

Achieving Spatial Coordination Through BIM

A Guide for Specialty Contractors

David E. Quigley

*A publication jointly developed by
MCAA, NECA, and SMACNA*

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Dedication

In memory of the many fathers and grandfathers who have passed their love and passion for their trade to their children. . .

And with great admiration and in loving memory of my father, who passed it to me.



*Robert Howard Quigley 1916–1987
President, R.G. Harrington Inc.
Plumbing and Heating Union Shop
Ware, Massachusetts*

Table of Contents

FOREWARD	vii
INTRODUCTION.....	viii
CHAPTER 1 Spatial Coordination in a BIM Environment	1
CHAPTER 2 BIM and Spatial Coordination Basics.....	11
2.1 Project Delivery Methods	11
2.2 Types of models.....	12
2.3 Types of software.....	15
2.4 Level of Development Specifications.....	16
CHAPTER 3 Building the Team.....	19
3.1. Building an Effective Spatial Coordination Program	19
3.2. Preparing Your BIM Implementation Plan	20
3.4 Internal Inventory of Skills	25
3.5 Internal Communication Procedures	28
3.6 Human Resource Requirements	32
3.7. Outsourcing	33
3.8 Working Within the Collaborative Process	37
CHAPTER 4 BIM Execution Plans	39
4.1 The Contents of a BIM Execution Plan.....	39
4.2 Model Management Procedures.....	52
4.3 Schedules.....	59
4.4 Reviewing a BIM Execution Plan.....	61
4.5 Authoring a BIM Execution Plan	65
CHAPTER 5 Managing the Process	67
5.1 Establishing Norms for the Project	67
5.2 Setting Up the Project Environment	70
5.3 Clash Detection.....	75
5.4 Red Flags from the Coordination Process.....	83
CHAPTER 6 Documents of Record.....	85
6.1 Working with Documents of Record.....	85
6.2 Receivables from the Design Team	86
6.3 Internal Receivables from Your Project Team	90
6.4 Inter-Trade Receivables	91
6.5 Other Receivables.....	93
6.6 Deliverables	93
6.7 Communication with the Design Team.....	98
6.8 Managing Documents During the Coordination Process.....	100

Table of Contents

CHAPTER 7 Benefits of BIM Beyond Spatial Coordination	103
7.1 By-Products of Spatial Coordination Data.....	103
7.2 Improving Project Management.....	107
7.3 Aligning Company Databases	112
CHAPTER 8 Evaluating Spatial Coordination Contract Language.....	115
8.1 Reviewing Spatial Coordination Contractual Requirements	115
8.2 Specific Legal Considerations Concerning Spatial Coordination .	118
8.3 Spatial Coordination Related Provisions for Consideration	122
8.4. Other Important Industry Contract Reference Material:	
ConsensusDocs.org.....	127
CHAPTER 9 BIM Technologies for an IT Infrastructure	129
9.1. What is an IT Implementation Plan?.....	129
9.2 Hardware Specifications	133
9.3 Software Requirements	134
9.4 Types of Software Used in Spatial Coordination.....	135
9.5 Stand-alone vs. Network-Based Licensing	140
9.6 Software Versioning and Upgrades.....	141
9.7 Making the Right Decision for Your Firm	145
ACKNOWLEDGEMENTS	147
APPENDIX A: Examples of Internal Deliverables	151
APPENDIX B:	
An Outline for Developing a BIM Implementation Plan	153
APPENDIX C: Scrubbing a Design-Intent Model.....	156
APPENDIX D: Industry References and Software	160
GLOSSARY	164

Foreword

*By Steve Shirley
Chairman, MCAA
BIM Committee*

Having been involved in the mechanical contracting business for the past 40 years and with Building Information Modeling for more than a dozen, I've had a unique opportunity to be part of the transformative, game-changing process that technological innovations have brought to the design and construction industry. I do not doubt that BIM is bringing the power of the digital age to an industry overlaid with inefficiencies yet full of opportunities for improvement.

Driven by facility owners who have recognized that using these new technologies and associated processes will ultimately reduce their construction risks, the U.S. contracting industry has finally embraced the vision of what BIM can do and has "turbocharged" its adoption. Industry stakeholders who cling to entrenched ways of doing business are finding themselves at odds with owners and clients who are looking to use collaborative BIM to eliminate waste and duplication of efforts while holding everyone accountable for the timeliness and quality of their work products. It's a new game in so many ways. Change can be difficult and true progress can be even more challenging. Relinquishing familiar ways to face a new and uncertain future can be daunting, but the industry is moving ahead. The choice is to embrace progress or be left behind.

MEP contractors have been some of the greatest beneficiaries of this revolution and some of its biggest victims. The frontline of this BIM revolution has been the virtual building-systems spatial coordination process. What was once an exercise by a small cadre of professional craftsmen has grown into a major production, involving numerous stakeholders with a multitude of ideas and approaches. Even the smallest MEP contractors must be vigilant in recognizing and adapting to the forces in play. With the emergence of BIM, old standards and procedures and previously-held "rules of thumb" simply don't apply any longer.

As MEP contractors, we are constantly challenged with new rules and requirements from clients with differing understandings and expectations relative to BIM. For MEP contractors new to the BIM environment, the spatial coordination process can seem overwhelming, and little guidance or assistance has been available to help along the way. Achieving MEP Spatial Coordination through BIM is focused on bridging this gap. It is the work of a great number of individuals in the MEP industry, from hands-on practitioners to managers, consultants, and CEOs. It is not a "how-to" manual but rather a "take this into consideration" set of guidelines. Organized to address some of the most important current elements of BIM associated with spatial coordination, this Guide also recognizes that these elements will continually change to meet the demands of business.

I am confident that this Guide will prove to be helpful in educating MEP contractors on the challenging and expanding demands upon our industry. I applaud the MCAA, SMACNA, and NECA for recognizing that the BIM revolution is transforming the industry and thank them for generously providing the structure and resources to develop this Guide.

