Providing Vision and Leadership for the Future of the HVAC and Sheet Metal Industry

PRECONSTRUCTION PLANNING PROCESS FOR HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) AND SHEET METAL CONTRACTORS

IMPLEMENTATION MANUAL

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vision future

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2007

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1 INTRODUCTION AND OVERVIEW

1.1 Introduction

HVAC and sheet metal contractors continue to be faced with the challenge of improving productivity to remain successful in an increasingly competitive industry. As a result, many contractors are searching for new ways to increase their productivity and decrease their costs in order to gain or maintain market share.

While there may not be a single measure of productivity, it is generally acknowledged that increased project and company efficiency are key components of enhanced productivity and profitability. The competitive nature of the construction industry has motivated many contractors to search for ways to improve efficiency by increasing their quality and decreasing their costs in order to strengthen their market share. As a result, contractors are turning to "better planning" as a method for improving their efficiency and, subsequently, increasing their profitability. In fact, a consensus exists in the construction industry that more formalized preconstruction planning is necessary to remain successful. Accordingly, contractors are turning to preconstruction planning as one approach to improving their competitive edge.

This research proves that companies that have a formal preconstruction planning process experience higher profit margins and increased numbers of successful projects. The benefits of having a preplanning process are quantifiable and concrete, yet these benefits have not been fully recognized by the HVAC and sheet metal industry. In 2004, the New Horizons Foundation addressed the issue of preconstruction planning by sponsoring a research project that assists contractors of various sizes to develop a formal preconstruction planning process.

1.2 How the Preconstruction Planning Process Was Developed

In 2004, the New Horizons Foundation funded this research project to develop a model preconstruction planning process that could be used by heating, ventilation, and air conditioning (HVAC) and sheet metal firms to improve their planning practices and overall project performance. The three-stage study evaluated the relationship between preconstruction planning and project performance. Phase 1 of the research surveyed the sheet metal construction industry about company-level preconstruction planning practices. Phase 2 of the research used the results from the first phase to develop a model HVAC and sheet metal preconstruction planning process based on industry best-planning practices. In the third and final phase, in-depth project-specific information was collected on the planning effort and project outcome for several "successful" and "less-than-successful" projects. This data collection was followed by a detailed statistical analysis of the planning practices of these two groups to identify clear differences between successful and less-than-successful projects. Ultimately, 19 companies from 8 states agreed to be interviewed for the research project. Data were collected on 15 successful and 12 less-than-successful projects.

The planning activities that were performed on the successful projects were used to develop the model HVAC and sheet metal preconstruction planning process. The model process was designed after those projects that exhibited superior planning and achieved a successful outcome. The model planning process incorporated the best-planning practices in the HVAC and sheet metal construction industry.

The planning processes of successful and less-than-successful projects were compared to the model HVAC and sheet metal preconstruction planning process. It was concluded that projects with planning processes that more closely matched the model process resulted in more successful performance.

1.3 Purpose of Preconstruction Planning

The purpose of preconstruction planning is to increase the probability of executing a successful construction project. Contractors use many characteristics when classifying a project as successful. A successful project is defined as one that:

- Is profitable
- Identifies and manages risk
- Results in a high level of customer satisfaction
- Meets/beats the budget
- Achieves a high level of quality
- Is safe
- Results in repeat business
- Results in project team satisfaction
- Finishes on schedule

1.4 What is Preconstruction Planning?

Preconstruction planning is a comprehensive set of procedures initiated after contract award and prior to construction execution. Preconstruction planning has also been referred to as before-job planning, preplanning, or execution planning. This document will use the terminology, "preconstruction planning."

Planning for a project begins when the estimator first reviews a project to create a project estimate. The estimator develops a plan of how the company will execute the project including what construction methods will be used, how the project will proceed, and what is included in the scope of work. The model HVAC and sheet metal preconstruction planning process presented here will commence at contract award and will not cover bid preparation planning. However, it will include a formal turnover of the project from the estimator to the project manager (PM)/ superintendent/foreman. Figure 1.1 displays the timeline of when preconstruction planning should occur. Due to the compressed schedule of some projects, there may not be sufficient time between contract award and construction execution to complete the entire process. When this situation arises, it is acceptable to complete preconstruction planning during the early stages of construction execution.

The model HVAC and sheet metal preconstruction planning process includes 50

planning activities subdivided into 12 preconstruction planning categories. The activities have been statistically linked to more successful project outcomes. As a result, the successful completion of these 50 planning activities will help prepare a project team to efficiently execute a construction project.

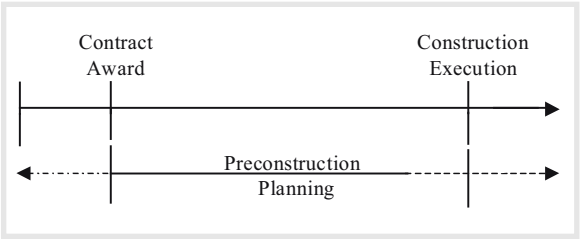

Figure 1.1: Preconstruction Planning Timeline

1.5 Survey Results

The data gathered during Phase 1 of the research were used to develop the model HVAC and sheet metal preconstruction planning process. The model was then completed in Phase 3 to the final model, which is presented here. In Phase 1, over 1,000 surveys were sent to HVAC and sheet metal companies located in 44 states. One hundred thirty-eight (138) companies completed the survey that requested information on preconstruction at a company level. Table 1.1 displays how companies described their company's preconstruction planning program and the number of preconstruction planning activities they perform on a typical project. A formal process was defined as "a comprehensive, written process and set of guidelines, operating procedures, and checklists that are used on every project." A semiformal process was defined as "using checklists and holding meetings on most or all of the projects." An informal process was defined as "mainly verbal with meetings held on most of the projects."

Table 1.1: Type of Preconstruction Planning Process

Preconstruction Planning Program	Number of Responses	Percent (%)	Average Number of Activities Performed
Formal	18	13	90.3
Semiformal	55	40	68.4
Informal	61	44	57.2
Other	4	3	45.1
Total	138	100	

The companies were provided a list of 104 preconstruction planning activities. They were asked what activities they typically perform and to list what they feel are the 10 most important planning activities. The complete list of possible preconstruction activities is shown in Table 1.2. Table 1.2 also shows the percent of contractors who perform the activity and the percent of top 10 lists on which the activity appeared.

Table 1.2: Possible Preconstruction Planning Activities

	Activity	% of Contractors	
		Performing the Activity	Top 10 List
1	Hold a kickoff meeting	71.1%	31.9%
2	Perform formal turnover of project	55.8%	23.9%
3	Select team members (PM, foreman, etc.)	84.1%	24.6%
4	Review the plans, specifications, and scope	97.8%	52.2%
5	Review the signed contract	71.7%	19.6%
6	Review the general and supplementary conditions	68.1%	5.8%
7	Review lessons learned from previous projects	58.7%	10.1%
8	Identify special requirements	83.3%	10.1%
9	Create a list of "known" and "unknown" information	37.0%	13.0%
10	Convert "unknowns" to "knowns" as soon as possible	36.2%	9.4%
11	Assess risk associated with "unknown" information (costs, etc.)	34.1%	4.3%
12	Review reporting procedures	51.4%	3.6%
13	Establish meeting schedules	58.0%	5.1%
14	Identify job log requirements	55.1%	2.2%
15	Allocate accountability	52.9%	4.3%
16	Identify substituted materials and equipment	84.8%	29.7%
17	Discuss alternative duct routes	85.5%	21.0%
18	Identify opportunities for shop fabrication	78.3%	13.8%
19	Estimate quantities of materials and equipment needed	69.6%	9.4%
20	Determine long-lead-time items	91.3%	24.6%
21	Create list of standard and special tools needed	55.8%	2.9%
22	Identify machinery needed (crane, etc.)	75.4%	2.2%
23	Identify sources of overhead (trailer, etc.)	65.2%	0.0%
24	Price materials and equipment from takeoff	65.9%	8.7%
25	Price substitute materials and equipment from value engineering	65.9%	7.2%
26	Price tools and machinery needed	39.9%	0.0%
27	Identify subcontract costs	73.2%	3.6%

Table 1.2: Possible Preconstruction Planning Activities Continued

Activity		% of Contractors	
		Performing the	Top 10 List
28	Price manpower costs	42.0%	5.1%
29	Identify potential cost savings	70.3%	10.1%
30	Obtain and review owner/GC/CM schedule	91.3%	37.0%
31	Develop sequence of work and create work breakdown structure	64.5%	21.0%
32	Identify and establish delivery dates for long-lead-time items	90.6%	14.5%
33	Identify construction equipment delivery dates (crane, etc.)	73.9%	1.4%
34	Establish your subcontractors' start/finish dates	62.3%	4.3%
35	Identify work by others that directly impact your activities	81.9%	19.6%
36	Develop a coordination schedule with other subs (electrical, etc.)	65.2%	14.5%
37	Identify mobilization/demobilization dates	68.8%	1.4%
38	Identify the need for "two-week look-ahead" schedules	45.7%	3.6%
39	Review general accounting procedures	43.5%	3.6%
40	Review billing procedures	78.3%	13.0%
41	Prepare billing schedule	79.0%	9.4%
42	Coordinate with the work breakdown schedule	50.0%	3.6%
43	Create schedule of values	87.0%	13.8%
44	Create a labor breakdown for accounting	63.8%	8.7%
45	Develop purchase orders for materials and equipment	92.0%	8.0%
46	Identify labor tracking codes from work breakdown structure	51.4%	9.4%
47	Develop a labor tracking report	50.7%	15.2%
48	Develop an average labor rate worksheet	29.0%	2.2%
49	Review the estimated work hours	67.8%	13.8%

Table 1.2: Possible Preconstruction Planning Activities Continued

Activity		% of Contractors	
		Performing the Activity	Top 10 List
73	Hire a fabrication subcontractor	17.4%	0.0%
74	Review subcontractor bids and qualifications	87.7%	7.2%
75	Review scope of work with subcontractors	65.2%	2.2%
76	Negotiate subcontractor costs	75.4%	12.3%
77	Write contracts for selected subcontractors	82.6%	2.9%
78	Involve subcontractors in the preconstruction planning process	44.2%	4.3%
79	Review request for information procedures	79.0%	2.9%
80	Review change order procedures	83.3%	6.5%
81	Identify field reporting procedures	70.3%	8.0%
82	Identify telecommunications requirements	52.2%	0.7%
83	Identify subcontractor reporting procedures	48.6%	0.0%
84	Establish daily field/office teleconferences	26.8%	1.4%
85	Include owner/GC/CM designer in your information network	44.9%	2.2%
86	Select a quality control official	11.6%	2.2%
87	Review specification requirements	74.6%	7.2%
88	Establish an inspection schedule	23.9%	1.4%
89	Determine quality acceptance and rejection standards	23.9%	0.7%
90	Identify cure procedures for quality deficiencies	23.9%	0.0%
91	Inform workers of required quality standards	70.3%	2.9%
92	Select an on-site safety official	44.2%	2.9%
93	Review safety and OSHA requirements	78.3%	16.7%
94	Establish an internal inspection schedule	45.7%	0.7%
95	Determine safety acceptance and rejection standards	35.5%	0.0%
96	Identify cure procedures for safety deficiencies	38.4%	2.2%
97	Inform workers of required safety standards	79.0%	8.0%
98	Report inspection results to all personnel	41.3%	0.7%
99	Document lock-out/tag-out procedures	60.1%	0.0%
100	Review safety lessons learned from previous projects	62.3%	5.1%
101	Identify commonly reported hazards	67.4%	1.4%
102	Walk the site to search for hazards before construction begins	64.5%	5.8%
103	Document potential hazards found on-site	68.8%	4.3%
104	Identify hazard reporting procedures	50.7%	0.0%

During the final phase of the research, a linear regression statistical model was used to verify the effectiveness of the HVAC and sheet metal preconstruction planning process. The model fit a project's preconstruction planning score and project characteristics to the probability of the project being successful according to the model in Chapter 6. The model fit very well. Figure 1.2 shows the results of the fit. The vertical axis is the probability of a successful project and the horizontal axis represents how close each project's planning resembled that of the model HVAC and sheet metal preconstruction planning process. Points above the horizontal axis represent successful projects. Points to the right of the vertical axis represent projects with planning processes that more closely fit the model HVAC and sheet metal preconstruction planning process.

