, climate and weather? | Sometimes contractors show calendar day but WsDOT requires working days. |
| | For time extensions, do contractors submit a narrative and schedule? How do you review to approve? | This depends on the cause of the delay. WsDOT asks contractors to submit overhead cost and impact cost in case the owner caused the delay. They must show that the delay impacted the critical path. WsDOT can also request an updated schedule at any time since they pay contractors for it. So if there is a delay, they ask for an updated schedule and recovery schedule afterwards. |

**Figure 4.25** continued

| DOT | Vermont DOT | |
|---|---|---|
| Position | Director of Construction & Materials | |
| From Survey | **Questions** | **Comment** |
| | Do you request resource-loaded schedules from the contractor? | Our spec is new and implementation needs to be incremental; resource loading would be phase 2. |
| | What type of scheduling training is provided to your DOT personnel? | We provided training as part of our new specifications implementation and designated a champion as the go-to person for support. |

*Interview*

| | Questions | | Answers |
|---|---|---|---|
| **Current scheduling specifications** | Q1 | Current status issues for scheduling | We have new specifications that require certain items such as a critical path, narrative and when an update is needed.<br>We have some very simple contracts ($0.5 million) and bigger projects ($10 million). For smaller projects, we do not use these scheduling specifications but we use it for bigger projects. For larger firms dealing with larger projects, they already had in-house schedulers so the transition was easier than for smaller firms.<br>Specifications require that a progress schedule needs to occur 5–10 days prior to preconstruction conference (kick-off meeting for the job). |
| | Q2 | How do you enforce? | Specifications have a withholding payment provision but we have not reached a point where we need to use it. Contractors usually need some help to submit complete submittals. |
| | Q3 | What is the current status of new specifications and concerns? | We have received mixed review. Some contractors think it is beneficial while others don't. Current concerns are more on the owner's end that we will not be able to keep up with the level of sophistication. |
| | Q4 | How do you classify projects? | We classify projects based on:<br>• Dollar value<br>• Traffic location and pattern<br>• Location<br>• Accelerated bridge projects require more specificity |
| | Q5 | How do you perform review? | We have a combination of state employees and consultants and this project team does the detail review then gets passed by a regional manager before it gets sent back to the contractor. The requirement is to review it for conformance of the specifications that there is a logic-based critical path schedule in a specific format. We do not review the contractor's means and methods. In most design-bid-build projects, we leave the means and methods to the contractor. |
| **Current training programs for scheduling** | Q6 | What training courses do you provide? | The person in charge of rewriting the specifications trained the staff in how to review and what to look for. We also sent a few people to a formal training. |

**Figure 4.26** SPR-3907 phone interview with Vermont DOT.

| | | | |
|---|---|---|---|
| **Delay issue** | Q7 | For time extensions, do contractors submit both a narrative and schedule? How do you review to approve it? | We see how the critical path is affected since they already submit schedules and we try to make them maintain the schedule throughout the project. |
| | Q8 | Weather change does affect the delay issue? | There are weather shutdown days in the specifications. |
| **Improvement** | Q9 | In order to simplify the scheduling method and improve contractor compliance, what should be improved? | We created a pay item to this specific work and the quantity is by the "EACH" (each baseline/update). So the contractors get one unit for the baseline and one unit for each monthly update. For any extra updates, they would get paid the "each." |

**Figure 4.26** continued

| DOT | TxDOT | |
|---|---|---|
| Position | Construction Section Director | |
| From Survey | **Questions** | **Comment** |
| | What type of Scheduling training is provided to your DOT personnel | We have a curriculum (four separate course) for schedulers. The curriculum progressively gets more involved in analysis. Schedulers only take the courses they need to perform their duty. |
| | If you use a narrative, what information do you request to be presented in it | After the baseline has been established, the contractor only needs to summarize major changes to the schedule. If the contractor is requesting a time extension, the contractor will submit a detailed narrative. |
| | What are the issues and challenges in implementing the current scheduling requirements | Schedules are not a priority. They are rarely being used to justify time extensions. We receive the baseline schedule but few monthly updates. TxDOT folks scrutinize schedules too much. There are no repercussions when the contractor does not submit schedules. |
| | Do you request resource-loaded schedules from the contractor? | The contractor is responsible for the means and methods (which includes resources for the project). So this information is only used if the contractor is requesting compensation for damages and we are confirming that they brought the equipment and crews they committed to bring to the project. |

***Interview***

| | **Questions** | | **Answers** |
|---|---|---|---|
| **Current spec for the scheduling** | Q1 | Current status issue for scheduling | Our struggle for construction scheduling has been IT related. Construction personnel are not focusing on the IT training.<br>Most of the construction projects rely on the consultant. We have series of consult contracts.<br>We treat scheduling as side job not full time job.<br>The knowledge of the scheduling varies depending on the contractors but in general constrictors are struggling with the scheduling. |
| | Q2 | Current status of the scheduling specifications | TxDOT had used Primavera Project Planner (P3) and now we utilize the Primavera Scheduling System (P6) for big projects.<br>There is no training for P6 so we normally need consultants to manage the scheduling aspect.<br>Criteria: Large projects including more than 50M with complicated and various activities involved<br>For smaller projects, a simple bar chart is used. In general, these don't require advanced scheduling techniques. |
| | Q3 | Why are schedules not a priority? | We don't know exactly how to do it and there are no repercussions when the contractor does not submit schedules. |
| | Q4 | What core functionality(s) do you require from the contractor's scheduling method in the projects? | The requirements from the contractor's scheduling are minimum level like maximum 20 days for any activities and basic coding.<br>We have a special revision of scheduling "Article 8.2 Progress Schedules, Section B. Construction Contracts." |