Introduction

My father was a Master Plumber. He owned and operated a mid-sized union plumbing and heating firm in western Massachusetts for almost 40 years. He had me cutting and threading pipe when I was 8, welding at 15, and pre-fabricating sprinkler systems at 17. At 18, I became a union plumber.

As much as I loved working with my father, I felt I had another calling—teaching and computer technology—which I pursued with his full support.

The path I followed for the next 35 years gave me a unique perspective on the power of innovation and technology standards to transform an industry. I was active in the development of three industry standards. The first was the initiative of the U.S. Defense Department to create a single universal programming language aimed at reducing the cost of development and maintenance for large defense projects (air, land, and sea). The second was the creation of a graphical user interface standard for the UNIX operating system. This open standard made it possible to use software applications on many different hardware platforms, eliminating the redundant work required to support them all. The third was a de facto industry standard from Microsoft to increase software developer efficiencies by utilizing standard, “intelligent” objects within an object-oriented design.

In each case, a large and influential entity—the U.S. government, a consortium of the largest computer manufacturers, and the world’s largest software publisher—invested significant resources, money, and reputation over a long period of time to achieve the same goal: removing the barriers to communication between programs and people. Each recognized that without the intervention of a standard and defining sets of rules for communicating and sharing data; people to people; people to software and software to software, the inefficiency and duplication of effort inherent in following the status quo would grind innovation in these industries to a halt.

Does this sound familiar? The building services industry has been struggling with the same issues and is now in the process of adopting its industry standard—Building Information Modeling—designed to address the same requirements for better communications, defining reasonable rules for engagement, setting reliable expectations, and improving the construction workflow through innovation.

To date, the acceptance, growth, and implementation of BIM across the construction industry is still in its infancy. To understand how, why, and at what rate standards are adopted, the work of Everett Rogers, a world-renowned innovation researcher, is helpful. Rogers identifies five qualities that can be used to predict the adoption of an innovation through an industry and its constituencies.

1. Relative advantage: The degree to which an innovation is perceived as better than the idea it supersedes by a particular group of users, measured in terms that matter to those users or perceived as advantageous

2. Compatibility with existing values and practices: The degree to which an innovation is perceived as being consistent with the values, past experiences and needs of potential adopters

INTRODUCTION

3. Complexity or better described as simplicity and ease of use: The degree to which an innovation is perceived as difficult to understand and use

4. Trial-ability: The degree to which an innovation can be experimented with on a limited basis

5. Observable results: The easier it is for individuals to see the results of an innovation the more likely they are to adopt it*

If you replace “an innovation” with “BIM”, you have a fairly accurate description of why BIM is beginning to take hold throughout the building services industry and within each of its stakeholder constituencies. This is especially true for MEP contractors, who tend to be more pragmatic and need to see results before embracing an innovation. First, in reference to Roger’s quality of “relative advantage,” MEP contractors who have adopted BIM methodology and technologies would never go back to the old way of construction; the benefits outnumber any limits or constraints. Second, as they gain more experience, contractors have found that BIM is indeed “compatible with existing values and practices.” Their roles and responsibilities are enhanced, and they are recognized as major contributors to the construction process. Third, BIM and its technologies are not difficult to incorporate into the existing workflow, which the success of the early adopters demonstrates. Fourth, in regard to “trial-ability,” most software technologies in this practice make trial versions of their software available to potential customers. Fifth, the observable results are in. The majority of the early adopters have gone to great lengths to measure their results, and keeping in mind that nothing in life is perfect, the results are largely positive. Those contractors improved on each project, which strengthened their commitment to continue with BIM.

Well-run BIM projects eliminate waste and reward the many skills required to plan and perform the work. Contractors remain 100% accountable with their contract deliverables, which, in turn, are reliable and accurately reflect what will be manufactured and built. The BIM Forum’s Level of Development Specification** also provides a standard reference for the completeness and content of project model elements, which also clarifies expectations and improves communication; when a coordination team receives an LOD 350 or LOD 400 model from a contractor, they know it contains exactly what they expect. Nasty, expensive, last-minute surprises are infrequent and all but eliminated.

* Everett Rogers, *Diffusion of Innovations*, 5th ed. (New York: Free Press, 2003), pp. 15–16.

** Level of Development Specification ©2013 by BIMForum

INTRODUCTION

BIM is a better way to build. From what I've seen in my work on standards, BIM is here to stay. If you have been waiting on the sidelines, now is the time to engage, because there is no turning back. Those MEP contractors who embraced this innovation early have learned much from their many BIM projects that can be of value to you. That information is available in this Guide.

The changes that BIM introduced support the fundamental motivation of every steam and pipe fitter, tin knocker, electrician, and specialty contractor: the pride in a job well done. It is also worth noting that these early adopters consistently bring their best game to the table. It is my hope that other domains in the building process will rise to the occasion by bringing their A-game to their LOD commitments, joining the MEP and specialty contractors who are already pushing the industry to new levels.

*David E. Quigley
Milford, New Hampshire
October 2013*

Chapter 1

SPATIAL COORDINATION IN A BIM ENVIRONMENT

The goal of the construction spatial coordination process is to integrate physical objects, components, and systems into the architectural spaces allocated in the contract documents. In the last 30 years, the tools and processes used for spatial coordination have evolved dramatically. The construction industry has adopted new technology—Building Information Modeling, or BIM—that presents an opportunity for MEP contractors to perform spatial coordination with a greater degree of accuracy and collaboration.

This chapter presents a brief history of spatial coordination within the MEP and specialty contractor segment of the construction industry. This is valuable for anyone who wants to better understand what led up to spatial coordination and 3D modeling using BIM. It then describes how BIM has changed the building industry and what is required of companies that want to respond to those changes. Finally, the chapter describes what the rest of Guide covers and some different ways to use it.