1.6 Why Preconstruction Planning Is Important for HVAC and Sheet Metal Firms

The very nature of sheet metal construction establishes the need for preconstruction planning. Ductwork, one of the largest building components, is typically prefabricated, and sheet metal contracting is very labor intensive. Ductwork is also among the first interior systems to be installed during construction. Therefore, the progress of sheet metal work has the potential to impact progress on the entire job. Ductwork typically occupies the largest amount of above-ceiling space, thus it requires a significant amount of coordination. This unique aspect to sheet metal work results in the contractor assuming an unbalanced amount of risk in the early stages of a project. To counteract that higher

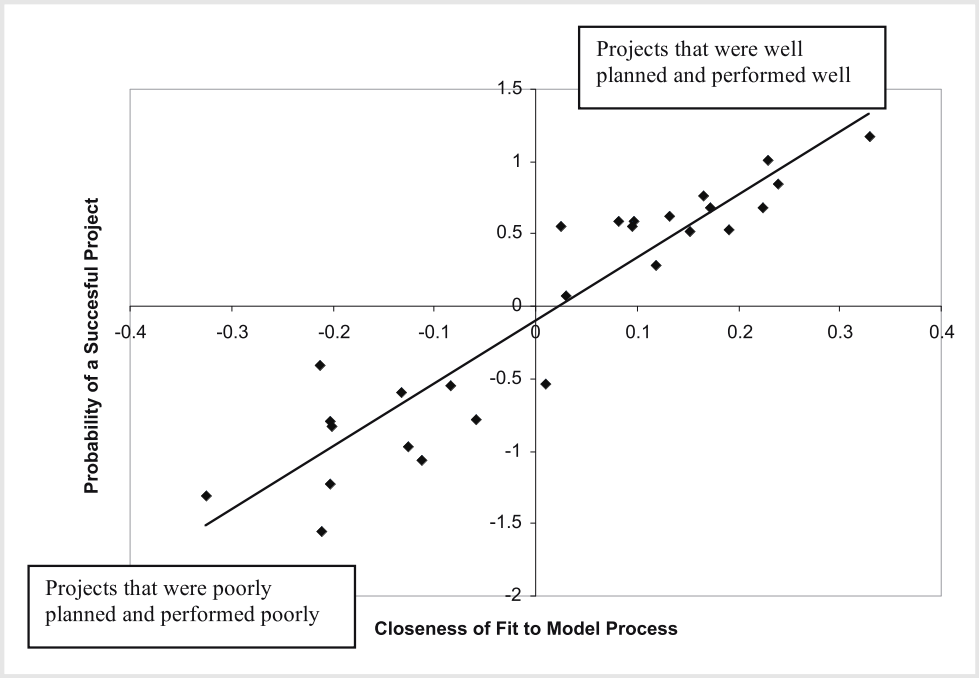

Figure 1.2: Relationship between Planning Score and Project Success

risk, contractors should invest in a proper preconstruction planning process that positions the contractor more likely to succeed on every project.

Literature review revealed that the ability to change the outcome of a project is directly related to the stage of the project. Thus, the earlier one tries to change the outcome of a project, the greater probability of success. Figure 1.3 shows the relationship between percent completion of a project and ability to change the outcome.

1.7 Preconstruction Planning Process and Project Success

The database created during this research revealed that projects that used effective preconstruction planning are more profitable. However, preconstruction planning is only a tool. Preconstruction planning is similar to project tracking, manpower loading charts, scheduling, etc., in that it is a tool that a project manager can use to increase the chances of having a successful project. Using preconstruction planning or any other tools does not guarantee a successful project; however, these tools can help account for one or more of the many variables associated with construction. Therefore, using the HVAC and sheet metal preconstruction planning process is not a guarantee the company will never have another less-than-successful project; the company must still perform on the project.

1.8 Conditions for Successful Preconstruction Planning Implementation

Preconstruction planning must become the company standard and part of the company culture. It should be mandatory for all projects regardless of size or type of construction. However, the process should be tailored to the unique characteristics of each project, including complexity, duration, and volume of work. The

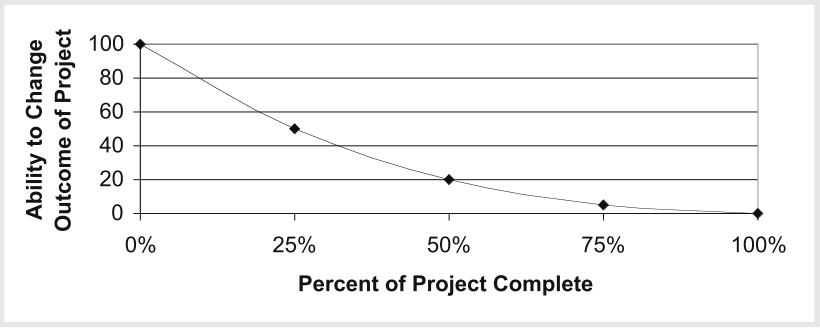

Figure 1.3: Project Stage Relationship to Ability to Change Outcome [1]

key conditions for successful implementation of the HVAC and sheet metal preconstruction planning are as follows:

- It is supported by top management
- Foreman takes off the job
- It is executed early
- It is formal and mandatory
- Productivity is measured as estimated
- Turnover meetings are effective

The process presented here will be a major change to companies, project managers, foremen, etc., who are more used to an "on-the-fly" style of project management. Reasoning that the company has completed a project similar to the current project is no excuse to skip preconstruction planning. All projects are unique and present their own set of challenges; therefore, each project requires specific preconstruction planning.

2 USER'S GUIDE TO THE IMPLEMENTATION MANUAL

2.1 Introduction

The purpose of this implementation manual is to present HVAC and sheet metal contractors with a comprehensive preconstruction planning process. The process is presented in Chapter 3 in a graphical flowchart format to illustrate the interrelationship between planning activities. Each planning activity has a corresponding brief, but detailed, implementation guideline associated with it.

The process organizes 50 preconstruction planning activities into a framework that represents key planning categories. Each category will be presented and discussed in this manual, and each activity will have a set of implementation guidelines to assist with performing the activity. The process can be implemented fully or partially to accommodate each company's unique project planning situation.

2.2 Purpose of This Implementation Manual

This implementation manual presents the HVAC and sheet metal preconstruction planning process and provides guidance on:

- *When* to use the preconstruction planning process
- *Which* planning activities have been effective at improving project success
- *Who* should be involved in the preconstruction planning process
- *How* to successfully implement a preconstruction planning process
- *What* the expected benefits of proper preconstruction planning are

There is flexibility in the HVAC and sheet metal preconstruction planning process that allows it to be used as is, modified to match the company's characteristics, or as a supplement to the preconstruction planning process already used by the company.

2.3 How to Use the Preconstruction Planning Process

The HVAC and sheet metal preconstruction planning process targets three primary audiences:

1. Companies that do not currently have a formal preconstruction planning process and want to adopt the model process
2. Companies that have a semiformal preconstruction planning process and want to modify and formalize their process to be aligned with the model process
3. Companies that already have a formal preconstruction planning process and want to verify or adjust their process based on the information provided in this manual

The planning process is presented in a flowchart that identifies a suggested sequence of activities. To be most effective, each activity should be performed during the proper category. However, the activities within each stage may occur concurrently unless completion of one activity is dependent on the completion of a preceding activity.

2.4 Other Related Documents and Tools

Chapter 7 of this manual contains several sample forms related to specific activities. The forms can be used as is or modified to fit the characteristics of the company. "Alliance Project Management," published by the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) in 1998, also contains over 100 sample project management forms and checklists that could be used by the company.

2.5 Organization of the Manual

Chapter 3 presents an overview of the HVAC and sheet metal preconstruction planning process, including relevant definitions, team member involvement, and guidelines for successful implementation.

Chapter 4 identifies the 12 planning categories and their associated planning activities. Each set of activities has a description and explanation on execution. Many activities also contain a brief example (in italic text) following the description of how other companies have executed that activity or key points companies made about the activity.

Chapter 5 discusses the outcomes of preconstruction planning. It identifies the tangible results of preconstruction planning such as project schedules, labor breakdown reports, etc. Activities that result in a tangible outcome are listed with an asterisk (*).

Chapter 6 defines project success and the definition of project success used to create this model. It also discusses reasons for projects success and project failure, including early warning signs for potential project failure.

Chapter 7 contains several sample forms to be used in conjunction with preconstruction planning and construction execution.

3 OVERVIEW OF THE PRECONSTRUCTION PLANNING PROCESS

3.1 Introduction

Nearly all contractors perform some amount of project planning before or during the execution of their construction projects. Their planning may be very formal, including written instructions with checklists and delivery plans, or very informal, where the planning is done primarily in the project manager's mind. This research has resulted in the development of the model HVAC and sheet metal preconstruction planning process. Based on project data collected for this research, projects that used a planning process similar to this process performed more successfully — they achieved an average profit margin of 23 percent while projects that were poorly planned experienced an average net loss of –3 percent. Furthermore, projects that were well planned tended to perform above average on profitability, budget achievement, schedule achievement, and labor productivity. Chapter 1.5 presented more detailed information on the relationship between planning and project performance. This chapter presents an overview of the HVAC and sheet metal preconstruction planning process, and Chapter 4 in this section addresses each planning category and the associated activities.

3.2 Flow of the Model Sheet Metal Preconstruction Planning Process

Figures 3.1 and 3.2 present the model HVAC and sheet metal preconstruction planning process that resulted from the detailed analysis of planning processes used on successful sheet metal projects. The process consists of 50 activities divided into 12 categories. Figure 3.1 is an overview of the process. It establishes the sequencing of the planning process. The numbers under each category box reference the associated planning activities that fall under that category. Figure 3.2 displays the entire HVAC and sheet metal preconstruction planning process including the activities associated with each planning category.