**Figure 4.27** SPR-3907 phone interview with Texas DOT.

| | | | |
|---|---|---|---|
| **Current training programs for scheduling** | Q5 | What four separate courses do you have? How did you break it down and do you have four different types of projects as well? | We have different courses for scheduling: Design Project management, Contract time determination scheduling, and Construction scheduling. |
| **Delay issue** | Q6 | For time extensions, do contractors submit both a narrative and schedule? How do you review to approve it? | There are four steps for Time Impact Analysis.<br>Step 1. Establish the status of the project immediately before the impact.<br>Step 2. Predict the effect of the impact on the schedule update used in Step 1.<br>Step 3. Track the effects of the impact on the schedule during its occurrence.<br>Step 4. Establish the status of the project after the impact is complete and provide details identifying any mitigating actions or circumstances used to keep the project ongoing during the impact period. |
| | Q7 | Weather change does affect the delay issue? | Weather can be addressed. Each district can estimate the average amount of precipitation and the number of delayed date in advance based on the historical data. |
| **Improvement** | Q8 | In order to simplify the scheduling method and improve contractor compliance, what should be improved? | (1) The challenge for the scheduling is IT, experience and training.<br>(2) If we know the risks, we can manage the schedule. In terms of risk consideration for the higher level of scheduling, user cost is important. User cost is a measure of the traffic congestion created by the construction project which can be evaluated before and after the project. Therefore, we can put the cost of damage to the contractor to give them a high motivation not to delay the project. |

**Figure 4.27** continued

| DOT | INDOT |
|---|---|
| **Position** | Field Engineer |
| ***Interview*** | |
| **Questions** | **Answers** |
| What are some issues INDOT faces in its current scheduling specifications? | Specifications are required for scheduling. It is important to create a schedule, review it and look at the operations on the critical path. Current scheduling specifications are too complicated and detailed so they are hard to follow. It is not very convenient to use. |
| | In general, we require a baseline schedule from contractors. However, sometimes contractors don't submit the baseline schedule in the preconstruction meeting. |
| What are some issues INDOT faces in its current training programs? | INDOT doesn't have any training for Primavera so we don't know how to use it. This is one of the reasons why we don't review the schedules, due to the lack of knowledge. |
| What are some reasons why contractor don't submit schedules? | They don't have the knowledge or resources to create schedules. If the Critical path changes, they don't know how to fix it. This is related to their lack of training and education of scheduling. |
| For time extensions, what does the contractor submit? How do you review it? | I have never ever seen a reasonable time delay documentation from contractors. Also INDOT does not track the contractor's delay but we check utility delays to see whether the delay affected the critical path. When we have a change order, the contractors submit documentation for it. For example, contractors should submit documentation for the extra work agreements (extra crews) which is like a spreadsheet. |
| What other scheduling documents do you require from the contractor? | We require three-week look ahead schedules in the regular meetings. We don't delve deeply into the schedule until some problems appear. |
| Does INDOT withhold payments when the contractor doesn't submit the schedule? | This situation is not often because it would hurt the relationship between contractors and field engineers. In general, we check the baseline schedule and sometimes we withhold the payment. |
| What is the most useful scheduling method? | CPM is the most useful of the scheduling methods since we can track the critical path. Narratives are also good to navigate and explain the project, but we rarely use them. |
| Do you differentiate between pavement, bridge, and other project types in terms of scheduling? | We do not differentiate between them. All projects are treated the same in scheduling. |
| What factors increase the project cost? | Weather delays. Although we have historical data, it has not helped in recent years because we don't know how much it will delay the schedule. |
| In order to simplify the scheduling method and improve contractor compliance, what should be improved? | We don't have training program. We need to be trained to improve the scheduling processes Project size or pay items can be considered to classify big projects which can use CPM while smaller projects do not need such complexity. In general, we use bar chart for projects less than 10M otherwise we use CPM. But we need more specific guidelines to inform us of the criteria for classifying projects. |

**Figure 4.28** SPR-3907 phone interview with INDOT.

### 4.6 Summary of Interviews

Based on the responses from survey 2, it can be seen that some DOTs have applied more advanced scheduling specifications while others are in the process of revising their specifications. The results from survey 2 were analyzed and five leading DOTs were targeted for follow-up interviews in addition to INDOT. The questions were mainly divided into two categories: common questions and individual questions. The common questions were about how the DOTs classify the projects, what they require from the contractor in terms of submittals and level of detail, how they incorporate weather shutdown and how they handle delays. The individual questions varied depending on their responses to the second questionnaire.

The interviews are summarized as follows:

1. Projects are classified into specific levels according to specific criteria such as projects' complexity and level of risks. For example, Virginia DOT has developed the following six categories:
   - Category 1: simple projects with a duration of one construction season and a cost of $1 million or less (a narrative).
   - Category 2: more complex projects with a duration of one to two construction seasons and a cost between $1–3 million (a narrative describing the overall plan, a schedule (either bar chart or CPM)).
   - Category 3: this is the first level that requires a CPM schedule. It is for moderately complex projects with a duration of 2–3 seasons and consists of multiple crews in multiple locations (A narrative, CPM schedule, Primavera file).
   - Category 4: this category is for medium to large and more complex projects with higher risks that are three (3) or more construction seasons. They usually have more constraints, multiple concurrent work and a cost of $10–75 million.
   - Category 5: this category is reserved for very large and complex projects that require a project management team with a project scheduler available on-site. The difference between category 4 and 5 is the complexity and level of risk.
   - Category 6 requires resource loading. Contract time determination is used to also see the number of concurrent operations, which affects the complexity of the project.
2. Some DOTs used a different classification where the types of schedules were divided into three (3) levels (instead of classifying the projects into levels). An example of this is Washington STATE DOT which developed three levels of scheduling methods in their specifications:
   - Type A: very simple method where the type of submitted baseline is left to the contractor to decide. Both bar charts and CPM schedules are accepted.
   - Type B: a CPM schedule is usually requested.
   - Type C: Primavera is used in this level.