- **1.1 The History of Spatial Coordination** [on page 1](#)
- **1.2 The Traditional Drafting and Coordination Process** [on page 2](#)
- **1.3 Building with BIM** [on page 4](#)
- **1.4 Using This Guide** [on page 8](#)

1.1 The History of Spatial Coordination

For more than 50 years, spatial coordination drawings have been Documents of Record for most major commercial building projects (Figure 1.1 [on page 3](#)). These drawings were the product of an iterative review of contractors' installation and shop drawings to identify how and where these systems interfered with each other and with the structure. A small team of representatives from each contractor performed this coordination, carefully reviewing and revising their drawings and realigning them as needed. When they were satisfied that they had eliminated all the "clashes," they submitted their final drawings to the Design Teams for review and approval.

The submission of these coordination drawings was often a major milestone on many projects. Often, MEP contractors could not begin fabrication and installation until the Owner, Construction Manager, Architect, and Engineer of Record had signed off on them. This exercise was one of the measures taken to ensure that the participating contractors were providing some level of coordination and to give the designers assurance that the contractors were following their design intent.

Yet, despite painstaking efforts by professionals in the field, these drawings were rarely able to eliminate all MEP problems and interferences. The discrepancies presented many contractors with very costly challenges, especially when design-related issues were being resolved concurrently with coordination and construction.

The enhanced tools now available to MEP contractors and the industry in general, in particular Building Information Modeling, have significantly changed the processes and improved the results of these coordination efforts. BIM has also brought new opportunities and challenges.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

1.2 The Traditional Drafting and Coordination Process

The traditional MEP contractor's drafting and coordination activities began with the receipt of drawings and specifications from the Engineers of Record. MEP detailers would then enhance or re-create the information contained in these documents with additional detail needed for their installation, shop drawing, and submittal approval processes.

MEP engineers usually followed an iterative process of establishing their design performance requirements. They selected preferred system profiles, coordinated these selections with the Architects and structural and other specialty engineers, chose the equipment to use as the basis of their designs, and performed necessary calculations to meet the criteria for system performance and compliance with the building code. Then they initiated a drafting program to capture all this information and also provide some level of design coordination to ensure that their designs could be constructed and would fit within the allocated spaces in the structure.

1.2.1 2D Drafting and Coordination

When the drafting and coordination processes were done solely on paper, the engineering drawings restricted the display of MEP-related systems to a single-line format or reflected these systems in a double-line format but without adequate coordination by the Design Team. In almost every case, these drawings could reflect only the MEP equipment and products used as the basis of the design, not the products actually purchased. In addition, much of the critical information, including graphical representations relating to equipment or important components, could not be adequately presented in a drawing and was often buried in the written specifications and notes on the drawings—or was simply ignored. Incidental items, such as hangers and the routing of conduit, were usually left for the contractors to coordinate among themselves.

Because the design engineers' selections and specifications were based on performance criteria, MEP contractors usually had to work prescriptively to purchase and install their products to fulfill their contractual obligations. Design engineers, to avoid the appearance of anticompetitive practices and any associated legal problems, would permit multiple options for equipment or product selections that all would satisfy their performance requirements, but they would draft and coordinate only to their first choice. The responsibility for modifying and coordinating products that were not the basis of the design into the drafting and coordination efforts fell to the installation MEP contractor. Adjustments for size, weight, fit, access, and maintenance were common.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

The professional draftsmen employed by MEP contractors, many with trade knowledge acquired over many years, tackled the construction coordination process with only their individual aptitudes for 3D visualization, their light tables, and their common desire to avoid problems and clashes for the installation crews. An experienced, technically proficient MEP coordinator could anticipate and resolve thousands of clashes, yet it was and still is beyond the capacity of any human being to fully visualize, from plans and even 3D drawings, the complexity of all building systems. It was not possible for anyone to detect all potential physical interferences, recognize the optimum installation routing and sequence, determine whether every required clearance or tolerance had been provided for, and meet tight schedules and budgets.

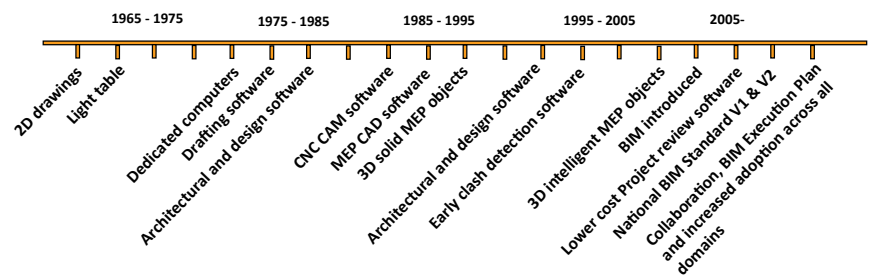


Figure 1.1 History of Spatial Coordination and the MEP Contractor

1.2.2 3D Drafting and Coordination

In the late 1980s, the price and capabilities of computer-aided design (CAD) technology had reached the point where the commercial construction industry began to adopt computerized drafting and modeling. These enhanced 3D renderings of 2D drawings represented a significant improvement in quality and accuracy, and the technology was embraced early by MEP contractors, structural steel designers and fabricators, and a few enlightened architects. The balance of the commercial construction industry continued to use 2D drafting and coordination processes.

Although early CAD software represented MEP components as solid objects, the ability to shape, route, and adjust MEP work products was a big improvement over traditional processes, one that justified the considerable investment. The adoption of CAD also provided the transition for many knowledgeable craftsmen to a new tool: the computer.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

1.3 Building with BIM

During the early to mid-2000s, Building Information Modeling migrated from Europe and from other industries to the U.S. construction industry. Most contractors viewed it as “3D detailing on steroids.”

They did not anticipate that this new technology would revolutionize both the industry and their business processes. Some jumped in only when their clients demanded it or simply to stay “in the game.” What most didn’t recognize was that BIM instigated the open exchange of digital information that had already overwhelmed other industries.