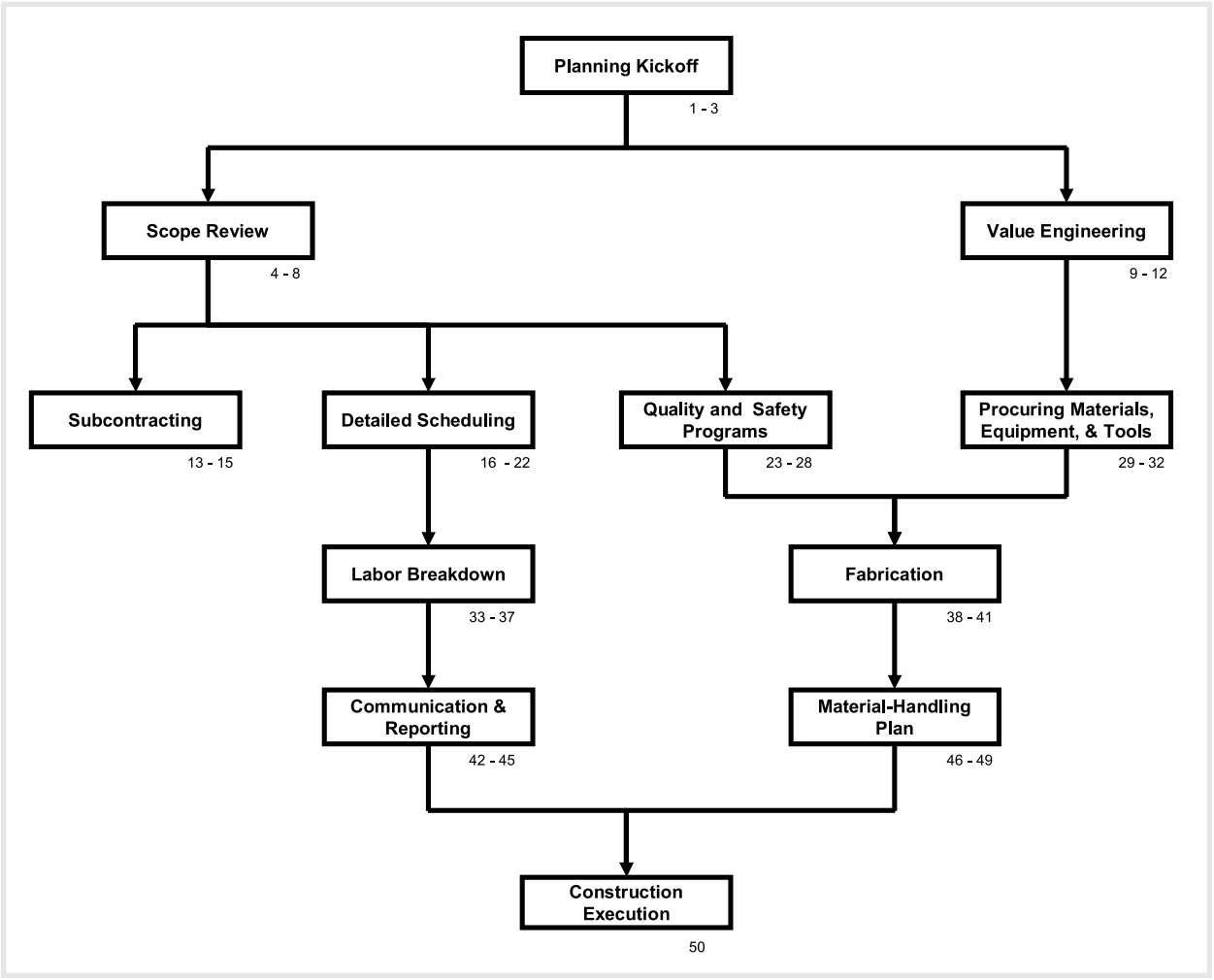

Figure 3.1: Overview of Model HVAC and Sheet Metal Preconstruction Process

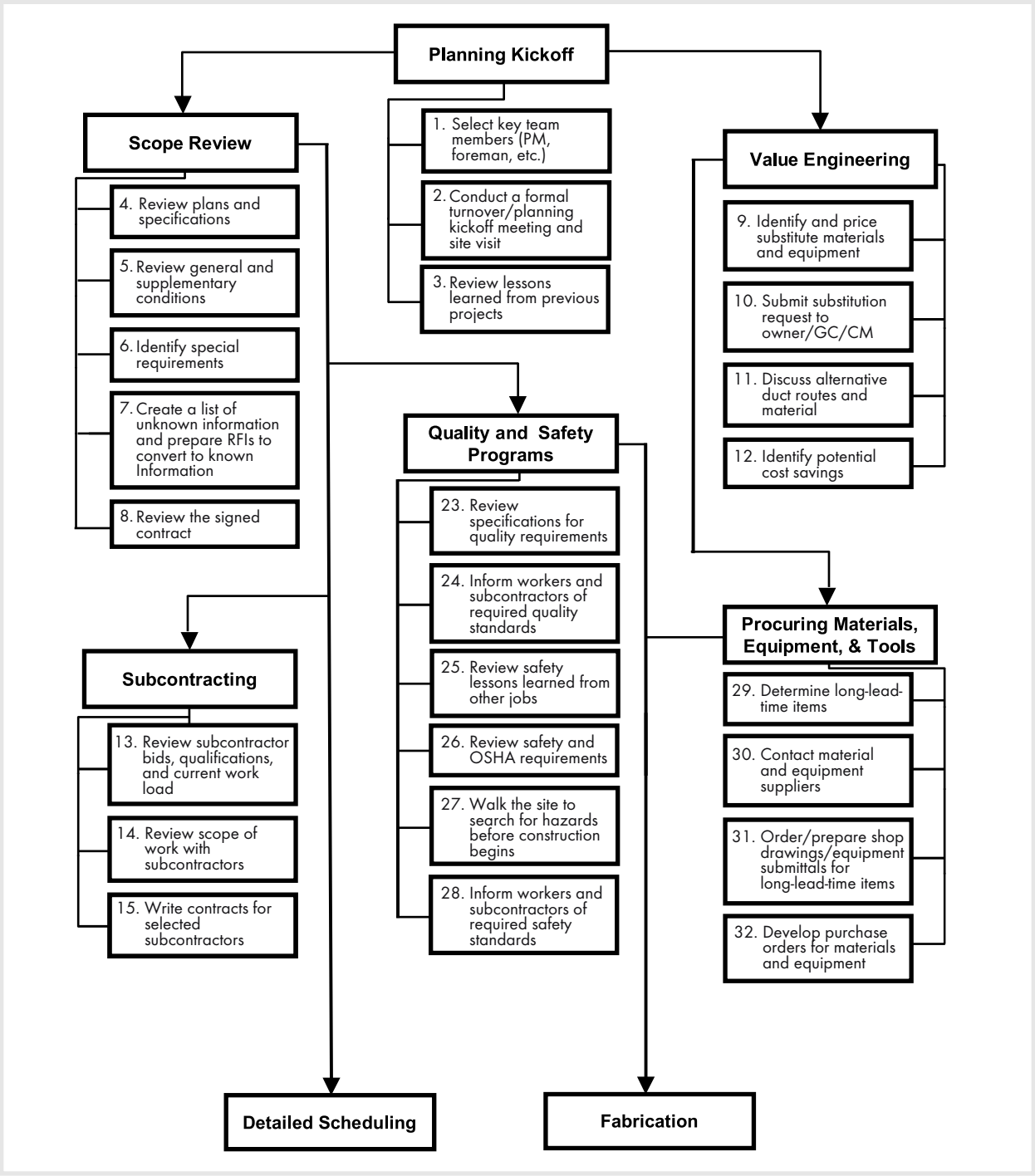

Figure 3.2: Preconstruction Planning Activities

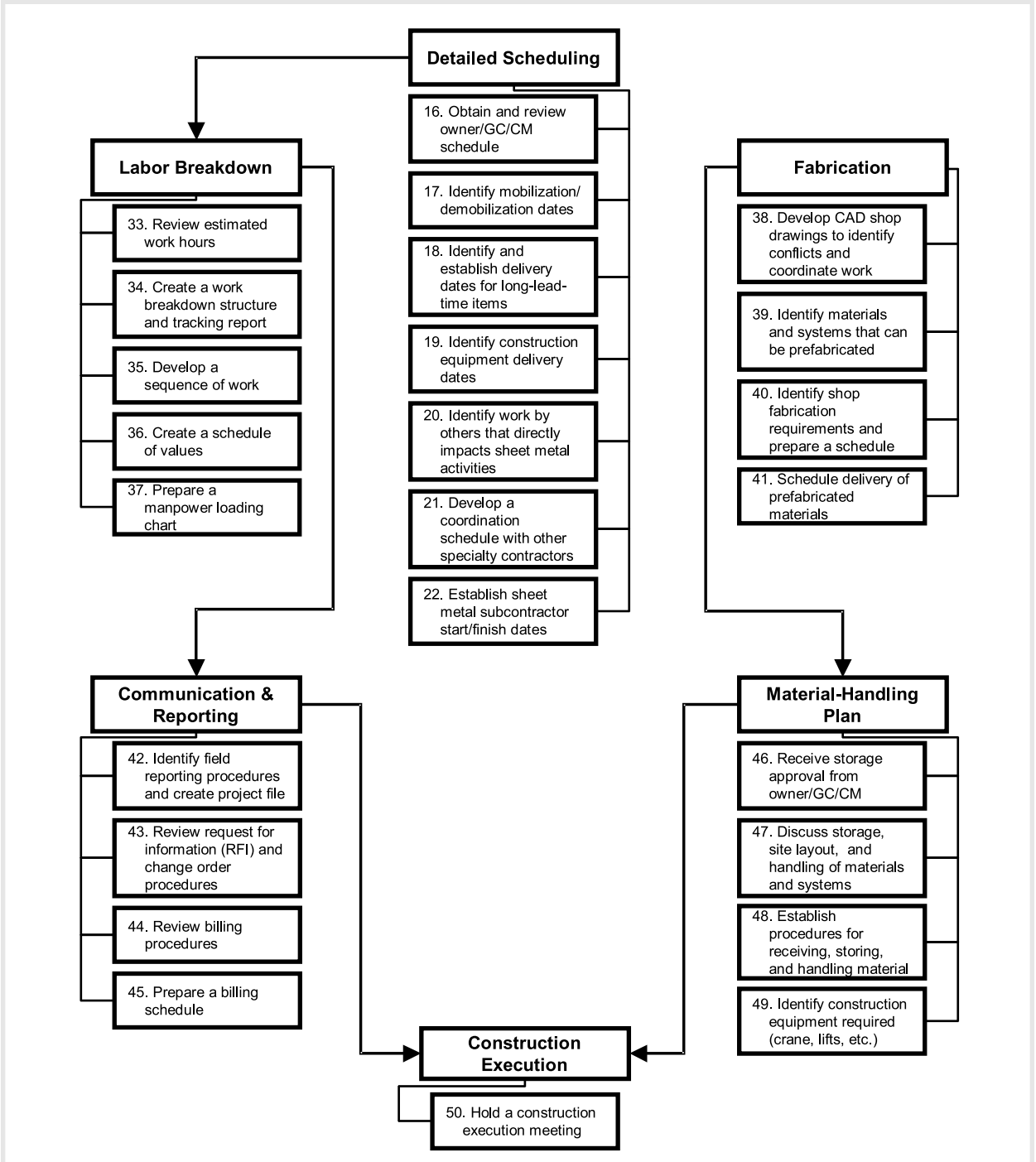

Figure 3.2: Preconstruction Planning Activities Continued

3.3 Concurrent Activities

There is not one direct path through the preconstruction planning model. While the activities are numbered 1 through 50, that does not mean that planning activities must be completed in order from 1 to 50. Many of the activities will be completed concurrently with other activities in that category as well as with activities in other categories.

Similarly, the categories do not follow a consecutive order. Planning in the different categories will also be done concurrently. The different levels, depicted by color on the HVAC and sheet metal preconstruction planning overview, Figure 3.1, show categories that may occur concurrently.

3.4 Order of the Activities

The order of the activities presented in the model preconstruction planning process should work for the majority of sheet metal projects. However, some projects will require an adjustment of the order. For example, Activity 18 is "Identify and establish dates for long-lead-time items" and Activity 32 is "Develop purchase orders for materials and equipment." On the majority of projects, sufficient time will be available to review the schedule and determine when to order the equipment so that is delivered on time; the schedule will drive when the equipment delivery is scheduled. However, on short-duration projects, the project schedule may be developed around when the equipment will be available for delivery; the equipment will drive the creation of the schedule. Therefore, it is important to review the characteristics of the project to determine if the order of activities needs to be adjusted to fit the project.

3.5 Who Should Complete Each Preconstruction Activity

The details for some activities identify specifically who should complete the activity, whether it is the project manager, foreman, or entire project team. However, most of the activities do not identify a specific team member. This allows the process to be adjusted to fit the characteristics and personnel employed by the company. Activity 2, "Conduct a formal turnover/planning kickoff meeting and site visit," includes the creation of a planning responsibility matrix. At this step, the project team will identify whose skills and job description best match each activity.

3.6 Definitions

Terminology differs from company to company and from region to region. To avoid confusion, the following are terms and their definitions as used in this manual.

- Specialty contractor – a specialized company contracted by the general contractor (GC) (sheet metal, electrical, plumbing, etc.)
- Subcontractor – a third-party firm contracted by the sheet metal company with services for certain parts of the project (insulation, fabricator, controls, etc.)
- Prefabrication – manufacturing ductwork or parts of an assembly in one location and delivering them for installation in another location. [2]

4 PRECONSTRUCTION PLANNING ACTIVITIES

4.1 Introduction

This chapter identifies the 12 planning categories and their associated planning activities. Each activity has associated with it a description of the activity and explanation on how to execute the activity. Many activities also contain a brief example of how companies have executed that activity or important points companies made about the activity that follows the description in italic text. Additionally, activities followed by an asterisk (*) will result in a tangible outcome that will become part of the project planning binder discussed in Chapter 5.

4.2 Planning Kickoff

Planning kickoff signals the start of a new sheet metal project. This is the time to set a positive attitude for the project and the preconstruction planning effort. If team members approach the planning effort with the attitude that it is a waste of time, that is exactly what it will be.

Activity 1. Select Key Team Members

Project team members should be selected to fit the characteristics of the project. Selection criteria for project managers, superintendents, and foremen should be their previous experience with the following:

- Type of project: Office building, school, hospital, etc.
- Type of duct construction or installation: Galvanized, flex, stainless steel, etc.
- Type of systems involved: High/low pressure duct, ducted vs. plenum return, exhaust, etc.
- Size of project: Labor hours and value
- Complexity
- Owner/general contractor/construction manager (CM)/engineer
- Project manager/superintendent/foreman selected for the project: Put the right team of people together

The leadership ability, duration of the project, current workload, management experience, and skill set possessed by each individual should also be considered. Finally, it may come down to instinct about those who are believed to be the best match for the project and who will warrant the respect of their fellow workers.

A common cause of poor project performance is shifting leadership and manpower during projects. If it is known that a project manager will be assigned to a large project starting in two months that will consume all of the project manager's time, it would not be wise to assign him to a project that will not be completed by the start of the large project.