   Classification A is the default while B is the most commonly used and C is for the most complex projects.
3. Leading DOTs have dealt with the issue of addressing requested time extensions through the time impact analysis method. For example, Texas DOT has analyzed the Time Impact Analysis through the following steps:
   - Step 1. Establish the status of the project immediately before the impact.
   - Step 2. Predict the effect of the impact on the schedule update used in Step 1.
   - Step 3. Track the effects of the impact on the schedule during its occurrence.
   - Step 4. Establish the status of the project after the impact is complete and provide details identifying any mitigating actions or circumstances used to keep the project ongoing during the impact period.
4. Weather delay has been considered in a couple of DOTs. For example, Texas DOT has estimated the average amount of precipitation and the number of delayed dates in advance based on the historical data. Michigan DOT considers 2~2.5 days per month as rain days. These days are not included in the baseline.
5. One DOT has stated that they review the submittals more closely. For example, Vermont DOT reviews submittals with state employees as well as their consultants. The project team does the detail review which then gets passed on to a regional manager for approval before it gets sent back to the contractor. The requirement is to review it for conformance of the specifications and to ensure that there is a logic-based critical path schedule in a specific format.
6. Employee training is still a challenging task to a number of the DOTs. However, Texas DOT has different courses for scheduling: Design Project management, Contract time determination scheduling, and Construction scheduling. With respect to construction scheduling, they have hired two instructors to train their field engineers. Each district has held a two-and-a-half-day construction scheduling class.
7. Most of DOTs who responded to the interviews have not requested resource-loaded schedules since they don't have the expertise to review these resource-loaded schedules correctly. Virginia DOT is the only DOT that has a category (number 6), which specifically requires resource loading for certain projects.
8. One question asked if DOTs differentiate between certain project types (such as pavement, bridge, etc.) and the interviewees answered that projects are classified by their complexity, size, risks and environmental and traffic impacts but not project types. Michigan DOT responded that they do not differentiate between project types and that all projects are treated equally in terms of scheduling.

### 4.7 Comparison Between INDOT and Other DOTs

Surveys 1 and 2 were classified into the same four areas in order to facilitate the comparison between INDOT and other DOTs. The comparison can be seen in Table 4.4.

TABLE 4.4
**Comparison between INDOT and other DOTs.**

| | INDOT | Other DOTs |
|---|---|---|
| ***Scheduling Specifications*** | | |
| **Updates** | 50% of responses: YES<br>Updates on 2–3 week look-ahead or in an email, not necessarily in a bar chart/CPM schedule format<br>Updates could be inaccurate | Monthly (18 states)<br>Provided when requested (e.g., contract change, contract delay, work falls behind) |
| **Regular meetings** | 80% of responses: YES<br>Informally discuss the schedule | 11 states hold regular meetings with the contractor to review proposed and actual schedules<br>5 states do not hold regular meetings<br>15 states have meetings as necessary to discuss scheduling issues. |
| **Resources** | 20% of responses: YES<br>Review only for extra work or where schedule seems inaccurate | 16 states do not perform any review to ensure the availability of contractor's resources<br>Seven (7) states hold weekly meetings with the contractor to review resources |
| **Other issues** | Contractors do not submit updated schedules in a timely manner throughout the project execution | Contractors do not submit updated schedules in a timely manner throughout the project execution |
| ***Scheduling Technologies/Tools/Software*** | | |
| **Ranking of scheduling methods used** | **CPM schedule** about 22%<br>**Bar chart** about 68%<br>**Others:** 10% such as excel spreadsheet or a list of operations in an e-mail | **CPM** (23 states) followed by<br>**Bar chart** (18 states)<br>(WSDOT, VDOT, Texas DOT use several levels of scheduling methods based on the projects) |
| **Effectiveness of scheduling methods** | Varies according to project | 11 states hold regular meetings with the contractor to review proposed and actual schedules<br>5 states do not hold regular meetings<br>15 states have meetings as necessary to discuss scheduling issues. |
| ***Field Personnel Skill and Training Methods/Commercial Software*** | | |
| **Training provided by DOT** | None | CPM training (specifically Primavera)<br>NHI and internal training<br>Mostly on-the-job training<br>Consultant provides webinars on occasion |
| ***Enforcing Issues*** | | |
| **Ranking of scheduling methods used** | Withholding pay estimates in rare occasions | 20 states (74%) have used this for contractors to comply with the scheduling specifications |
| **Effectiveness of scheduling methods** | Not-requested | 71% of respondents indicated that they don't request resource-loaded schedules from the contractor<br>Only on projects over $20 million, complex projects and special provision projects (4 states) |

## 4.8 Discussion

This chapter presented the analysis for surveys one and two as well as the phone interviews. The first survey was conducted to explore the current issues for scheduling specifications faced by INDOT to serve as a basis for exploring alternatives to solve these issues. 65 responses from INDOT field personnel were received. Some of the problems INDOT faces include lack of compliance of contractors with regards to scheduling practice. INDOT has tried to enforce the specifications through withholding payments at certain instances but contractors still do not always comply. The survey results show that the bar chart is the most commonly used method followed by CPM schedules. Another problem that was discovered through the survey is INDOT personnel's lack of experience and training in CPM scheduling. INDOT does not classify projects in terms of requirements.

The second survey was intended for other states DOTs and thirty-one (31) with 35 people responses were received. Many of the DOTs suffer from common issues such as lack of contractor compliance to the scheduling specifications. Regarding the scheduling method, CPM and bar chart have been commonly used. However, the scheduling method is chosen depending

on the type of project and magnitude of complexity. Contractors with trained CPM employee were found to be very timely, especially when it comes to time impact analysis reports. Therefore, a solid training program is necessary for both DOTs field engineers and contractors. Based on the results of survey 1, an understanding of problems with INDOT's current scheduling practices was established. The problems can be divided into three areas: specification-related, personnel-related and contractor-related which are presented below:

1. Specification-related issues
    - Lack of specific requirements for scheduling practices
    - Gap between current requirements in specifications and actual practices in projects
2. INDOT (personnel)-related issues
    - Difficulty in understanding contractors' schedules
    - Lack of training in scheduling techniques
    - Lack of guidelines for review items/checklist for field personnel to follow
3. Contractor-related issues
    - Absence of contractor compliance to INDOT scheduling requirements
    - Contractor not well-trained in project scheduling

These problematic areas were compared with other DOTs after analyzing results of survey 2. Phone interviews were also conducted to delve deeper into these issues and reach possible suggestions to overcome them. Among the issues that were found to be lacking in INDOT's specifications was the classification of projects to a number of levels in order to differentiate between the simpler projects that do not require much details to be shown and the more complex projects that require more control throughout their life cycle. Some DOTs also have procedures for dealing with delays and specify the process of how to create time impact analysis report such as Texas DOT.

## 5. GUIDELINES AND RECOMMENDATIONS

### 5.1 Introduction

This chapter discusses the proposed guidelines for INDOT's future implementation regarding scheduling techniques for field personnel. These guidelines have been developed based on the results compiled from surveys one and two as well as the phone interviews conducted.