This disruptive innovation caught many MEP contractors totally off guard. New expectations brought new consequences. New players were now involved; these first-time stakeholders, who didn’t know the old rules, had bigger expectations. Some MEP firms were selling services they could not perform adequately; learning curves were ignored. Chaos seemed to reign, and in some areas, it still does. BIM did more than put new technical capabilities in the hands of designers and contractors; it thrust completely new social dynamics upon an industry that was not prepared for it. Also destroyed when the paradigm shifted were long-utilized budgets and resource allocation tools that MEP contractors had rolled into their concept of detailing.

The game had changed—but how?

The BIM models contain far more information than the 3D CAD models did just a few years ago. The objects used in CAD models can describe the size, shape, and location of the system components. To this basic geometry, the objects in BIM models can add the manufacturer, the SKU number, the price, the weight, product options, special instructions and maintenance information. And you can easily add other manufacturer-specific information to BIM model objects, for example, spec sheets and hyperlinks. The biggest change is that the demand for information begins much earlier in the project. Instead of identifying issues (coordination or design) through the construction cycle, they are now identified in the coordination phase. Project Teams, and not just detailers, must engage much earlier—Project Managers, Project Engineers, design professionals, and site foremen.

1.3.1 Incorporating BIM into the Spatial Coordination Process

As it has taken hold, BIM has brought new opportunities to the design and construction industries. Its importance, usefulness, and potential is widely recognized. The McGraw Hill Smart Market report in [Figure 1.2 on page 5](#) indicates that by 2009, BIM had become a big deal.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

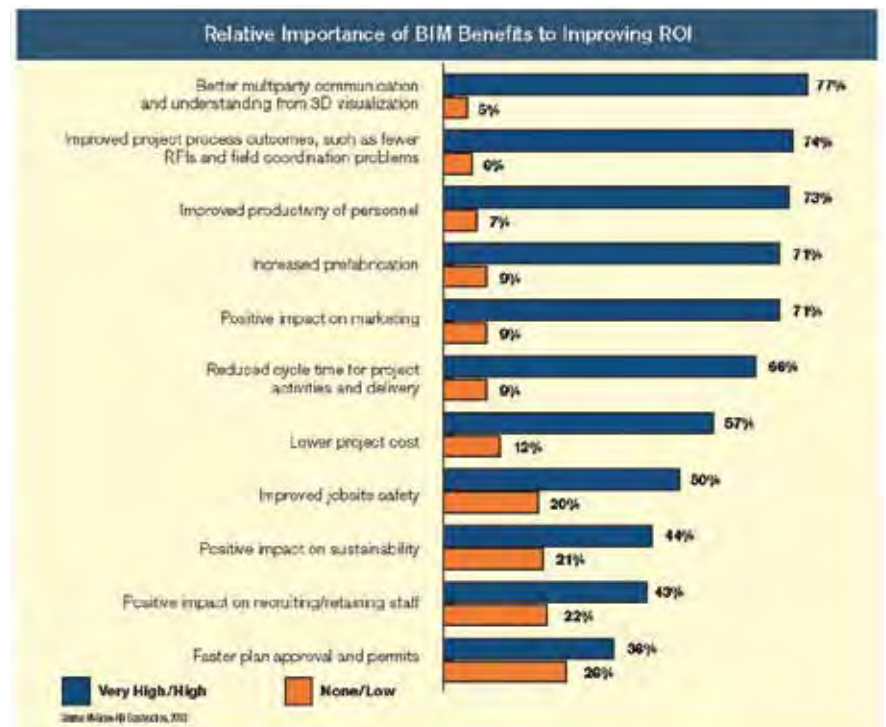


Figure 1.2 McGraw-Hill Market Research, 2009*

The adoption of BIM has also brought new challenges. The biggest one MEP contractors face is in the area of spatial coordination. In this arena, all industry stakeholders are confronting new business demands and expectations, adopting new business practices, discarding or changing old means and methods, and learning to play a new game.

The BIM models reveal what the MEP coordinator in the traditional process cannot see: the full complexity of the building and its systems from different perspectives in three dimensions.

The use of BIM technology makes it possible to generate virtual models of the building and its systems.

When changes are made, the models can be regenerated quickly, making any ripple effects evident immediately.

It is not easy to execute the processes and make the changes that will bring the most value from these powerful tools. BIM builds on the knowledge and skills that have made MEP contractors successful. To be successful on BIM projects, MEP contractors need to approach spatial coordination, and ultimately the way they do business, differently.

*McGraw Hill Construction, *The Business Value of BIM in North America*, 2009. Printed with permission.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

The new game has the same objective as the old game: to construct a building on time, on budget, and up to code. But, the new game demands players who can deal with a myriad of new people in new roles and with what frequently seems like an overwhelming amount of data.

1.3.2 Clear Lines of Communication

Large volumes of information must be gathered and shared. All members of the Coordination Team, (who are called “Project Participants” in this Guide) must communicate effectively with each other and within their own companies, both to obtain, confirm, question, analyze, and modify information used for the project and to recognize the needs, actions, and consequences of their participation on the project.

Project Participants must learn to speak a common language. For example, what “the Model” refers to is understood differently by different people, and without realizing it, Project Participants can be talking past each other.

1.3.3 The Technical Skills and Experience of the Project Participants

With BIM, the distinct realms of knowledge, expertise, and responsibility of design engineers and MEP contractors have not changed; engineers remain responsible for design, and contractors remain responsible for construction-coordinated installation. However, to participate effectively, MEP contractors need to acquire a level of modeling skill that is equal to, or greater than, that of engineers. MEP contractors need to create models with the accuracy and detail required to coordinate their systems and products within allocated spaces, to lay out and insert decks and walls for sleeves and inserts, to prefabricate components racks and assemblies, and to provide the installation crews with the information and references they will need to efficiently install their systems.