Activity 2. Conduct a Formal Turnover/Planning Kickoff Meeting and Site Visit*

The purpose of the turnover meeting is to transfer all knowledge of the project from the estimator to the project manager and field foreman. Companies that do not have

separate estimating and project management individuals will still need to complete this turnover meeting in order to transfer information from the project manager to field foreman. The turnover meeting should cover the following:

- Information conveyed to bidders including alternates
- Scope
- Plans and specifications
- Estimate (costs, labor hours)
- General contractors, specialty contractors, proposed subcontracts
- Schedule and sequence of work
- Value engineering proposed and accepted
- Prefabrication
- Special safety considerations
- Specified project quality requirements
- Identified project risks

An effective way to conduct a turnover meeting is through the creation of a turnover binder containing information on all the topics of discussion. Each team member should receive a copy of the turnover binder for reference. Form 7.1 is a sample project data sheet that should be part of the turnover packet.

The turnover meeting should also be used to assign the remaining preconstruction tasks to the appropriate team members. This will create accountability for the preconstruction planning. Form 7.2 is a sample responsibility matrix.

Tip: Contractors reported that failure to hold a turnover meeting between the estimator, project manager, and field supervisor — or a turnover meeting that did not address all issues — caused the project to get off to a poor start; in contrast, an extensive turnover process often resulted in a project that was well organized and properly managed. The duration of the turnover meeting should be dictated by the amount of information that needs to be reviewed. A large project may require 1 or 2 days, but a small project may only required 15 to 30 minutes to review all the information.

A site visit should be a part of this activity, because it is important for the contractor to have an understanding of the site.

Activity 3. Review Lessons Learned from Previous Projects

Reviewing lessons learned is one of the easiest methods to avoid similar problems that occurred on previous projects. Lessons learned can be referenced to review productivity on similar projects, previous conduct of the general contractor and other specialty contractors, and construction methods and materials that proved to be beneficial on previous projects.

Tip: Every construction worker possesses a mental lessons-learned library, but, until the lessons learned are recorded in a fashion where company employees can access them, the benefit of those experiences goes unrealized. The creation of a lessons-learned library allows contractors to review relevant information that might benefit them on the current project. Contractors have developed lessons learned through post-job/postmortem/wrap-up meetings where the recently completed project is discussed in detail. Smaller contractors hold weekly meetings with all project managers and

field supervisors. Project managers and field supervisors at these meetings are able to share information on all construction means and methods that worked especially well or did not work well on their projects. A simple way to develop a lessons-learned library is to ask every project manager and foreman to provide one good idea every month and then compile these ideas. The New Horizons Foundation has funded a research project on "Creating a Learning Culture for HVAC and Sheet Metal Contractors" that will further address lessons learned.

4.3 Scope Review

To be successful on a project, each team member must have a total understanding of the project. To obtain this understanding, the project documents should be reviewed in detail to identify the scope of work as well as any unusual requirements or discrepancies that might impact the cost of the work.

Activity 4. Review Plans and Specifications*

The plans and specifications describe the entire project; therefore, their thorough review is crucial. Below is a list of key items that should be noted during the review.

- Matching of final project specifications to those used to prepare the estimate
- Equipment schedules: Equipment missing; details provided, model numbers, supports and pads, etc.
- Construction standards specified
- Testing: Pressure testing, balancing, vibration, sound attenuation, etc.
- Type of material specified: Aluminum, stainless steel, galvanized, flex duct, etc.
- Fitting requirements
- Inspection process

Form 7.3 provides a list of suggested items that should be verified while performing the scope review.

Tip: When a project manager distributes plans and specifications to the foreman for scope review, a system to create accountability needs to be in place. Some contractors ask a few brief questions on key items they found in the specifications. Questions such as "What did you think about the allowable leakage limits?" will allow the project manager to determine if the foreman did a sufficient review or if more time is needed to review the documents. A foreman or project manager without a complete understanding of the scope of work may perform extra work for the owner without seeking just compensation. Based on the data collected for this research, missing part of the scope was one of the top-ranked causes of poor project performance.

Activity 5. Review General and Supplementary Conditions

The general conditions are "the portion of the contract document in which the rights, responsibilities, and relationships of the involved parties are itemized" [3] and the supplementary conditions are the portion "which supplements, modifies, changes, adds to, or deletes from provisions stated in the general conditions." [4] Reviewing general and supplementary conditions is extremely important because the conditions lay out the basis for the project. The supplementary conditions are the most important to review, because they contain unique requirements for the specific project.

The following is a list of key items to review in the general conditions: [5]

- Temporary services (heating, trailers, temporary power, dumpsters, etc.)
- Material and equipment storage
- Site communication requirements
- Bonds and insurance requirements
- Changes in contract scope, price, and time notice requirements
- Inspections and corrections of work
- Progress payments
- Subcontracting
- Contract closeout procedures
- Warranty of work
- Dispute resolution
- Termination of contract

Key items to review in the supplementary conditions include the following:

- Wage requirements (prevailing wage)
- Owner-furnished equipment
- Parking and site access
- Site security, access restrictions, security badges
- Insurance coverage limits
- Minority Business Enterprise (MBE)/Women Business Enterprise (WBE) requirements

Activity 6. Identify Special Requirements

During the review of the project documents, any special requirements involved in the project should be noted. The impact of the requirement to cost, schedule, and labor productivity should be determined. Examples of special requirements to look for include the following:

- Access doors
- Duct sealer
- Shutdowns
- Shift work
- Indoor air quality
- Noise control
- Fire control
- Welding
- Testing requirements (leakage, water gauge)
- Unusual situations

Activity 7. Create a List of Unknown Information and Prepare RFIs to Convert to Known Information*

As the plans, specifications, and general and supplementary conditions are reviewed, notes should be made about any questions that arise about the systems, intent, design, schedule, and equipment. A list of questions and concerns should be created. These questions should be submitted formally as a request for information (RFI) according to the procedure set forth by the general contractor/construction manager/engineer. A formal procedure for tracking RFIs should be in place, because RFIs often turn into change orders.

Tip: Some sheet metal contractors have found a meeting with the design engineer beneficial. This meeting allows the contractor to receive timely responses to questions and obtain a complete understanding of the intended design. It is recommended that as many RFIs as possible should be prepared and sent during the preconstruction stage to allow adequate time for response from the engineer.

Activity 8. Review the Signed Contract

A signed contract should be required for all work undertaken. Although numerous projects for a customer may have been completed with nothing more than a handshake, a signed contract is designed to protect both parties.

If the contract is a standard form contract (AIA, ASA, AGC, EJCDC), careful note should be made of any lines ruled out or additions made. The contract may require legal review if it is not a standard form contract. All inclusions and exclusions from the scope of work, drawing enumeration, drawing dates, contract amount, completion date for work, and addendum should be noted. Unsatisfactory terms and conditions of the contract should be negotiated. Clauses that could hold the sheet metal contractor to the same terms and conditions as the general contractor should be reviewed.

SMACNA has published "Contract Bulletins" that help a contractor identify and manage contract risk.

4.4 Value Engineering

Value engineering (VE) is defined as a process that "identifies opportunities to remove unnecessary costs while assuring that quality, reliability, performance, and other critical factors will meet or exceed the customer's expectations." [6] VE is not choosing the cheapest option; it is a process of questioning everything in order to add value to the project by building it better, faster, less costly, or decreasing the lifecycle cost.

The design team completes the vast majority of VE prior to releasing the project for bids. However, there are two remaining periods of VE that a sheet metal contractor may be involved in on a traditional delivery project, design — bid — build.

1. The first period occurs during bid preparation. During this stage, VE ideas are presented to the owner as possible cost-saving options. These ideas will typically lower the bid price and can aid in submitting a successful bid. This stage is not included as part of preconstruction planning.
2. The second period of VE occurs after the contract is signed. This is the stage of VE that is executed during preconstruction planning, when company practices are reviewed to internally control material cost and overhead without any sacrifice to the quality of the project.

Activity 9. Identify and Price Substitute Materials and Equipment

To be successful in VE, the contractor must have a systematic approach. Planning Activity 9 and Activity 10 work through the standard five-step approach to VE. [7] Following the first three steps presented here will help to create and develop possible substitution ideas. The final two steps are presented in Activity 10.

Step 1. Information Gathering
a. What function is being provided?
b. What does the function cost?
c. What is the function worth?
d. What function must be accomplished?

Step 2. Creativity and Idea Generation
a. What else could perform the function?
b. How else may the function be performed?

Step 3. Analyze Ideas/Evaluation and Selection
a. Will each idea perform the required function?
b. How might each idea be made to perform the required function?

Areas for cost savings identified during the research were serviceability, price agreements with manufacturers, worker's experience with similar equipment from different manufacturers, and earlier delivery dates. It is important that, during the VE analysis, project risk at the company is not increased because the design was changed. The engineer's approval should be required prior to proceeding with any substitution.

Tip: Activity 7 suggests a meeting with the design engineer. During that meeting it may also be beneficial to discuss any VE ideas. In this way the engineer is kept in the loop. The engineer may be more accepting of VE ideas because the engineer was involved with their development.

Activity 10. Submit Substitution Requests to Owner/GC/CM

The final two steps in the five-step VE approach will help sell the VE ideas to the owner. A list should be made of the advantages and disadvantages of the substitutions being recommended.

Step 4. Development of Proposal
a. How will the new idea work?
b. Will it meet all the requirements?
c. How much will it cost?
d. What is the life-cycle cost impact?

Step 5. Presentation/Implementation and Follow-Up
a. Why is the new idea better?
b. Who must be sold on the idea?
c. What are the advantages/disadvantages and specific benefits?
d. What is needed to implement the proposal?

Activity 11. Discuss Alternative Duct Routes and Material

Alternative duct routing is a huge potential for savings, but it also represents significant risk. Prior to rerouting ductwork, proper approval must be received according to the conditions of the contract. Ductwork rerouting that is not approved can lead to extensive hours spent on rework and increased material costs. Duct rerouting should be considered to

- Reduce installation costs
- Reduce material cost
- Reduce fittings
- Arrange duct that does not fit as shown
- Ease installation of insulation or insulation will not fit as shown

Activity 12. Identify Potential Cost Savings

Identifying potential cost savings is a process that starts with preconstruction and continues throughout the duration of the project. Some common areas to recognize cost savings are prefabrication of ductwork and modular

systems, quantity purchases, the decision to purchase or fabricate ductwork, and equipment buyout.

Tip: One sheet metal contractor noted that his shop had capacity to fabricate only 10-foot sections of gutter. He instead purchased the gutter in 30-foot lengths from another fabrication shop, which resulted in a significant savings in installation cost.

4.5 Subcontracting

Labor is one of the largest construction risks. Proper subcontracting allows the sheet metal contractor to shift some risk associated with the project to another company. Subcontracting also allows access to companies with experience in specialized construction. Choosing the correct subcontractors can make the job run smoothly and be more successful.

Activity 13. Review Subcontractor Bids, Qualifications, and Current Work Load

Subcontractor bids should be reviewed to ensure that the correct scope of work has been included. Any qualifications, inclusions, or exclusions must be reviewed. It should be verified that the subcontractor has obtained certification if required, i.e., welding, SMACNA. It must be determined if the subcontractor has sufficient insurance, a good safety record, proper equipment, quality craftspeople, and the manpower required to complete the work on time. [8] Subcontractors should have an effective safety program that meets or exceeds federal, state, and local safety requirements. Previous experience with subcontractors can assist in selecting the correct subcontractor.

Tip: Many sheet metal contractors consistently work with the same subcontractors. A strong relationship in which each team member knows the strengths of each respective subcontractor and the level of quality and workmanship that can be expected is the result of repeatedly working with the same group of subcontractors. While this will eliminate the advantage of receiving additional bids, it will also reduce the possibility of working with an inferior subcontractor. Working with quality subcontractors is a key to project success.

Activity 14. Review Scope of Work with Subcontractors

Once a list of possible subcontractors is established, the scope of work should be reviewed with all subcontractors to ensure that they have a thorough understanding of the project and have included all appropriate costs in their bid. Any qualifications, inclusions, and exclusions should be reviewed. A subcontractor that has included more work in his scope may be advantageous, because it allows for shifting additional risk. Unsatisfactory terms and conditions should be negotiated at this time. The sample scope review, Form 7.3, can also be used to review subcontractors' scope of work. SMACNA created a publication on "CSI, Master Bid Specification" that can further assist with scope review.

Activity 15. Write Contracts for Selected Subcontractors

Policy should be that all subcontractors have signed contracts. The contract should be checked for completeness, as ambiguities in any contract are construed against the drafter. A standard form contract or company standard subcontract created with the

assistance of a lawyer should be used. Parallel and consistent terms should flow from the contract with the general contractor to ensure that the general contractor has to follow the same terms and conditions. The contract should reference:

- Original contract documents, plans, and specifications
- Special clauses in the contract with the general contractor or owner (liquidated damages, warranty)
- The subcontractor's entire scope of work

4.6 Detailed Scheduling

Scheduling is key to project success. Scheduling allows for effective time management on a project. A project schedule is constantly changing. Therefore, the schedule that is created during the preconstruction planning phase of the project must be updated periodically throughout the duration of construction. The rate at which the schedules should be updated is dependent upon the characteristics of the project.