The information collected draws attention to several important problems/issues:

1. Specification-related issues
    - Lack of specific requirements for scheduling practices
    - Gap between current requirements in specifications and actual practices in projects
2. INDOT (personnel)-related issues
    - INDOT field personnel's difficulty in understanding contractors' schedules
    - INDOT field personnel's lack of training in scheduling techniques
    - Lack of guidelines for review items/checklist for field personnel to follow
3. Contractor-related issues
    - Absence of contractor compliance to INDOT scheduling requirements
    - Contractor not well-trained in project scheduling

### 5.2 Guidelines

The problematic areas seen from the analysis can be divided into three areas: specification, personnel and contractor related problems. The discussion below shows each problem area followed by the proposed solutions for each one.

*Problem #1*

**Specification-related problems**

- Lack of specific requirements for scheduling practices.
- Gap between current requirements in specifications and actual practices in projects.

**Proposed solutions**

- Enforce requirements in **current** specifications and enforce a penalty otherwise.
- Modify INDOT's **current** scheduling specifications based on survey and interview results to match the best practice such as requiring bar charts from certain types of projects and enforcing CPM schedules using Microsoft Project or Primavera in other projects.
- **Classify** projects based on project type/number of bid items/project cost.
- **Customize** scheduling requirements by project type/number of bid items/project cost.
- Create a **template/checklist** for reviewing projects.
- Enforce compliance of **new** requirements.
- Ensure that the contractor knows INDOT's expectations in scheduling.
- For smaller and less complex projects, request that the contractor submit a schedule using Microsoft Project. It is an easy tool to use and would show the list of activities, relationships and dates which would make it easy to review the plan.
- For larger and more complex projects, request a CPM schedule using Primavera.
- Request a narrative for all projects that explains the basic assumptions made for the software, the sequence of work and an explanation of the critical path.

*Problem #2*

**INDOT (personnel)-related problems**

- Difficulty in understanding contractors' schedules.
- Lack of training in scheduling techniques.
- Lack of guidelines for review items/checklist for field personnel to follow.

**Proposed solutions**

- Provide **training** to INDOT field personnel to increase their knowledge in CPM scheduling.
- **Customize** training level according to the project needs to maximize benefits (from basic to more advanced), which will help them review schedules submitted by contractors.
- Create a thorough **checklist** for INDOT personnel to use in reviewing contractors' schedules. This will be a useful tool for INDOT personnel because it will make their review systematic and will reduce the time wasted.
- Hire a **scheduler** to be involved in reviewing all CPM schedules and training INDOT field personnel. Although it is recommended to train INDOT personnel in scheduling, they already have other tasks that are more critical to their job. Hence, a full-time scheduler is recommended. Depending on the number and complexity of the projects, the number of schedulers can be determined. Some DOTs hire one scheduler per district.
- Hire a **consultant** for large projects to be responsible for the schedule review and delay analysis. Many DOTs rely on outside consultants since they do not have the resources or the required training to do the job.
- Use Citrix or WebPM for online access to Primavera onsite instead of having to download the software on every computer.

*Problem #3*

**Contractor-related problems**

- Lack of contractor compliance to INDOT scheduling requirements.
- Contractor not well-trained in project scheduling.

**Proposed solutions**

- Create a **pay item** in the bid items list specifically for schedules. This should include the baseline and updates. So the contractor will only be paid for each item after its submittal and approval.
- Conduct a **scheduling meeting** prior to the start of work with the contractor to discuss the scheduling requirements and expectations. A joint training can also be beneficial in order to get both sides on the same page.
- Enforce **penalties** or withhold payments in response to contractor delays in schedule/update submission.
- Create a **timeline** with the contractor for schedule and update submittal.
- Ensure that the contractor has the required **skill set** to submit the required schedules by including a provision in the contract.
- Regular meetings with the contractor scheduled based on project complexity and size.

### 5.3 Sample Criteria for Classifying Projects

There are various criteria to consider when deciding how to classify projects into different levels. These criteria will help make project scheduling more consistent since the schedule submittals for similarly grouped projects would be the same making the review easier. Some of these criteria that were established from this research include:

- Number of bid items: a higher number of bid items would be present for bigger projects that would need more control. Thus, a cutoff level should be established so that projects with a higher number of bid items would require a more rigorous schedule.
- Concurrency of operations: a higher number of concurrent operations would increase the chances of a delay occurring and increase the inherent risks in a project. Therefore, the higher the concurrency, the more the project should be controlled and more details should be expected from the schedule.
- Traffic: projects in high-traffic areas or those that would require many diversions or for long periods of time that would affect the inhabitants are expected to require more level of details in their scheduling in order to better control them and reduce any possible risks.
- Project cost: some DOTs have a cutoff level of $10 million where any project below that is considered smaller and requires less detail. Other DOTs have multiple levels such as Virginia DOT that has six (6) levels so their cutoff points could be at $1, $1–3, $3–10, $10–75 and more than $75 million for the last two levels.
- Risks: if a project has an expected high level of risk, a more rigorous schedule is needed to monitor and control it.
- Others: other points of consideration include environmental hazards or other limitations due to the area itself (such as in-water work).

### 5.4 Sample Checklist Template for Reviewing Baseline Schedules

- Review the "**schedule log**" (Primavera output) to make sure that all activities are linked and that there are no constraints in the schedule.
- Review the list of **activities** to verify that no major activities are missing.
- Verify that activities relating to possible high **risks** are present. This can be ensured through discussions between all parties in the preconstruction meeting.
- Review contractor's **logic** and flow of work.
- If there is **repetitive** work, look at the logic in each segment to ensure that they match and that there is no discrepancy.
- Verify that the correct **calendars** are used for activities (e.g., 5-day workweek for construction activities and 7-day workweek for submittal approvals).
- Verify that **weather** shutdown dates are included in the calendar or in activity durations.
- Track the **critical path** and make sure that the activities flow continuously.
- Make sure that the activities on the critical path should in fact be critical.

### 5.5 Steps to Simplify Construction Scheduling for Field Personnel

- **Enforcement** of project baseline and update submittal.
- Require **resource**-loading for projects (higher than a certain cost or number of bid items).
- Provide **training** to INDOT personnel.
- Create a **checklist** to review contractors' schedules.
- Hold regular **meetings** with the contractor to discuss project schedule, progress, resources and possible delays.
- Hire a scheduler/consultant to be involved in all CPM schedules. His role would be to review schedules, train INDOT personnel in understanding the schedules and be available on-site if necessary.
- Create guidelines for the scheduling **conference** that should happen prior to starting work.