1.3.4 The Social Skills of the Participants

In a BIM environment, constructive working relationships and the interpersonal skills that build and nurture them matter more than ever. Coordination remains a collaborative process, but the team of contractors with field experience and technical knowledge now includes stakeholders with different skills and levels of understanding. Inexperienced but computer-savvy individuals can be put in charge of large and complex projects. To accomplish assigned tasks, your Project Team must be able to work with a broad range of personalities whose agendas may conflict.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

1.3.5 An Understanding of the Responsibilities and Roles of All Participants

The MEP contractors who have pioneered BIM warn of a persistent difficulty: lack of clarity about the roles and responsibilities, details and definitions, and the internal processes of the Coordination Team. The fog rolls in from vague or arbitrary statements in the documents or when critical roles have not been assigned.

In a Design-Bid-Build contract environment, the spatial coordination process is usually led or managed by the Construction Manager or General Contractor. However, the primary installation contractors perform most of the actual work. Any Coordination Project must assign the critical roles and responsibilities to specific individuals or firms. When expectations about the scope of responsibility and commitments are not clear to all before the project begins, the exposure to risk and higher expenses for MEP contractors can increase significantly.

1.3.6 A Clear Set of Expectations and Deliverables

To establish reasonable expectations for the scope of the work by an MEP contractor on a BIM project, the three major MEP trade associations (MCAA, SMACNA, and NECA) approved a definition of “normal and expected spatial coordination.”

This is the summary from that definition:

Spatial Coordination using 3D Modeling is a cooperative and collaborative effort among the design professional, owner, general contractor or construction manager and the trade contractors. Normal and expected spatial coordination performed by the trade contractors after the execution of a contract is not design. Rather, it is the reflection of the design in a three-dimensional model. Trade contractors rely on complete and accurate designs when bidding projects in order to provide accurate bid pricing. In return, trade contractors, such as those represented by the MCAA, SMACNA and NECA, using that design, are able to produce reliable models by which the project can be constructed in a more efficient, timely and cost effective manner.

It is important to recognize that this definition explicitly excludes redesign from the proper use of construction spatial coordination with 3D modeling. Design and redesign are not part of “normal and expected spatial coordination.”

Project Participants require a clear understanding of the scope of the expected coordination process, what the Owner (who is usually paying the bills) expects in the form of process efficiencies (for example, fewer changes and deliverables), what the construction management firm has contracted for or is expecting, what other trades are expecting, and what their own companies expect from the process.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

1.3.7 A Supportive Infrastructure

Many MEP contractors who have taken on BIM projects have learned—the hard way—that success often depends on getting their own houses in order. A BIM Implementation Plan is an important first step. This plan is based on an inventory of the skills and equipment you have, from which you can identify what you need and consider how to fill any gaps.

Sending a detailer into the world of BIM spatial coordination without instruction, support, or the tools to perform is a recipe for disaster. These individuals cannot succeed in a vacuum. The full support of your project management teams, your field installation supervisors, your purchasing and procurement personnel, and your senior staff is necessary (Figure 1.3 on page 8).



Figure 1.3 Internal collaboration and support

1.4 Using This Guide

BIM is much more than an item to be checked off to win major projects. BIM is changing how the construction industry does business. With the BIM process, you and the other stakeholders can construct, in cyberspace, a completely coordinated, fully constructible model of the building you are going to build. This model can provide all of the information needed to design, coordinate, procure, schedule, sequence, prefabricate, build, test, commission, and maintain the building.

The cost and effort of entering into the BIM process is substantial. Many of the MEP “BIM pioneers,” after finishing a number of projects with this new delivery methodology, discovered that most of their early investment paid off. The BIM efforts had forced them to replace

SPATIAL COORDINATION IN A BIM ENVIRONMENT

disjointed and nonstandard practices and communication patterns with linear, repeatable operating procedures. They found the data they needed from previous bids and projects and learned to repurpose it. They learned to recognize the risks buried in vague specification and contact language, and they challenged expectations that were unreasonable. They developed new skills that enhanced their value to potential clients and parlayed those investments into a better bottom line. They became stronger companies.

The adoption of BIM in any aspect of your business processes is a journey, not a destination. If you are considering taking your company in that direction, you need to have confidence that the road will lead to a place you want to go. This Guide was written to prepare you for that trip, and particularly if you are working on a BIM project for the first time.

Consider this Guide an industry reference for acceptable standard practices for spatial coordination for a well-defined, consistent, and repeatable framework for spatial coordination of Mechanical, Electrical, Plumbing, and Fire Protection systems (MEP). You won't learn how to perform spatial coordination, and you won't find much that is focused on the concerns of a particular trade; indeed, a great effort was made to keep the focus on what is important to all trades. But you will learn how to review, use, and contribute to the many documents that establish the scope of the work; how to set up a BIM coordination program in your company; how to contribute productively to the Coordination Team; how to recognize the red flags along the way; and repeatable, standard practices to adopt for accomplishing all of this.

You can read the Guide cover to cover, or you can read Chapters 1 and 2 and then focus on the chapters that cover areas your firm may need to pay greater attention to. Or, you can share the Guide with contractors you're partnering with on a project to reach a consensus on your approach to spatial coordination. You can also use the Guide to train your Project Team on BIM and its role in spatial coordination.

Here is a summary of what lies ahead:

- **Chapter 2, "BIM and Spatial Coordination Basics,"** [on page 11](#) introduces the fundamental concepts and technology that frame the subject and are used through the Guide.
- **Chapter 3, "Building the Team,"** [on page 19](#), is aimed at executives, senior managers, or Construction Managers who are responsible for managing or overseeing the implementation and adoption of 3D modeling and BIM technologies within your firm.