Activity 16. Obtain and Review Owner/GC/CM Schedule*

The sheet metal contractor should review the preliminary schedule provided by the general contractor or provided with the bidding documents and insist upon involvement in the creation of the project schedule. The schedule should be reviewed for:

- Proper sequencing of work
  - Is the work sequenced according to how the project was bid?
  - Do activities have proper preceding and succeeding activities?
- Appropriate durations for planned crew size
- Missing activities
  - Is time scheduled for submittals, lead time, owner-furnished items, and finishing activities such as inspection, punchlist, and commissioning?
- Appropriate overlap of activities

Activity 17. Identify Mobilization/Demobilization Dates

The construction schedule should be reviewed for sheet metal construction start and finish dates to confirm that the dates are those listed in the contract. The required resources and manpower to meet theses dates must be guaranteed to be available. A typical project starts upon receiving the notice to proceed and ends upon achieving substantial completion.

Activity 18. Identify and Establish Delivery Dates for Long-Lead-Time Items

The project bid must be reviewed for the equipment that is required on the project. Lead times should be determined from vendors and suppliers or from a review of quotes. Lead times and shipping time must be included when determining when to order the equipment and delivery dates. Delivery dates should be coordinated with the project schedule. Once these dates have been established, the vendors should be held accountable.

Tip: A current trend in construction is "owner-purchased equipment." This presents a savings for the owner, because there is no contractor markup on the equipment. However, this presents a problem when the

owner does not coordinate the purchase and delivery of equipment with the sheet metal contractor. If the owner on the project is purchasing equipment, the sheet metal contractor should offer to coordinate the purchase and delivery of the equipment at an agreed-upon cost. When the ownership of the equipment transfers and storage costs if the equipment is delivered early must be clarified with the owner. The New Horizons Foundation recently completed a project on owner prepurchased equipment.

Activity 19. Identify Construction Equipment Delivery Dates

Construction equipment (manlifts, cranes, carts, welders, etc.) required on the project must be identified. The schedule should be reviewed for dates when equipment is required. Construction equipment availability must be determined and delivery scheduled. If equipment is unavailable for the required dates or is not possessed by the company, an equipment rental company must be contacted.

Activity 20. Identify Work by Others That Directly Impacts Sheet Metal Activities

When the project schedule is reviewed, the preceding and succeeding activities that may impact sheet metal work activities must be determined and these activities noted on the schedule. The reliability of the contractors whose work directly impacts sheet metal work must be reviewed. On past projects have they been able to keep up with the project schedule or do they consistently fall behind? Completion of work required for sheet metal work to commence must be verified prior to sending crews to the project. Many labor hours can be wasted when crews show up to install grills and diffusers only to find the suspended ceiling grid has yet to be hung.

Activity 21. Develop a Coordination Schedule with Other Specialty Contractors*

Coordination with other specialty contractors is a key to project success. Lack of coordination can lead to stacking of trades, having workers on-site prior to the work being ready, and adversarial relationships on the project. This schedule should be part of or coordinated with the schedule provided by the general contractor. The more detail that is provided in the schedule, the more beneficial it will be; however, there must be accountability to ensure that other contractors stick to the schedule.

Tip: One-week, two-week, or three-week short-interval schedules are ideal for detailed coordination. Scheduling the amount of detail required for coordination several months in advance might not present as much benefit due to the volatile nature of a project schedule. Form 7.4 presents a sample three-week short-interval schedule.

Activity 22. Establish Sheet Metal Subcontractor Start/Finish Dates

The project schedule provided should be reviewed to determine the start/finish dates of sheet metal subcontractors and these dates noted on the project schedule. Subcontractors must be kept current with the progress of the project and changes to the project schedule prior to the start of their work. Keeping subcontractors up-to-date with the project progress allows them to plan for the upcoming work and have the necessary equipment, material, leadership, and manpower available to complete the work in the allotted duration.

4.7 Quality and Safety Programs

High levels of quality and safety are two areas that can differentiate a company from others. Quality and safety are two key factors owners and general contractors look for when selecting and prequalifying specialty contractors to bid and work their projects. High levels of quality and safety also equate to increased profit levels by reducing cost associated with rework/warranty work and insurance costs.

Activity 23. Review Specifications for Quality Requirements*

The specification should be reviewed to determine what standards are specified (SMACNA, Air Conditioning Contractors of America, etc.).

- Is the specification correct for the site?
- What testing and certifications are required?
- What is the crew's comfort and familiarity with the level of quality, materials, and equipment specified?

If the ductwork is going to be purchased from a specialty fabricator, the specialty fabricator must be familiar with the quality requirements on this project and capable of achieving that level of quality. If the ductwork is going to be fabricated in-house, the shop foreman must be informed of the quality specifications required on the project for each type of ductwork and installation. If the company has developed shop standards, those standards should be reviewed to ensure that they meet the project specifications.

Tip: A folder of shop standards for the project should be created, which includes the specifications for each type of ductwork on the project and any specialty ductwork:

- Flex
- Stainless steel
- Dishwasher, etc.

This folder should be readily available for the shop foreman to reference standards throughout the project. A new folder should be created for each project; however, there should not be a need to start from scratch on each project because there will typically be a lot of similarity between projects. Even if not required by the project specifications, it is still beneficial to submit a copy of the shop duct construction standards to the engineer for approval.

Activity 24. Inform Workers and Sub-contractors of Required Quality Standards

The quality standards for the project should by first reviewed by the project manager and superintendent and then issued to the foreman and shop. This can be done efficiently with the folder produced in Activity 23. The workers should be allowed to review the quality standards and have answered any questions that arise from their review.

Activity 25. Review Safety Lessons Learned from Other Projects

Safety is a continuous activity throughout the project. However, prior to construction, the project should be reviewed for any unique safety considerations. Similar projects completed in the past should be reviewed for circumstances of accidents or near-miss

accidents to determine how similar situations can be avoided on the current project. If it is a repeat customer, special safety provisions they require on their projects should be reviewed.

Tip: Companies have found it beneficial to e-mail all foremen when an accident occurs, detailing the circumstances of the accident and allowing them to make the necessary changes to prevent a similar accident from occurring on their project. In addition, this information should be added to the lessons-learned library.

Activity 26. Review Safety and OSHA Requirements

The project specifications should be reviewed to determine any special safety requirements above and beyond the Occupational Safety & Health Administration (OSHA) standards and company standards. Are there mandatory jobsite safety meetings? If it is a remodel or shutdown project does the owner have any special requirements? Is special safety training required for the type of work to be performed? In addition to answering these questions, a schedule for safety inspections and toolbox/tailgate safety talks should be established.

Activity 27. Walk the Site to Search for Hazards before Construction Begins

The project manager, superintendent, and foreman should walk the project site, making note of any special safety considerations. Do the job size, working conditions, project environment, etc., represent a great safety risk to workers? Safety concerns noticed during the inspection should be photographed and documented during the site walk. The owner/general contractor/construction manager should be informed in writing of any safety concerns observed during the site walk. Key items to be examined during the before-job safety walk around the site include:

- Openings
- Rigging requirements
- Fall protection
- Welding fire watch
- Ladders
- Lead paint, asbestos
- Current jobsite/general contractor's attitude toward safety

A safety checklist can help ensure a thorough site review. Form 7.5 is a sample jobsite safety checklist that can be modified to match the type of work performed at the company. SMACNA also publishes "Jobsite Reporting Forms and Checklists," a handheld checklist to assist foremen, supervisors, and safety personnel.

A majority of accidents occur as a result of working in an unsafe manner or in direct violation of safety rules. Indifferent supervision, lack of instruction, and unsatisfactory project management are main causes for an unsafe work environment. The proactive approach of leadership reviewing a project site prior to sheet metal workers commencing work establishes the importance of safety on the project. When workers are informed of possible hazards at the site prior to their arrival, they will be conscious of how seriously safety is considered on this project.

Activity 28. Inform Workers and Sub-contractors of Required Safety Standards

Safety should be reviewed and explained to all employees when they are first hired. Safety

must be presented as extremely important, and project leadership should enforce this with all employees. The safety considerations particular to the project, such as confined spaces/elevated work/etc., should be reviewed with employees and subcontractors to ensure that everyone has the tools necessary to work safely. Current hot topics in safety, results of the site inspection, and special safety considerations unique to the project should be reviewed, including:

- Indoor air quality
- Security identifications
- Locking out
- Elevated work
- Welding
- Evacuation requirements
- Special requirements by the owner, etc.

Tip: Many tools are available to train employees and keep them current with safety standards. Each employee should review a safety manual and be trained on commonly used equipment (forklifts, scissors lifts, etc.) when first hired. A short review or test for employees will force them to take the time to understand the material and also convey how important safety is at the company. Tailgate and lunchbox talks should also be used to keep employees current on important safety issues. SMACNA has published several volumes of "Safety Toolbox Talks," each a collection of 100 safety topics related to sheet metal work in the field and shop.

4.8 Procuring Materials, Equipment, and Tools

Project buyout presents an excellent opportunity for cost savings on equipment and materials. However, it can also significantly impact the project if it is not done correctly or completed on time. Equipment required by sheet metal contractors is most often special-order equipment that may have lengthy lead times. The timely completion of shop drawing submittals and ordering of equipment can reduce the chances of delays and impacts to productivity as a result of late equipment delivery.

Activity 29. Determine Long-Lead-Time Items

Quotes the estimator received from vendors while preparing the project bid should be reviewed. The quotes should contain an estimated lead time for each piece of equipment. The lead-time requirements should be reviewed with the schedule to determine when equipment needs to be ordered. Lead time and shipping time must be considered when determining the date to order the equipment. Deliveries should be scheduled to arrive when the equipment is to be installed. Equipment that arrives prior to the work being ready requires additional handling and presents the possibility for damage.

Tip: Late equipment deliveries can severely impact labor productivity. Productivity drops when crews have to work back to an air-handling unit as opposed to working from the unit. Purchasing equipment early also allows the contractor to bill the owner to increase the contractor's cash flow early in the project.

Activity 30. Contact Material and Equipment Suppliers

The material and equipment suppliers should be notified that the contract has been awarded. The prices that were quoted by the supplier and provided in the bid for the project should be confirmed and the supplier provided with the required delivery dates for material and equipment. If the supplier cannot meet the required delivery dates, other suppliers should be contacted to find one that can meet the required delivery dates.

Activity 31. Order/Prepare Shop Drawings/Equipment Submittals for Long-Lead-Time Items*

The shop drawings/equipment submittals should be ordered as soon as possible to allow adequate time for proper review of the product data/samples. [9] Specifications for requirements regarding the following should be reviewed:

- What must be submitted?
- What is to be included in submittal?
- How many sets are required?

The shop drawings/equipment submittals should be reviewed to ensure that the equipment is as specified, with correct sizes and number of items. The specifications and drawings should be compared to the purchase order.

Tip: Creating a submittal log will help keep track of the submittal progress. It will also be helpful in a claims case if the owner or general contractor slows the approval of submittals, thereby causing delays in the equipment approvals. Form 7.6 is a sample submittal log.

Activity 32. Develop Purchase Orders for Materials and Equipment*

Who will be responsible for purchasing what material and equipment, and if field personnel will purchase any material, should be determined. Purchase orders for material and equipment should be developed according to the company standard. Revisions to the estimate and cost breakdowns should reflect the actual purchase price of materials and equipment. The vendor should have signed and returned a copy of the purchase order.

4.9 Labor Breakdown

Proper labor breakdown allows companies to track progress on the project and realize and address labor concerns when they occur. Project tracking also creates the opportunity to compile a database that will help in estimating labor on future projects. A lack of labor breakdown was a common theme for less-than-successful projects during this research.

Activity 33. Review Estimated Work Hours

The project manager and foreman should review the estimated work hours for the project. They should review how the estimator thought the project was going to be built and what crew sizes were anticipated on the project. A thorough review of the hours should uncover any items missed in the scope. It is better to know in the beginning that the project is short on labor hours than to find out three-quarters of the way through.

Tip: The foreman should review the budget and "buy into" the hours. He should know that this is the time to raise any concerns about the number of hours to complete the work. Accountability should be created so that, at the end of the project, poor performance cannot be blamed on a bad estimate.