### 5.6 Summary

This chapter presented INDOT's problems with scheduling along with the proposed guidelines. INDOT's main problematic areas are related to the specifications, personnel and the contractors. These problems can be tackled by following the options in the guidelines to enhance contractor compliance and personnel skill.

A sample for the criteria to consider when creating a classification for INDOT's projects was proposed. Among these criteria is project complexity and cost, number of bid items, influence to traffic plans, concurrency of operations and finally environmental restrictions. This chapter also presented a sample checklist template for reviewing schedules. It consists of the steps required for the review process such as review of the activities to make sure all major operations are present, verify that the correct calendars are in use and track the critical path. Another main item presented was the steps required to simplify scheduling for INDOT's field personnel.

## 6. SUMMARY AND CONCLUSIONS

### 6.1 Summary

This research presented the results from the synthesis study conducted to determine INDOT's shortcomings with regards to schedule review/monitoring and propose guidelines to eliminate them. This study presented the schedule review/monitoring techniques and explained the research needs as well as the work scope and objectives.

*Literature Review*

An extensive literature review is presented in Chapter 2 covering the current scheduling techniques in use, tools available and INDOT's scheduling requirements. Bar charts and CPM schedules are the most commonly used tools with narratives also requested as supplemental material. The most widely used software are Microsoft excel, Microsoft Project and Primavera. Microsoft excel is used to create a table of the project activities and is very basic in terms of what can be shown. Microsoft project is slightly advanced where it can show relationships and a bar graph. The most advanced is Primavera which can show the critical path, cost and resource loading and has multiple uses.

Chapter 2 also presents previous research about other DOTs' practices and what they request from the contractors in their specifications.

*Survey 1*

The first survey was distributed to INDOT field personnel to gather information about the problems they face and their current practices with regard to schedule review/monitoring. Some of their problems include lack of knowledge and training, lack of contractor compliance to the specifications and that the specifications are too detailed.

*Survey 2*

The second survey was distributed to all DOTs to gain knowledge about their best practices with respect to schedule review/monitoring. Chapters 3 and 4 present the data collection and analysis phases in detail. Among their practices, it was noticed that the majority of the DOTs either have in-house schedulers who are mainly tasked with the review of the contractor's schedules or hire consultants to perform this job, especially for larger projects. It was also found that they classify their scheduling needs for the projects based on a set of criteria such as number of bid items and project complexity. The rest of the analysis is available in chapter 4.

*Phone Interviews*

Phone interviews were conducted with five DOTs as well as INDOT. INDOT's interview was a pilot in order to test the questions and review INDOT's scheduling problems. The remaining five DOTs were chosen based on their responses to the second survey.

*Findings*

The results of surveys one and two are summarized Table 6.1 (this table is also discussed in section 4.7, Table 4.4). The results were divided into four main areas: scheduling specifications, scheduling technologies/tools/software, field personnel skill and training methods/commercial software and enforcing issues.

The results of the phone interview indicated that some DOTs are currently revising their scheduling practices and specifications, others indicated that they had just finished with the revision while a number of them already had good practices that were useful in making the contractor comply with their needs. The data collection and results of the interviews are presented in chapters 3 and 4. These helped create the guidelines that are discussed in detail in chapter 5.

TABLE 6.1
**Comparison between INDOT and other DOTs.**

| | INDOT | Other DOTs |
|---|---|---|
| ***Scheduling Specifications*** | | |
| **Updates** | 50% of responses: YES<br>Updates on 2–3 week look-ahead or in an email, not necessarily in a bar chart/CPM schedule format<br>Updates could be inaccurate | Monthly (18 states)<br>Provided when requested (e.g., contract change, contract delay, work falls behind) |
| **Regular meetings** | 80% of responses: YES<br>Informally discuss the schedule | 11 states hold regular meetings with the contractor to review proposed and actual schedules<br>5 states do not hold regular meetings<br>15 states have meetings as necessary to discuss scheduling issues. |
| **Resources** | 20% of responses: YES<br>Review only for extra work or where schedule seems inaccurate | 16 states do not perform any review to ensure the availability of contractor's resources<br>7 states hold weekly meetings with the contractor to review resources |
| **Other issues** | Contractors do not submit updated schedules in a timely manner throughout the project execution | Contractors do not submit updated schedules in a timely manner throughout the project execution |
| ***Scheduling Technologies/Tools/Software*** | | |
| **Ranking of scheduling methods used** | **CPM schedule** about 22%<br>**Bar chart** about 68%<br>**Others:** 10% such as excel spreadsheet or a list of operations in an e-mail | **CPM** (23 states) followed by<br>**Bar chart** (18 states)<br>(WSDOT, VDOT, Texas DOT use several levels of scheduling methods based on the projects) |
| **Effectiveness of scheduling methods** | Varies according to project | 11 states hold regular meetings with the contractor to review proposed and actual schedules<br>5 states do not hold regular meetings<br>15 states have meetings as necessary to discuss scheduling issues. |
| ***Field Personnel Skill and Training Methods/Commercial Software*** | | |
| **Training provided by DOT** | None | CPM training (specifically Primavera)<br>NHI and internal training<br>Mostly on-the-job training<br>Consultant provides webinars on occasion |
| ***Enforcing Issues*** | | |
| **Ranking of Scheduling methods used** | Withholding pay estimates in rare occasions | 20 states (74%) have used this for contractors to comply with the scheduling specifications |
| **Effectiveness of scheduling methods** | Not-requested | 71% of respondents indicated that they don't request resource-loaded schedules from the contractor<br>Only on projects over $20 million, complex projects and special provision projects (4 states) |

*Guidelines and Recommendations*

Chapter 5 illustrates the guidelines and recommendations obtained from the research study. It includes guidelines for overcoming the three (3) main issues INDOT faces: specification, personnel and contractor-related issue. It presents a sample for the criteria to be used to classify projects and the respective scheduling needs. It also presents a sample checklist to perform schedule review. Table 6.2 shows the summary of the guidelines for the three issues discussed. These guidelines are based on the results from surveys one and two as well as the phone interviews conducted.