SPATIAL COORDINATION IN A BIM ENVIRONMENT

- **Chapter 4, “The BIM Execution Plan,” on page 39**, is aimed at senior and project management and presents what you should expect to find within a competent BIM execution plan. The chapter provides options and suggestions for what to do when you receive an Execution Plan that is vague, missing critical BIM information and possibly contains well-known “red flags.”
- **Chapter 5, “Managing the Process,” on page 67**, is aimed at project managers, virtual construction managers or whoever is representing the firm on a project Coordination Team.
- **Chapter 6, “Documents of Record,” on page 85**, is aimed at the senior executives, Project Managers, or Construction Managers who are responsible for the receivables and deliverables of a firm within the scope of Design-Bid-Build projects with spatial coordination. The Guide introduces all the required and many optional documents of record that are critical to a successful project.
- **Chapter 7, “Improving Your Operations,” on page 103**, is aimed at senior operational managers and Project Managers. It introduces the secondary uses of the data that is generated throughout the building lifecycle of projects built with BIM through a 3D spatial coordination process.
- **Chapter 8, “Contract Language,” on page 115**, is aimed at senior management responsible for the firm’s contract business. This chapter explains issues and language within the contract documents that your firm must identify and fully understand before engaging in any BIM project.
- **Chapter 9, “BIM Technologies for an IT Infrastructure,” on page 129**, is aimed at senior management, IT managers, or whoever is responsible for your firm’s IT Implementation Plan. The chapter frames a majority of the key elements needed within a capable IT infrastructure designed to support spatial coordination and BIM.

However you choose to use the Guide, it is hoped you will come to see that when the majority of the Project Team agrees to and follows common coordination practices, your project is more likely to run smoothly.

Chapter 2

BIM AND SPATIAL COORDINATION BASICS

This Guide reflects some basic assumptions and also makes abundant use of specific concepts and terminology, all of which are explained in this chapter.

- **2.1 Project Delivery Methods** on page on page on page 11
- **2.2 Types of Models** on page 12
- **2.3 Types of Software** on page 15
- **2.4 Level of Development Specifications** on page 16

2.1 Project Delivery Methods

A handful of project delivery methods are used to build and deliver commercial building projects.

One method is Design-Build in which the design and construction services are contracted by a single entity, known as the design-builder or design-build contractor, and the design phase and construction phase overlap. Design-Build places the responsibility for design errors and omissions on the design-builder, relieving the owner of legal liability and managerial responsibilities. The burden for these costs and associated risks are transferred to the design-build team.

The delivery method mostly widely used is Design-Bid-Build. In this method, the owner contracts with separate entities for the design and for the construction of a project. Design-Assist deliveries are a variant of this type of delivery, often permitting earlier participation by a contracting team to assist the designers or engineers in expediting their processes or reducing potential post-design problems.

There are notable differences in each approach with specific implications of risk, responsibilities, schedule, and costs. Because of these differences and the MEP contractor practices unique to each delivery method, this Guide focuses exclusively on the Design-Bid-Build method. Most MEP contractors are familiar with the standard protocols and methods for Design-Bid-Build projects, and those MEP contractors who have not worked with BIM can more easily grasp the nature of the operational changes that BIM introduces.

The other delivery methods that use BIM and spatial coordination require the contractor to take a different perspective, use different procedures, and maintain a different set of expectations of the other participants. That said, the suggestions, lessons learned, and general practices of BIM discussed in this Guide are easily transferred to the other delivery methods.

BIM AND SPATIAL COORDINATION BASICS

2.2 Types of Models

To understand how an MEP contractor's detailing and coordination efforts relate to BIM, you need to understand what is meant by "the Model." Considerable effort has gone to defining this term—through establishing standards, practice documents, and industry nomenclature—yet none of this has aligned expectations of what the Model actually represents. A model from one stakeholder may represent a version of the project that is completely different from what another stakeholder was expecting to receive.

As used in this Guide, the Model represents the building project as designed, with all its details and systems. The Model is the Design-Intent Model created by the Design Team and is the base model that is extended during the coordination phase to create the construction model. The MEP contractors and other trades contribute models of their respective systems to the Model. The coordinated model, the construction model, and the as-built model represent the Model at different stages of its development. In this Guide, the terms "the Model," "Design-Intent Model," and "coordination model" refer to the same thing.

In the early textbooks and academic presentations about BIM, one of the core tenets of the methodology is the capability to take an architectural conceptual model, and at every phase of the project, pass a version of this model to the next domain (that is, from architect to engineer, from engineer to contractor). Each version reuses existing elements and extends them with the knowledge, skills, and data relevant to the specific domain and the area of responsibility in the building process. Aggregating, integrating, or combining information into a single model (that is, the Model) is intended to eliminate redundant effort.

The ultimate goal has always been to achieve this seamless flow from conceptual model to the turnover construction package by extending the model and never redrawing. But we have not achieved that goal yet. Therefore, it is important to know what type of model you are receiving and what kinds of data can be derived and reused from it.

Two primary types of models are used in the design and construction industry: Integrated Models and Federated Models. A few other models are derived from the base Federated Model, but these should be viewed as contributing models, not the Model.

BIM AND SPATIAL COORDINATION BASICS

2.2.1 The Integrated Model

An Integrated Model is created with a single authoring platform that all design, construction, and maintenance stakeholders use throughout the construction cycle (Figure 2.1 on page 13). This method of extending the Model inside a single design platform is as close as the industry has come to achieving the BIM ideal, yet it is rarely used. The reason is that, although some commercially available software platforms meet most needs of the architects and designers and some needs of the engineers, these platforms do not provide all of the applications and functions that MEP contractors need and use.

The time may come when a single authoring platform or software environment supports the needs of each building services stakeholder, but at this writing, it has not.