Activity 34. Create a Work Breakdown Structure and Tracking Report*

The work breakdown structure (WBS) separates a project into its component parts, clarifying the relationships of the parts and the tasks to be completed for billing purposes. The WBS should be a logical breakdown of the project labor hours. Figure 4.1 illustrates the logical flow the WBS should follow. The labor hours might be broken down according to:

- Area/phase/floor of project
- Type of duct installation: high/low pressure, material
- Fabrication/material handling

The WBS should be used to create a labor tracking report. The labor tracking report should allow for record keeping to track the number of hours spent on an activity, the percentage of the activity completed, and the hours remaining. Form 7.7 is a sample labor tracking report.

Tip: A common theme on projects that were poorly performed was a lack of project tracking. On these projects, the project manager thought the project would be very easy and did not want to waste time creating a labor breakdown. Without a means to properly track progress on the project, it was not until too late into the project that the project manager realized there was a problem.

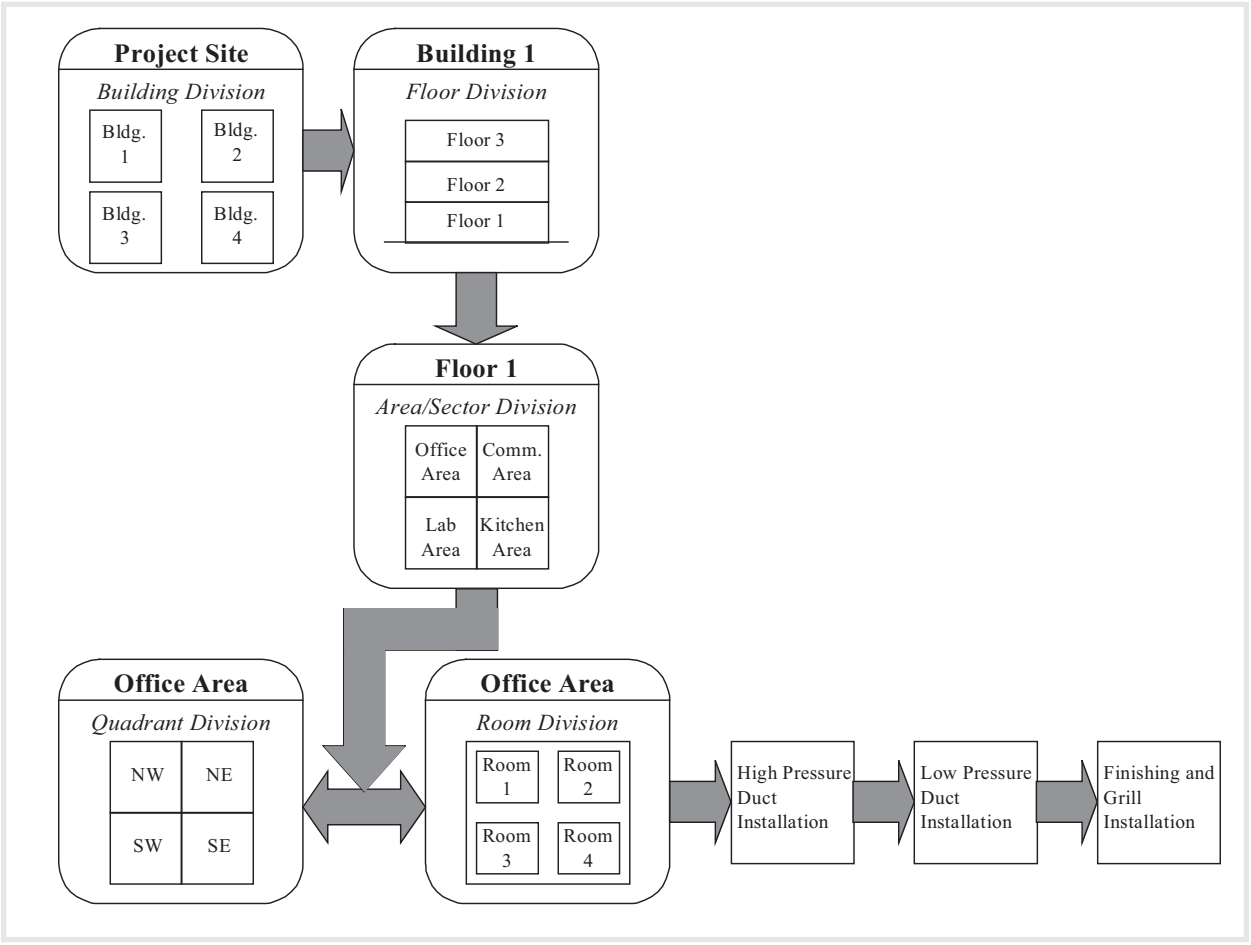

Figure 4.1: Work Breakdown Structure Development

Activity 35. Develop a Sequence of Work*

Color-coding a copy of the project drawing shows the phases of the work and how work is going to progress on the project. The project foreman should label the drawing with the crew sizes and the level of manpower anticipated for each section of the work. For greater levels of productivity, it is best to complete the work with small crews that are engaged in repetitive work. This drawing can then be used in creating the manpower loading chart, Activity 37.

Activity 36. Create a Schedule of Values*

The schedule of values subdivides the total contract sum into individual items and systems and establishes a value for each. [10] Many times the owner provides the project schedule of values; however, if there is a foreseeable problem with the proposed schedule of values, there is always the possibility for negotiation. If the owner does not provide a schedule of values, one must be created. It should be detailed enough so that the owner can understand the work completed and compensate the contractor completely and on time.

Tip: Some contractors may try to hide actual values in the schedule of values in order to receive more pay upfront for work they have not completed. This presents not only ethical concerns, but also the advantage is lost if the owner requires large amounts of time to review pay requests due to a lack of detail in the breakdown.

Activity 37. Prepare a Manpower Loading Chart*

The labor breakdown and the manpower levels anticipated by the foreman in Activity 35 should be used to create a manpower loading chart. The chart should show the project duration on the x-axis and the anticipated manpower level on the y-axis. At a minimum, the chart should track planned manpower and actual manpower. The base scope of work and change-order hours may also be tracked separately.

Figure 4.2 shows a sample manpower loading chart that tracks estimated manpower and actual manpower. The chart from this project shows the advantages of a manpower loading chart in providing early warning on a project. The project did not reach its planned peak manpower during Weeks 31 through 49. This results in the work being dragged out during Week 67 to completion. This work being completed behind schedule will be less productive due to stacking of trades and interference with other contractors.

4.10 Fabrication

The first determination must be whether to fabricate the ductwork in-house or purchase the ductwork from an outside source. There are advantages and disadvantages to both strategies. Either way, materials that are fabricated properly and delivered on time will keep crews in the field productive and working efficiently.

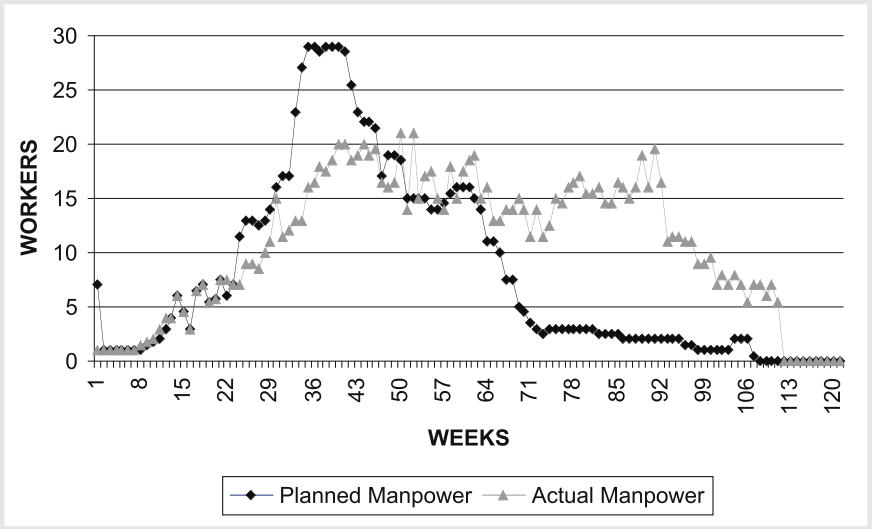

Figure 4.2: Sample Manpower Loading Chart

Activity 38. Develop Computer-Aided Drafting Shop Drawings to Identify Conflicts and Coordinate Work*

Computer-aided drafting (CAD) drawings are ideal for identifying conflicts and coordinating above-ceiling work. The ability to create three-dimensional drawings will identify duct conflicts with structural elements and other specialty contractor work. Single-line drawings provided by the engineer are not suitable for coordination or installation. Double-line drawings should be compiled from the engineer's drawings, site visits, and as-built drawings. The detailer should overlay the drawings with other above-ceiling elements to locate conflicts prior to fabrication and installation. A meeting with other above-ceiling contractors to coordinate the work and agree to a layout has proven beneficial.

The general contractor should be involved in the coordination process. One frustration sheet metal contractors have voiced is agreeing to a layout with other specialty contractors and then arriving on-site to find a free-for-all. The general contractor must enforce the layout agreed upon for the coordination to be effective. All other trades should sign off on the agreed-upon layout.

Activity 39. Identify Materials and Systems That Can Be Prefabricated

The project documents and cut sheets should be reviewed to identify prefabrication opportunities. Many contractors are or have established procedures to prefabricate all the ductwork directly from the three-dimensional CAD coordination drawings they create in Activity 38. Remodel projects, complex projects, or projects with very tight spaces may present fewer opportunities for prefabrication due to the highly complex nature of the project and systems. The amount of storage available for prefabricated material and systems must be determined to establish when fabrication can begin.

Prefabrication offers many advantages: [11]

- Saves time and money
- Reduces field labor hours and peak manpower level
- Reduces scrap at the jobsite
- Fabrication is completed in a controlled environment
- Takes advantages of advances in technology and efficient shop equipment
- Pretesting can be done in the shop
- Safety and quality are improved

Tip: Prefabrication requires a large amount of coordination to be successful. If other specialty contractors do not install their work according to the agreed-upon layout, prefabricated ductwork and systems will not fit. This will require a large amount of rework and result in a loss of many work hours and materials. If there is reason to believe the specialty contractors on this project may not follow the layout, or previous experience has shown they may not, then prefabrication may not be a benefit on this project.

Activity 40. Identify Shop Fabrication Requirements and Prepare a Schedule*

If the ductwork for the project is being purchased from an outside source, there will be no need to schedule shop fabrication time. The only requirement will be to notify the

fabricator of the necessary delivery dates. However, if the ductwork will be fabricated in-house, a fabrication schedule needs to be developed. Ductwork typically requires a large amount of storage space due to the nature of its bulkiness and size, so the majority of project sites will not have the necessary space to store large amounts of ductwork. When determining the shop fabrication schedule, the following should be reviewed:

- Delivery requirements
- Shop workload
- Other upcoming projects
- Quality requirements
- Fabrication rates
- Labor availability
- Material is in stock/delivery of required material
- Availability and lead time of specialty metals/materials
- Storage space availability
- Shop backlog

Tip: It is important to consider all other projects being completed at the company when developing the shop fabrication schedule. A project is not truly successful if it consumes all the company's resources and damages the progress of other projects.

Activity 41. Schedule Delivery of Prefabricated Materials*

Materials should be delivered to the site when they are required. Material that is delivered early requires multiple handling and additional storage space and presents an opportunity for it to be damaged. The delivery dates should be determined based on the project schedule and the availability of shop labor or the lead time provided by the fabricator. Scheduling delivery should be coordinated with the project foreman to ensure that the required materials are available when needed by the workers.

4.11 Communicating and Reporting

The majority of sheet metal construction projects do not warrant a full-time on-site project manager. This creates a situation where the person in charge of the project is isolated from the project and the daily concerns and occurrences of the work. Proper communication between the field and office management is vital to a smoothly running and successful project.

Activity 42. Identify Field Reporting Procedures and Create Project File

A standard method of communication between the project manager and the field foreman should be developed. Using one-to-one reporting, one person should be designated as the office contact and one person as the field contact. This will prevent miscommunication situations and information being lost between the field and office. The use of daily reports, disruption logs, RFIs, look-ahead schedules, and manpower requests will help ensure that all vital project information, especially delays caused by others, is shared between the field and office personnel. Form 7.8 is a sample daily construction report. In addition, the types of personal communication devices that are required for the project (cellular phones, two-way radios, fax machines, e-mail, office phone, etc.) should be identified.