Survey 1 questions and results are illustrated in Appendix A. Survey 2 questions and results are illustrated in Appendix B. The phone interview questions are illustrated in Appendix C.

## 6.2 Limitations

The limitations of this study were as follows:

- Out of the 50 state DOTs in the U.S., only 31 state DOTs with 35 people responded to the survey; although it shows a high response rate, it might not be a broad representation of the general opinions of all state DOTs.

TABLE 6.2
**Summaries of the guidelines.**

| | |
|---|---|
| **Specification** | • Enforce requirements in **current** specifications and enforce a penalty otherwise<br>• **Classify** projects based on project type/number of bid items/project cost<br>• **Customize** scheduling requirements by project type/number of bid items/project cost<br>• Create a **template/checklist** for reviewing projects<br>• Enforce compliance of **new** requirements<br>• For smaller and less complex projects, request that the contractor submit a schedule using Microsoft Project<br>• For larger and more complex projects, request a CPM schedule using Primavera<br>• Request a narrative for all projects that explains the basic assumptions made for the software, the sequence of work and an explanation of the critical path |
| **INDOT (personnel)** | • Provide **training** to INDOT field personnel to increase their knowledge in CPM scheduling<br>• **Customize** training level according to the project needs to maximize benefits<br>• Create a thorough **checklist** for INDOT personnel to use in reviewing contractors' schedules<br>• Hire a **scheduler** to be involved in reviewing all CPM schedules and training INDOT field personnel<br>• Hire a **consultant** for large projects to be responsible for the schedule review and delay analysis<br>• Use Citrix or WebPM for online access to Primavera on-site instead of having to download the software on every computer |
| **Contractor** | • Create a **pay item** in the bid items list specifically for schedules. This should include the baseline and updates<br>• Conduct a **scheduling meeting** prior to the start of work with the contractor to discuss the scheduling requirements and expectations<br>• Enforce **penalties** or withhold payments in response to contractor delays in schedule/update submission<br>• Create a **timeline** with the contractor for schedule and update submittal<br>• Ensure that the contractor has the required **skill set** to submit the required schedules by including a provision in the contract<br>• Regular meetings with the contractor scheduled based on project complexity and size |

- Out of the eight (8) DOTs that were targeted for an interview, only six responded.

## 6.3 Recommendations for Future Study

- Develop a detailed checklist for INDOT review
- Develop a training plan for INDOT personnel
- Develop best practices for INDOT's schedule review process that includes the combination of training its personnel and hiring an outside consultant for larger projects or hiring a District Engineer to be responsible for the scheduling area
- Perform a thorough study to classify projects based on certain criteria in order to create requirements that best suit each type

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# APPENDIX A: SURVEY 1 QUESTIONNAIRE

**SPR-3907: Simplified Construction Scheduling for Field Personnel**

PURDUE UNIVERSITY

Indiana Department of Transportation and Purdue University are studying the possibility of improving the effectiveness of INDOT scheduling practices. Part of the study is to understand the current scheduling methods and best practices in use by INDOT. The survey mainly asks questions about (A) Scheduling specifications; (B) Enforcing issues; (C) Field personnel skill set and understanding of the specs and scheduling methods/commercial software; and (D) Ideas for scheduling technologies/tools/software. The survey result will be shared with the respondents upon their request.

1. What are the issues and challenges in implementing the current specifications?
2. Do contractors submit updated schedules (revisions, actual task completion dates, percent complete, narrative, etc.) in a timely manner throughout the project execution? If the answer is No, please provide more details under "Comments."
3. Do contractors always follow INDOT scheduling specifications? (If Yes, go to 4 and if No, go to 5)
4. What changes could be made to the current bid documents to increase the compliance of contractors with the scheduling specifications?
5. How do you presently ensure that contractors comply with the scheduling specifications?
6. Does INDOT meet with the contractor (at least once each month) to review actual and proposed schedules (as stated in the scheduling specifications)? If no, please comment on the reasons
7. What scheduling method is used in your current project
8. How do you review the schedules? Also, please write in the "comments" section other if there are other methods that you use for tracking the progress of the project (other than bar chart/CPM schedule).
9. Do you evaluate contractor's resources to check their ability to execute the submitted plans before project commencement? If yes, please provide more information on the procedure used for resource evaluation
10. What can be added to the current bar chart/CPM schedule to make your review more effective?
11. If you use narrative (according to RSP 108-C-215), what are the problems with the current narrative?

# APPENDIX B: SURVEY 2 QUESTIONNAIRE

**SPR-3907: Simplified Construction Scheduling for Field Personnel**

PURDUE UNIVERSITY

Indiana Department of Transportation and Purdue University are studying the possibility of improving the effectiveness of INDOT scheduling practices. Part of the study is to understand the current scheduling methods and best practices in use by other DOTs. The survey mainly asks questions about (A) Scheduling specifications; (B) Enforcing issues; (C) Field personnel skill set and understanding of the specs and scheduling methods/ commercial software; and (D) Ideas for scheduling technologies/tools/software. The survey result will be shared with the respondents upon their request.

General information

| | |
|---|---|
| Positon | |
| Agency | |

1. **What are the issues and challenges in implementing the current scheduling requirements (such as INDOT's RSP 108 C 215)?**
- Specifications are vague
- Specifications are too detailed
- Contractor's lack of cooperation in following the specifications
- Absence of change log for updated specifications
- Untrained PE/PS (Project Engineer/Project Supervisor) in understanding specifications
- Others:

2. **What is the frequency of the updates required from the contractor?**
- Weekly updates
- Biweekly updates
- Monthly updates
- Other:

3. **Do you request resource-loaded schedules from the contractor?** Please provide more details under "Comments."
- Yes
- No
- Comments:

4. **Do contractors submit updated schedules (revisions, actual task completion dates, percent complete, narrative, etc.) in a timely manner throughout the project execution?** If the answer is No, please provide more details under "Comments."
- Yes
- No
- Comments:

5. **Do contractors always follow DOT scheduling specifications?**
- Always follow

- Mostly follow
- Neutral
- Sometimes follow:
- Rarely or don't follow at all
- Comments:

6. **How do you presently ensure that contractors comply with the scheduling specifications?**

- Penalty for contractor delays in submitting schedules
- Penalty for contractor non-compliance to scheduling requirements
- Enforce the use of CPM schedules for all projects (except certain small projects with shorter durations)
- Modify the requirements to include intermediate milestones related to contractor schedule submissions
- Delay/withhold payments
- Others:

7. **As a DOT, what scheduling method(s) do you use on your projects? (You can choose more than one.)**

- Bar Chart
- CPM
- None
- Other:

8. **As a DOT, what scheduling method do you find most effective in monitoring the contractor's progress? Please rank.**

- Bar Chart
- CPM
- Other (please specify):

9. **Do you review and approve the contractor's submitted baseline/updated schedule? Please elaborate under "comments."**

- Yes
- No
- Comments:

10. **Do you hold regular meetings with the contractor to review proposed and actual schedules?** If you have different answers, please provide more details under "Comments."