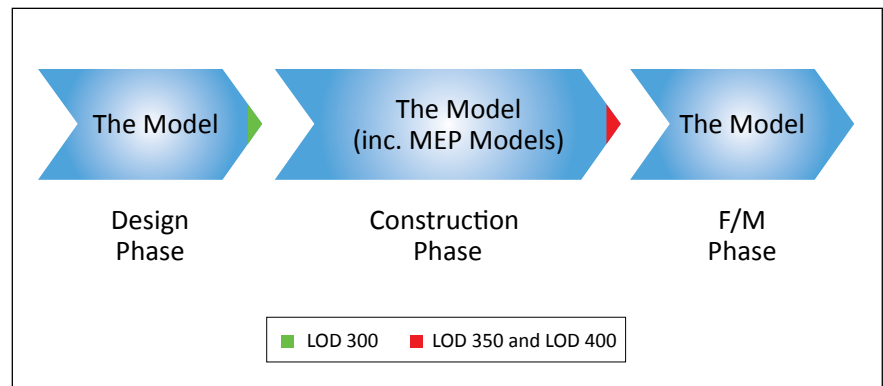


Figure 2.1 Typical Integrated Model

2.2.2 Standard Federated Models

A Federated Model is assembled from the various models created by the stakeholders on the construction project (Figure 2.2 on page 14). Although most of the intelligence and attributes of components in the contributing models remain with the software application that created them, the rendering of this federation of models is considered to be the Model.

The use of 3D CAD technology and Building Information Modeling in the U.S. expanded when the cost of specialized project review (also known as model review) software became available. Most stakeholders in the design and construction phases were able to view and process, or scrub, models created on other platforms (for example, Design-Intent Models) yet continue to use their specialized software platform applications. These new rendering programs also provided enhanced visualization capabilities and powerful features such as clash detection and recording.

BIM AND SPATIAL COORDINATION BASICS

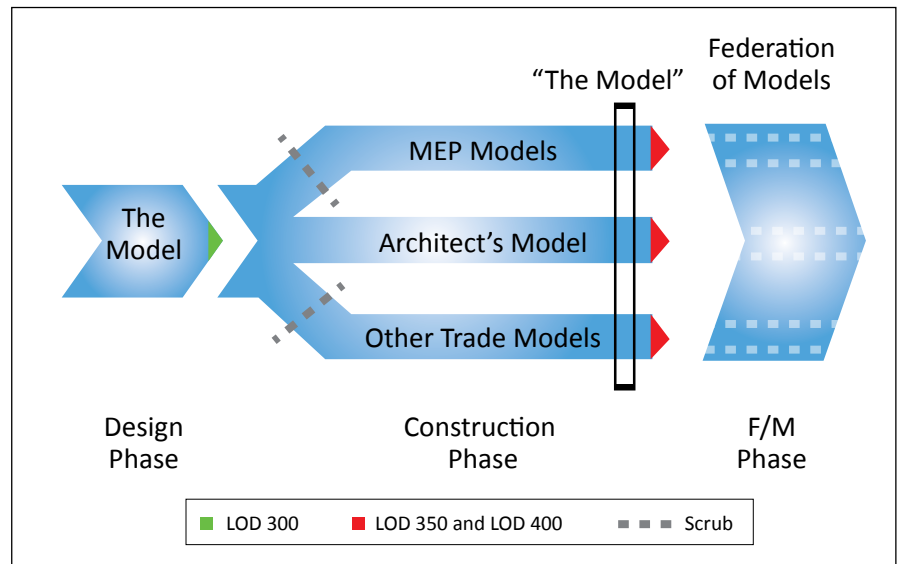


Figure 2.2 Standard Federated Model

2.2.3 Modified Federated Models

To work around the current limitations of software, some projects are melding the heterogeneous features and benefits of the Federated Model with the seamless integration of the Integrated Model (Figure 2.3 on page 14). In this process, the Design Team maintains control of the Model, and its specialty consultants process and integrate information from MEP models into it. Despite this duplication of effort, this model provides an Owner with a more robust deliverable.

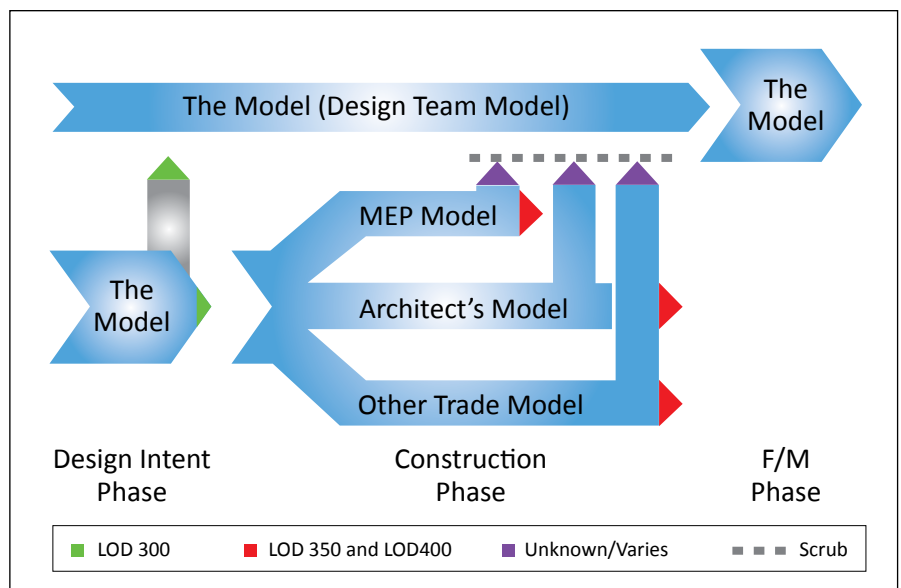


Figure 2.3 Modified Federated Model

BIM AND SPATIAL COORDINATION BASICS

2.2.4 Federated Construction-Only Models

The Construction-Only Model is the same as Standard Federated Model except that the modeling stops at the construction phase (Figure 2.4 on page 15). No model deliverables are required (or desired) by the Owner.