Activity 43. Review Request for Information and Change Order Procedures

Provisions provided in the contract regarding changes to the contract scope, cost, and schedule should be reviewed. If none are provided, they should be added to make sure that changes are handled in a fair manner. The company standard procedure for RFI and change order procedures should be reviewed and special requirements for this project determined. What are the proper channels that the RFIs and change orders have to follow in order to be answered/approved in a timely fashion? A system allowing all team members to receive a copy of every question and answer should be developed, with no deviations from the established system allowed. If questions are asked and answered in the field, a formal RFI should still be created as a method of record keeping. Similarly, if there is a field order, a formal write-up should follow.

> **Tip:** Creating an RFI log will help keep track of the questions and answers sent and received on the project. The log will also be helpful in claims if the owner/general contractor is slow in answering questions, thereby causing delays. Form 7.9 is a sample RFI log.

Activity 44. Review Billing Procedures

The company's standard billing procedures should be reviewed to determine the proper channels the billing request must follow to receive payment in a timely fashion. The contract should be reviewed to determine how the owner/general contractor wishes to handle billing on this project. The retainage and payment terms should be noted and the billing department notified of the procedure to be used on this project, including any special forms that are to be used.

Activity 45. Prepare a Billing Schedule*

The owner or the general contractor will most likely determine the billing schedule based on the contract with the owner. Billing dates should be included on the project schedule to ensure that no billing dates are overlooked or missed.

4.12 Material-Handling Plan

A good material-handling program can save many work hours through a reduction in material-handling hours and hours spent searching the storage area for misplaced materials. The material-handling plan will also reduce time lost due to insufficient materials at the worksite and incorrectly shipped materials. Studies have shown that maximizing productivity in the shop by producing all the ductwork at one time and storing on-site ends up costing the project as a result of lower productivity in the field caused by moving duct, searching for needed pieces, and damage to stored inventory.

Activity 46. Receive Storage Approval from the Owner/GC/CM

A material storage area should be chosen where it will have a minimal effect on the efficiency of workers. It should be located as close as possible to the work area. It may be beneficial to have multiple storage areas if the project is large or there are multiple work areas. Site layout and storage are topics that should be discussed during contract negotiations. A storage space should be secured that is close to the work area and will protect materials from the weather, theft, and damage, or additional space for storage trailers should be obtained.

Tip: The New Horizons Foundation published "Tool and Material Management Systems," a guide that provides practical considerations, tactics, and processes that apply to managing tools and material.

Activity 47. Discuss Storage, Site Layout, and Handling of Materials and Systems*

The ideal storage site is one that is "organized so materials are only moved once on the project site – from the storage location to the place of installation." [12] The storage site should minimize material handling and protect materials from the weather, theft, or damage. It should be organized to prevent loss of materials and to minimize time searching for misplaced materials and located for ease of delivery and access by workers.

The office trailer/change trailer, bathroom, and material storage area should be located to minimize their distance from the work area. Figure 4.3 is the site layout triangle. [13] The design of the triangle minimizes the distances between each location and the work area. This will reduce time loss due to long travel distances as well as increase productivity.

Construction equipment required to efficiently move stored material and equipment both outside and inside the building should be identified. The equipment should be capable of moving and offloading the material efficiently, not in a piecemeal fashion.

Tip: The storage area should be sketched on a site drawing, showing how the materials will be organized and including routes for the employees to use to obtain materials and the route drivers should use when delivering materials.

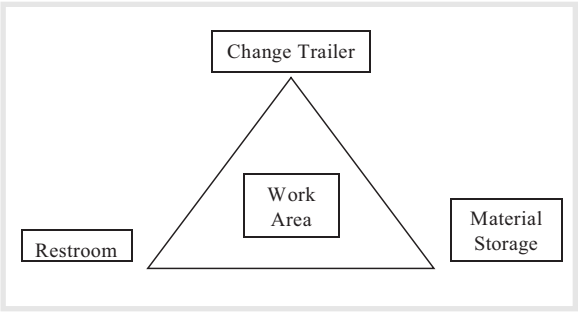

Figure 4.3: Site Layout Triangle

Activity 48. Establish Procedures for Receiving, Storing, and Handling Materials

Formal procedures should be established for receiving materials and equipment. The procedure should establish who is authorized to receive materials. Suppliers should be required to provide at least 24-hour advance notice of deliveries to the jobsite. Packing slips should be compared to what was delivered to determine if there are any shortages. The delivery should also be checked for damaged material; this way material can be reordered immediately, not when workers require the material. The used of a delivery log will simplify the process and help record deliveries. Form 7.10 is a sample equipment delivery log.

Activity 49. Identify Construction Equipment Required

The estimate should be reviewed with the foremen to determine if the construction equipment included in the budget is what is actually required. Whether the construction equipment is available in-house or if a rental equipment company will be required should be determined. The construction schedule should be reviewed to determine when the

equipment will be required and to reserve/schedule the delivery of equipment for that period. It is most efficient to use the large construction equipment the general contractor will have on-site for the few times sheet metal workers will need it to unload and install major equipment.

4.13 Construction Execution

Construction execution is the final step in preconstruction planning. It marks the end of the preconstruction effort and the start of a successful construction project.

Activity 50. Hold a Construction Execution Meeting

The construction execution meeting acts as a final turnover meeting when all the information gathered during the preconstruction process is discussed so that all team members are up-to-date on the project. This is the time to review all preconstruction activities for completeness and accuracy. Everyone involved with the project should be present during the construction execution meeting. The project team should review the:

- Project documents: Drawings, specifications, contract
- Turnover documents
- Any discoveries during preconstruction planning that may present a challenge during the project

The project planning binder, discussed in Chapter 5.3, should be reviewed during this meeting. Each member of the project team should receive a copy of the binder for future reference.

5 OUTCOMES OF PRECONSTRUCTION PLANNING

5.1 Introduction

The purpose of this research project was to develop a formal preconstruction process to be used by SMACNA contractors. As discussed earlier and shown in Table 1.1, the vast majority of contractors have some form of preconstruction planning process currently in place; however, only about 13 percent have a formal process. A formal process was defined as "a comprehensive, written process and set of guidelines, operating procedures, and checklists that are used on every project." Therefore, a formal preconstruction process will result in tangible outcomes of preconstruction planning, unlike the informal processes that result in most of the planning being done in the project manager's mind. The two outcomes of preconstruction planning are the turnover binder and the project planning binder.

5.2 The Turnover Binder

The project estimator will produce the turnover binder. The turnover binder will be used in Activity 2 to transfer project information from the estimator to the project manager, superintendent, and project foreman. The turnover binder should contain:

- Basic project information
- Project directory
- The project estimate
- Scope included in the estimate

- Preliminary project schedule including key milestones
- Special project requirements
- Questions and answers received during bid preparation

As discussed in Activity 2, a thorough project turnover is essential to a successful project. This is the time to ensure that all information is transferred between parties.

5.3 The Project Planning Binder

The project planning binder is the key result of preconstruction planning. It will contain a copy of all the documents prepared during preconstruction planning. Each member of the team should retain a copy of the project planning binder to reference during the project. The following section lists the planning activities that result in a tangible product. For example, Activity 37, "Prepare a manpower loading chart," will result in the production of a manpower loading chart to be added to the planning binder. However, Activity 28, "Inform workers and subcontractors of required safety standards," will not result in a tangible product to be added to the planning binder. The planning activities that result in a tangible product are also marked in Chapter 4 with an asterisk (*).

The following lists activities that should produce a tangible outcome and what corresponding forms should be added to the project planning binder.

Activity 2. Conduct a formal turnover/ planning kickoff meeting and site visit.

Meeting minutes from the turnover meeting should be included. The turnover meeting should result in the completion of Form 7.2, Responsibility Matrix. There will also be a turnover packet containing information from the bidding phase, including Form 7.1, Project Data Sheet.

Activity 4. Review plans and specifications.

Notes created during the scope review and a copy of the completed Form 7.3, Scope Review, should be included.

Activity 7. Create list of unknown information and prepare RFIs to convert to known information.

Copies of RFIs that have been answered and any outstanding RFIs should be included.

Activity 16. Obtain and review owner/GC/CM schedule.

A copy of the current project schedule should be included.

Activity 21. Develop a coordination schedule with other specialty contractors.

A copy of the current coordination schedule should be included.

Activity 23. Review specifications for quality requirements.

A copy of the specification folder or reference to its location should be included.

Activity 31. Order/prepare shop drawings/equipment submittals for long-lead-time items.

Copies of all shop drawings or reference to their location should be included.

Activity 32. Develop purchase orders for materials and equipment.

A copy of each purchase order should be included.

Activity 34. Create a work breakdown structure and tracking report.

A copy of the work breakdown structure and tracking report should be included.

Activity 35. Develop a sequence of work.

A copy of the color-coded drawings showing how work will progress on the project should be included.

Activity 36. Create a schedule of values.

A copy of the schedule of values should be included.

Activity 37. Prepare a manpower loading chart.

A copy of the manpower loading chart should be included.

Activity 38. Develop CAD shop drawings to identify conflicts and coordinate work.

Copies of project drawings or reference to their location should be included.

Activity 40. Identify shop fabrication requirements and prepare a schedule.

A copy of the fabrication schedule should be included.

Activity 45. Prepare a billing schedule.

A copy of the billing schedule should be included.

Activity 47. Discuss storage, site layout, and handling of materials and systems.

A copy of the site layout plan and sketch of the storage area should be included.

6 REASONS FOR SUCCESSFUL OR LESS-THAN-SUCCESSFUL PROJECT PERFORMANCE

6.1 Introduction

In order to develop a planning process that results in more successful projects, a clear definition of a successful project needed to be created. Contractors define and measure project success in many ways. The final definition used for this project was a weighted equation that included profit, owner and general contractor satisfaction, project relationships, budget success, quality, and project communication.

6.2 How the Definition Was Created

During the project interviews, the interviewees were asked to define a successful and less-than-successful project, identifying what characteristics would lead them to classify a project as successful or less-than-successful. For the most part, a less-than-successful characteristic was just the inverse of a successful project characteristic, i.e., a successful project is profitable, and a less-

than-successful project is not profitable. Figure 6.1 shows the results of this portion of the interview. These factors were used to weigh projects and determine what planning activities resulted in more successful projects.

6.3 Successful versus Less-Than-Successful Projects

In Phase 3 of the research, two interviews were completed at each of 19 companies. The interviews reviewed two projects recently completed by the company, one a successful project, and one a less-than-successful project. During the less-than-successful project interview, the interviewee was asked why the project did not go well. Occasionally there were multiple reasons, but mostly the interviewee could pinpoint one key reason why the project went poorly. The reasons could be broken into three different categories: (1) poor project management, (2) site issues, and (3) early warning characteristics.

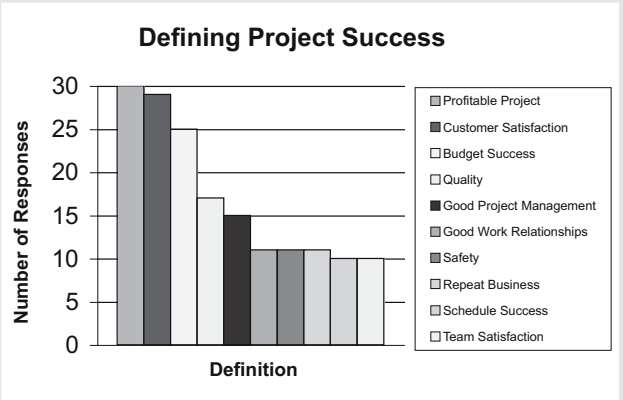

Figure 6.1: Contractor's Definition of a Successful Project

6.4 Early Warning Signs for Less-Than-Successful Project Performance

Early warning signs for less-than-successful project performance are project characteristics known at the start of a project, which should be recognized as increasing the possibility of poor project performance. When the company encounters a project with one or more of these characteristics, additional emphasis should be placed on planning to neutralize the characteristic. An example of an early warning sign is, "Missing part of the project scope." At the start of the project, it is known if only three of the four air-handling units were included in the bid. Missing an air-handling unit in the bid will most likely lead to a poor performing project. Early warning signs uncovered during the interviews included:

- Missed part of project scope
- Did not set up project tracking system
- Insufficient turnover between estimator and project manager
- Prime contractor did not include others contractors in preconstruction planning
- Taking on a larger project that company was capable of completing
- Taking on a project in a location (town) where they were not experienced or that was far from the home office
- Poor above-ceiling coordination with other subcontractors
- Owner was not familiar with the construction process

6.5 Other Reasons for Less-Than-Successful Project Performance

Below is a list of other reasons provided by contractors for poor performance on their project.