- No, we do not hold meetings
- Every 2 weeks
- Every 4 weeks
- Every 6 weeks
- Comments:

11. **Do you review the schedule to establish delay responsibility prior to awarding time extensions on a project? Please elaborate.**

- Yes
- No
- Comments:

**12. What type of Scheduling training is provided to your DOT personnel (such as PE/PS-Project Engineer or Project Supervisor) and how frequently?**

**13. How do you ensure the availability of the contractor's resources?**

- Reviewing the resource-loaded schedule
- Reviewing weekly look-ahead schedules
- Weekly meetings with the contractor to review resources
- We do not perform any review
- Others:

**14. If you use a narrative, what information do you request to be presented in it?**

- General information about the project and sequence of work
- Detailed information about the project including sequencing of work areas/activities and description of critical path
- Information about foreseeable risks
- Information about delays that occurred, reason and mitigation strategies
- Our schedule requirements do not require a narrative
- Other:

**15. Would you be available for a phone interview for a follow-up if necessary?** If yes, please fill in Contact Information below.

- Yes
- No

## General Information

| | |
|---|---|
| Name | |
| Phone number | |
| Email Address | |

**Contact information:**


- *Rana Khallaf, Graduate Student (Phone:765-714-8353, Email:* rkhallaf@purdue.edu)
- *Soojin Yoon, Graduate Student (Phone:765-775-6313, Email:* yoon88@purdue.edu)
- *Makarand (Mark) Hastak, PhD., PE, CCP, Professor and Head, Construction Engineering and Management, Purdue University (Phone:765-494-0641, Email:hastak@purdue.edu)*

# APPENDIX C: PHONE INTERVIEW QUESTIONS

***Indiana DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | Indiana DOT |
| Position | Field Engineer |
| Name | Andrew Pangallo |
| Email Address | apangallo@indot.in.gov |
| Phone Number | 317-946-9855 |

- Questions to ask:

| | |
|---|---|
| Interview | • How often do you request updates?<br>• Do contractors comply in a timely manner after you request an update?<br>• In what mode does the contractor submit resources for extra work agreements? CPM? Narrative?<br>• Does delaying/withholding payments from contractors make them comply in the future?<br>• you request do you divide the projects into narratives, bar chart, CPM?<br>• You mentioned before that INDOT is thinking about training its employees. How far along is this plan? Who is the target? How detailed will the training be?<br>• You mentioned you do not review/approve contractor's scheduling submittals due to lack of training/ experience, so do you receive these submittals to try and follow the contractor's work? Or is it helpful in any other way?<br>• Are you satisfied with the level of detail in the CPM schedules?<br>• You mentioned that you meet the contractor every 2 weeks to review proposed and actual schedules, how do you perform this review? Look at activities on-site? Track activities using the bid items list?<br>• How do you review the schedule to establish delay responsibility without the presence of regular updates?<br>• Is there any information you think should be added to the narrative to make your review easier? Anything that should be removed?<br>• Do you have concerns regarding the current Construction Scheduling methods or their use in the project?<br>• What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)<br>• In order to simplify the scheduling method and improve contractor compliance, what should be improved? |

***Florida DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | WSDOT |
| Position | State Roadway Construction Engineer |
| Name | Dave Erickson |
| Email Address | ericksd@wsdot.wa.gov |
| Phone Number | 360-705-7829 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| Issues and challenges in implementing the current scheduling requirements | We have 3 levels of schedule from a basic bar chart to a detailed CPM using Primavera |
| Do you request resource-loaded schedules from the contractor? | We have used a resource loaded schedule by a special provision to a contract on a few select projects. |
| What type of Scheduling training is provided to your DOT personnel | External training as needed. |

**Interview**

- How do you divide the projects into narratives, bar chart, CPM?
- Is such a classification effective? Does it have an impact on cost?
- Are your engineers well trained in scheduling?
- What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?

- What external training session do you use?
- Do you have concerns regarding the current Construction Scheduling methods or their use in the project?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

***Michigan DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | Michigan DOT |
| Position | Construction Operations Engineer |
| Name | Jason Gutting |
| Email Address | guttingj@michigan.gov |
| 5124162482 | 517-636-6334 |

- Candidate responses to some questions in the survey and questions to ask:

From Survey

| Question | Comment |
|---|---|
| Issues and challenges in implementing the current scheduling requirements | Our scheduling requirements are out of date. We are in the process of hiring a scheduling position to help us revise our specifications. |
| The frequency of the updates required from the contractor | The Contractor must update the progress schedule within 14 calendar days of several predefined events. |
| Do you request resource-loaded schedules from the contractor? | We are considering this. |
| As a DOT, what scheduling method(s) do you use on your projects? | We also have a form for contractor schedules and bar charts, charts and linear schedules can be submitted. |
| As a DOT, what scheduling method do you find most effective in monitoring the contractor's progress? | The response to this question greatly depends on the type of project and magnitude of complexity. The responses are ranked differently for different types of projects. |
| Do you review the schedule to establish delay responsibility prior to awarding time extensions on a project? | Yes, we try to do this but it can be very complicated, we are hiring staff to help with this endeavor. |

Interview Questions

- What do you want to revise in your spec?
- What concerns do you have regarding the current Construction Scheduling methods or their use in the project?
- What would you consider when you request resource-loaded schedules from the contractor?
- What form do you have for scheduling method? What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?
- Can you email us the forms that you have for schedules and bar charts?
- How do you rank the projects to choose the best scheduling method?
- How do you review the schedule to establish delay responsibility? What tools do you use?
- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)
- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

***Ohio DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| DOT | ODOT |
|---|---|
| Position | Project Manager |
| Name | Shane Ottosen |
| Email Address | shane.ottosen@odot.state.or.us |
| 5124162482 | 503-986-2698 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| What are the issues and challenges in implementing the current scheduling requirements | Scheduling has been all over the board. This has been on-going and we have been working with contractors to work thru this. |
| Do contractors always follow DOT scheduling requirements? | Work in progress |
| How do you presently ensure that contractors comply with the scheduling specifications? | None of the above. |

**Interview Questions**

- What scheduling method(s) do you require?
- What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?