- Poor sequencing of the work
- Late equipment deliveries
- Shifting manpower between projects
- Shifting leadership between projects
- Stacking of trades due to poor scheduling
- Poor material-handling procedures
- Lack of communication between the foreman and project manager
- Project appeared to be easy; therefore, no effort was put into preconstruction planning
- Project manager did not believe in necessity to plan; therefore, preconstruction planning was nonexistent
- Duct rerouting was not approved, thus requiring duct to be removed and installed as shown on drawings
- Accelerated schedule
- Adversarial relationships
- Poor team selection

7 SAMPLE FORMS

7.1 Table of Sample Forms

Form 7.1 Sample Project Data Sheet

Form 7.2 Responsibility Matrix

Form 7.3 Sample Scope Review

Form 7.4 Sample Three-Week Short-Interval Schedule

Form 7.5 Sample Safety Checklist

Form 7.6 Sample Submittal Log

Form 7.7 Sample Labor Tracking Report

Form 7.8 Sample Daily Construction Report

Form 7.9 Sample Request for Information Log

Form 7.10 Sample Delivery Log

PROJECT DATA SHEET

PROJECT INFORMATION			
Project Name:		Adress:	
Project #:		City:	
Project Manager:		State:	
Contract Type:		Zip:	
Project Description:		Start Date:	
		Finish Date:	

KEY PROJECT MEMBERS					
TRADE	COMPANY	CONTACT	PHONE	FAX	EMAIL
Owner					
General Contractor					
Architect					
Mechanical Engineer					
Plumbing Contractor					
Electrical Contractor					

SUBCONTRACTORS					

SUPPLIERS					

OTHER					

Form 7.1: Sample Project Data Sheets

PLANNING RESPONSIBILITY MATRIX

Project Name:

Project Number:

Preconstruction Activity	Director of Operations	Project Manager	Project Engineer	Estimator	Superintendent	Foreman	Safety Director	Detailer	Purchasing	Controller
PLANNING KICKOFF										
1. Select key team members										
2. Conduct a formal turnover/planning kickoff meeting and site visit										
3. Review lessons learned from previous projects										
SCOPE REVIEW										
4. Review plans and specifications										
5. Review general and supplementary conditions										
6. Identify special requirements										
7. Create list of unknown information and prepare RFIs to convert to known information										
8. Review the signed contract										
VALUE ENGINEERING										
9. Identify and price substitute materials and equipment										
10. Submit substitution request to owner/GC/CM										
11. Discuss alternative duct routes and material										
12. Identify potential cost savings										
SUBCONTRACTING										
13. Review subcontractor bids, qualifications, and current work load										
14. Review scope of work with subcontractors										
15. Write contracts for selected subcontractors										
DETAILED SCHEDULING										
16. Obtain and review owner/GC/CM schedule										
17. Identify mobilization/demobilization dates										
18. Identify and establish delivery dates for long-lead-time items										

Form 7.2: Responsibility Matrix

PLANNING RESPONSIBILITY MATRIX

Project Name: Project Number: Preconstruction Activity	Director of Operations	Project Manager	Project Engineer	Estimator	Superintendent	Foreman	Safety Director	Detailer	Purchasing	Controller
DETAILED SCHEDULING cont.										
19. Identify construction equipment delivery dates										
20. Identify work by others that directly impacts sheet metal activities										
21. Develop a coordination schedule with other specialty contractors										
22. Establish sheet metal subcontractor start/finish										
QUALITY AND SAFETY PROGRAMS										
23. Review specifications for quality requirements										
24. Inform workers and subcontractors of required quality standards										
25. Review safety lessons learned from other projects										
26. Review safety and OSHA requirements										
27. Walk the site to search for hazards before construction begins										
28. Inform workers and subcontractors of required safety standards										
PROCURING MATERIALS, EQUIPMENT, AND TOOLS										
29. Determine long-lead-time items										
30. Contact material and equipment suppliers										
31. Order/prepare shop drawings/equipment submittals for long-lead-time items										
32. Develop purchase orders for materials and equipment										
LABOR BREAKDOWN										
33. Review estimated work hours										
34. Create a work breakdown structure and tracking report										
35. Develop a sequence of work										
36. Create schedule of values										
37. Prepare a manpower loading chart										

Form 7.2: Responsibility Matrix Continued

PLANNING RESPONSIBILITY MATRIX

Project Name:

Project Number:

Preconstruction Activity	Director of Operations	Project Manager	Project Engineer	Estimator	Superintendent	Foreman	Safety Director	Detailer	Purchasing	Controller
FABRICATION										
38. Develop CAD shop drawings to identify conflicts and coordinate work										
39. Identify materials and systems that can be prefabricated										
40. Identify shop fabrication requirements and prepare a schedule										
41. Schedule delivery of prefabricated materials										
COMMUNICATION AND REPORTING										
42. Identify field reporting procedures and create project file										
43. Review request for information and change order procedures										
44. Review billing procedures										
45. Prepare a billing schedule										
MATERIAL HANDLING PLAN										
46. Receive storage approval from owner/GC/CM										
47. Discuss storage, site layout, and handling of materials and systems										
48. Establish procedures for receiving, storing, and handling materials										
49. Identify construction equipment required										
CONSTRUCTION EXECUTION										
50. Hold a construction execution meeting										

Form 7.2: Responsibility Matrix Continued

SCOPE REVIEW CHECKLIST

Project Name: _____

Project #: _____

Project Manager: _____

Completed	Who Furnishes?	Who Installs?	Item
☐			Access doors/panels
☐			Air balance
☐			Clean up
☐			Condensate drain
☐			Control dampers
☐			Control valves
☐			Control wiring
☐			Control conduit
☐			Control wiring between smoke detectors & units
☐			Crane
☐			Cutting and patching
☐			Demolition and removal
☐			Electric motors
☐			Electric starters/disconnects
☐			Excavation and backfill
☐			Gas piping
☐			Hoists for personnel
☐			Hoists for materials
☐			Interior layout
☐			Louvers
☐			Painting
☐			Roof curbs
☐			Site access
☐			Site surveying
☐			Smoke detectors
☐			Temporary utilities
☐			Variable frequency drives (VFDs)
☐			Welding

Misc. Notes

Form 7.3: Sample Scope Review

THREE-WEEK SHORT-INTERVAL SCHEDULE

Project Name:
Project #:
Date Issued:
Page ___ of ___

No.	Activity Description	Week 1 Monday's Date:						Week 2 Monday's Date:						Week 3 Monday's Date:						Requirements
		M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
1																				
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
13																				

Form 7.4: Sample Three-Week Short-Interval Schedule

JOB SITE SAFETY CHECKLIST

Project Name: _____

Project #: _____

Checked By: _____

		Description	Yes	No	N/A	Comment
1		Adequately lighted work areas				
2		All electrical equipment grounded				
3		Bloodborne pathogens program in place				
4		Clean work areas				
5		Combustible scrap and debris removed regularly				
6		Competent person present when scaffold erected				
7		Confined space entry procedures in place				
8		Ear plugs				
9		Electrical cords properly color coded				
10		Electrical dangers posted				
11		Emergency phone numbers posted				
12		Fall protection systems				
13		Fire extinguishers available				
14		First aid kit available				
15		Flammable liquid storage				
16		Floor hole covers				
17		Gas cylinders secured and stored properly				
18		Ground fault circuit interrupters (GFIs) in use				
19		Handrails and stair rails				
20		Hard hats				
21		Holes barricaded/perimeters guarded				
22		Ladders and scaffolding in good conditions, railings				
23		Ladders tie-off				
24		Lifelines/safety belts/harnessed lanyards				
25		Material safety data sheets (MSDS) on site				
26		OSHA notices posted				
27		OSHA reporting forms on site				
28		Personal protective equipment				
29		Powder actuated tool certification				
30		Proper clothing				
31		Proper lockout/tagout procedures				
32		Safety glasses worn				
33		Shoring for excavations				
34		Stairways clear of trash and hazards				
35		Tool box/tailgate safety meetings				
36		Tools/equipment inspected regularly				
37		Torches and hoses checked				
38		Traffic control signs and barricades				
39		Worker trained in first aid on-site				
40						
41						

Form 7.5: Sample Safety Checklist

SUBMITTAL TRACKING LOG

Project Name: ____________

Project #: ____________

Project Manager: ____________

Equipment Information						Submittal Information						
Sub No.	P.O. No.	Spec Section	Equipment	Supplier	Shop Dwg Received	Date to Architect	Date Return Requested	Date Returned	Approval Code*	Returned to Supplier	Expected Ship Date	Date Shipped

*A-approved, AN-approved as noted, RR-revise and resubmit, and R-rejected

Form 7.6: Sample Submittal Log

JOB TRACKING REPORT

Project Name: _____

Project #: _____

Project Manager: _____

	Estimated	Actual	% Comp	Earned Hours	Projected Remaining	Projected Final	Projected Over or Under
Project Management							
Hours	300.00	135.00	50.00%	150.00	135.00	270.00	(30.00)
Sheet Metal Field Labor - General Exhaust							
Hours	2000.00	950.00	50.00%	1000.00	950.00	1900.00	(100.00)
Sheet Metal Field Labor - Low Pressure Duct							
Hours	2000.00	500.00	20.00%	400.00	2000.00	2500.00	500.00
Sheet Metal Field Labor - High Pressure Duct							
Hours	5000.00	3000.00	70.00%	3500.00	1285.71	4285.71	(714.29)
Sheet Metal Shop Labor							
Hours	700.00	600.00	95.00%	665.00	31.58	631.58	(68.42)
Job % Complete		**57.15%**					
Performance Factor		**1.10**					

Estimated = Estimated workhours from estimate (activity level)

Actual = Actual hours from time sheets

% Comp = Foreman and Project Managers estimated % Complete for that portion of work

Earned Hours = Estimated x % Comp

Projected Remaining = Projected Final - Actual

Projected Final = Actual / %Complete

Projected Over or Under = Projected Final - Estimated

Job % Complete = Σ Earned Hours / Σ Estimated

Performance Factor = Σ Earned Hours / Σ Actual Hours

Form 7.7: Sample Labor Tracking Report

DAILY CONSTRUCTION REPORT

Job Name: _____

Job Number: _____ Date Prepared: _____

Job Location: _____ Prepared By: _____

1. Weather:

Temperature: _____ °F Conditions: _____

Did weather affect work? _____

2. Site Manpower:

	Quantity	Hours
Foremen		
Journeymen		
Apprentices		
Laborers		
Other		

Subcontractors:			Quantity	Hours

3. Work Completed: _____

4.

Equipment				Hours

Equipment				Hours

5. Extra Work: _____

6. Deliveries Today (PO #, Ref #): _____

7. Job site meeting today: Yes: ☐ No: ☐
Important items from meeting _____

8. Note any safety incidents and attach any forms: _____

9. Delays or lost time, hindrances, deals, problems with other trades: _____

10. Other Comments: _____

Form 7.8: Sample Daily Construction Report

REQUEST FOR INFORMATION LOG

Project Name:

Project #:

Project Manager:

RFI No.	Description	Reference Documents	Sent to	CC	Date Submitted	Requested Return Date	Date Returned	Comments

Form 7.9: Sample Request for Information Log

DELIVERY LOG

Project Name: ____________

Project #: ____________

Project Manager: ____________

#	Date	PO Number	Number of Pieces	Received by	Damaged or Back Ordered	Packing Slip Number	Comments
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

Form 7.10: Sample Delivery Log

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Awad S. Hanna is a professor and chair of the construction engineering and management program at the University of Wisconsin – Madison, Department of Civil and Environmental Engineering. Dr. Hanna holds M.S. and Ph.D. degrees from Penn State University and is a Register Professional Engineer in the United States and Canada. An active construction practitioner, educator, and researcher for over 30 years, he has taught construction management courses at Penn State University; Memorial University of Newfoundland, Canada; and the University of Wisconsin – Madison. Dr. Hanna has conducted several research projects for the New Horizons Foundation, including landmark studies on the cumulative impact of change orders on sheet metal contractors' labor productivity, schedule compression and acceleration, and preconstruction planning. Dr. Hanna has conducted research for other national organizations including the Electrical Contracting Foundation, Mechanical Contracting Foundation, Construction Users Roundtable (CURT), and the Construction Industry Institute (CII). In 2006, he received the prestigious CII outstanding researcher award. Dr. Hanna has taught more than 300 successful seminars and workshops in more than 35 states on topics such as change order impacts, project scheduling, earned value analysis, labor productivity, construction delay claims, schedule compression, and preconstruction planning.

Dr. Hanna is also a national consultant helping many contractors develop strategies to recover productivity losses related to change orders, acceleration and compression, delay, and trade stacking.