- What are the issues and challenges in implementing the current scheduling requirements?
- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

- How do you presently ensure that contractors comply with the scheduling specifications?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

- For time extensions, do contractors submit a narrative/schedule? How do you review to approve time extensions?

***Texas DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | TxDOT |
| Position | Construction Section Director |
| Name | Roxana Garcia |
| Email Address | Roxana.Garcia@txdot.gov |
| 5124162482 | 5124162482 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| What type of Scheduling training is provided to your DOT personnel | We have a curriculum (4 separate course) for schedulers. The curriculum progressively gets more involved in analysis. Schedulers only take the courses they need to perform their duty |
| If you use a narrative, what information do you request to be presented in it | After the baseline has been established, the contractor only needs to summarize major changes to the schedule. If the contractor is requesting a time extension, the contractor will submit a detailed narrative. |
| What are the issues and challenges in implementing the current scheduling requirements | Schedules are not a priority. They are rarely being used to justify time extensions. We receive the base line schedule but few monthly updates. TxDOT folks scrutinize schedules too much. There are no repercussions when the contractor does not submit schedules. |
| Do you request resource-loaded schedules from the contractor? | The contractor is responsible for the means and methods (which includes resources for the project). So this information is only used if the contractor is requesting compensation for damages and we are confirming that they brought the equipment and crews they committed to bring to the project. |

**Interview**

- What 4 separate courses do you have? How did you break it down and do you have 4 different types of projects as well?
- Why are schedules not a priority?
- What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?

- What are the issues and challenges in implementing the current scheduling requirements?
- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

- For time extensions, do they submit both a narrative and schedule? How do you review to approve it?

***Vermont DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | Vermont Agency of Transportation |
| Position | Director of Construction & Materials |
| Name | David Hoyne |
| Email Address | david.hoyne@vermont.gov |
| Phone Number | 802-828-2593 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| Do you request resource-loaded schedules from the contractor? | Our spec is new and implementation needs to be incremental; resource loading would be phase 2. |
| What type of Scheduling training? | We provided training as part of new spec implementation and designated a champion as the go-to person for support. |

**Interview Questions**

- What are main (new) contents in new spec?
- The reason (or purpose) for establishing the new spec?
- How did you enforce the new spec in your DOT as well as on the contractors?
- What are some improvements that you've seen after implementing the new specs? Any drawbacks?
- Do you have any concerns regarding the new spec or contractor compliance to the new spec?
- What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?

- The new spec includes training in scheduling, what do people learn from the training session? What does it focus on?
- As of now, do you have concerns regarding the new Construction Scheduling methods or their use in the project?

- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

***Virginia DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | Virginia Department of Transportation |
| Position | Assistant State Construction Engineer |
| Name | Alan Saunders, P.E., CCM |
| Email Address | alan.saunders@vdot.virginia.gov |
| Phone Number | 8043710661 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| Issues and challenges in implementing the current scheduling requirements | VDOT uses a narrative for simple projects, then bar charts and CPM schedules as projects become progressively more complex. |
| What type of Scheduling training | VDOT relies on NHI and internal training for scheduling and Primavera |
| if you use a narrative, what information do you request to be presented in it | VDOT has several schedule specifications, requirements vary based on project complexity |

**Interview Questions**

- How do you divide the projects into narratives, bar chart, CPM?
- Is such a classification effective? Does it have an impact on cost?
- Are your engineers well trained in scheduling?
- What core functionality(s) do you require from the contractor's scheduling method in the projects? (Qs from the Research plan deliverables) How do you review the submittals (using a checklist, maybe)?

- IS the National highway Institution(NHI) training course sufficient?
- What kind of internal training for scheduling do you provide ( or receive)?

- Do you have concerns regarding the current Construction Scheduling methods or their use in the project?
- Do you think that your several schedule specifications make DOT engineers and contractors work efficiently?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

***Washington State DOT***

PURDUE UNIVERSITY

- Candidate Information for the interview

| | |
|---|---|
| DOT | WSDOT |
| Position | State Roadway Construction Engineer |
| Name | Dave Erickson |
| Email Address | ericksd@wsdot.wa.gov |
| Phone Number | 360-705-7829 |

- Candidate responses to some questions in the survey and questions to ask:

**From Survey**

| Question | Comment |
|---|---|
| Issues and challenges in implementing the current scheduling requirements | We have 3 levels of schedule from a basic bar chart to a detailed CPM using Primavera |
| Do you request resource-loaded schedules from the contractor? | We have used a resource loaded schedule by a special provision to a contract on a few select projects. |
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**Interview**

- How do you divide the projects into narratives, bar chart, CPM?
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- What core functionality(s) do you require from the contractor's scheduling method in the projects? How do you review the submittals (using a checklist, maybe)?

- What external training session do you use?
- Do you have concerns regarding the current Construction Scheduling methods or their use in the project?

- What are the field engineer 's roles in project scheduling? (Do they review/approve/follow-up on the schedule?)

- In order to simplify the scheduling method and improve contractor compliance, what should be improved?

## About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,500 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at: http://docs.lib.purdue.edu/jtrp

Further information about JTRP and its current research program is available at: http://www.purdue.edu/jtrp

## About This Report

An open access version of this publication is available online. This can be most easily located using the Digital Object Identifier (doi) listed below. Pre-2011 publications that include color illustrations are available online in color but are printed only in grayscale.

The recommended citation for this publication is:

Khallaf, R., Yoon, S., Hastak, M., & Nantung, T. (2016). *Simplified construction scheduling for field personnel* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2016/28). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284316355