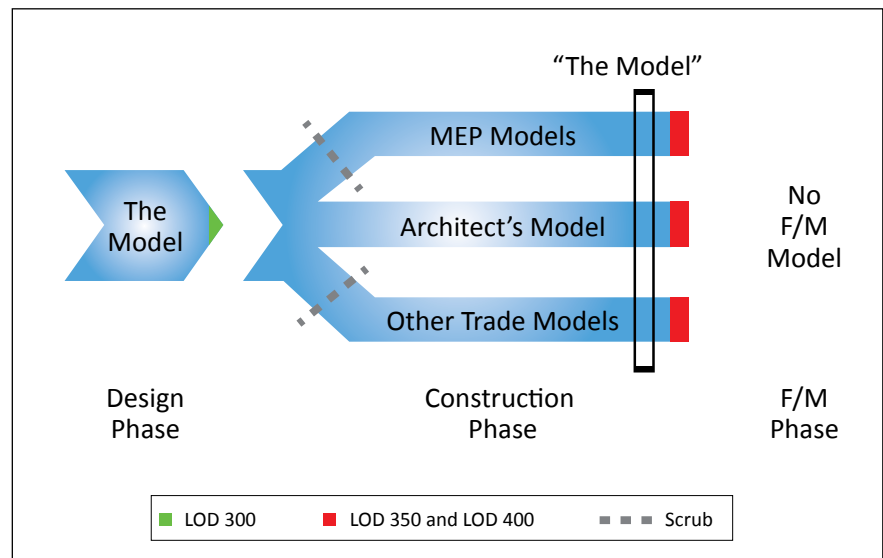


Figure 2.4 Federated Construction-Only Model

2.3 Types of Software

One of the questions that senior MEP executives who are new to BIM and spatial coordination raise most frequently is why so much software is needed to support the practice.

Chapter 9, “BIM Technologies in an IT Infrastructure” on page 129, answers many of these software-related questions and defines the five types of software to acquire and in which to build competency in so that Project Teams can support the workflow. It doesn’t take long to appreciate the value that these tools deliver at different stages in the project lifecycle.

The only question remaining is why MEP contractors need two CAD authoring software applications.

CAD (or authoring) software comes in a base version that is not tailored for specific uses or to specific users. Some base platforms are AutoCAD, ArchiCAD, AECOsim Building Designer, and Revit MEP. Their publishers develop their products to provide the greatest benefit to their entire, and quite diverse, user base.

BIM AND SPATIAL COORDINATION BASICS

The domain-specific tools sometimes referred to as “plug-in” software, are installed “inside” these base platforms. Software publishers that serve a specific domain—for example, fire protection equipment or plumbing systems—extend these base platforms to meet the specific requirements of their respective domains. Rather than invent or reinvent a base platform on which domain-specific software operates, these publishers build functions onto these base platforms to improve and power their own products.

Thus, the principle: to get the benefits of a domain-specific specialty software tool, contractors need to have the base platform, too.

2.4 Level of Development Specifications

To understand what a Level of Development* (LOD) is, you must understand what it is not: Level of Detail.

In 2011, the American Institute of Architects (AIA) introduced the term “Level of Detail” in preliminary draft of their Digital Practice Documents. The definition states that Level of Detail “equals the level of visual appearance of a particular element in a model.” It describes the levels of visual rendering on a computer screen that represents an object’s physical appearance.

Ever since this definition was released, many groups, regions, and contractors have used this term interchangeably with another term, Level of Development, issued as part of the same document release. The Level of Development Specification** represents an industry effort to establish a standard reference and a way to define “the degree of completion of a building model for the purposes of spatial coordination and construction.” The LOD Specification also offers a way to precisely describe what you received, what you should have received, what you agreed to receive, and what you agreed to produce or provide.

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*** The definitions for LOD 100, 200, 300, 400, and 500 included in this Specification represent the updated language that appears in the AIA’s most recent BIM protocol document, G202–2013, Building Information Modeling Protocol Form. The LOD 100, 200, 300, 400 and 500 definitions are produced by the AIA and have been used by permission. Copyright © 2013. The American Institute of Architects. All rights reserved. LOD 350 was developed by the BIMForum working group. Copyright © 2013. The BIMForum and the American Institute of Architects. All rights reserved*

BIM AND SPATIAL COORDINATION BASICS

Although there are six Levels of Development (100, 200, 300, 350, 400, and 500), the levels most important to MEP contractors are LOD 300, LOD 350, and LOD 400. The definition of what is to be modeled at these levels is determined at the start of the project and is often found and referenced in the BIM Execution Plan. Project Participants need to agree on both the modeling expectations and what the Owner is looking for as a final BIM deliverable, if required.

Elements that are modeled in a LOD 300 model—such as a 4" conduit, a wall-mounted plumbing carrier, or a 14x24 rectangular duct—are modeled as specific elements or composite assemblies at a specific location and represent an accurate shape and orientation (for example, thickness) of the specified assembly. For a Design-Bid-Build contractor, this is a good place to start your detailing activities. Non-geometric information such as standard ratings and special specifications may also be attached. A solid model element with accurate thickness and location that also contains the information usually included in any of these types of elements satisfies the requirements of LOD 300.

The official description of what the Design Team is expected to deliver in its Design-Intent Model at LOD 300, is defined as follows:

*The model element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphical information may also be attached to the Model Element.**

There is, however, no uniform deliverable product that design firms are contracted to provide in a Design-Intent Model. What this means in practical terms is that the information you need to begin your detailing and coordination work may or may not be delivered in the Design-Intent Model. There is no guarantee that the design model passed to you contains accurate, constructible, and coordinated LOD 300 elements. Therefore, you should rely more on what the Execution Plan and contract documents define as the set of domain-specific LOD elements that you should expect to receive. If you cannot find any references to these details, submit an RFI for clarification.

But regardless of whether the Design-Intent Model provides fully compliant LOD 300 elements, your task is to use what you can while working within it and avoid any redesign of it. So part of your BIM Execution Plan will define the elements that you are contractually obliged to model if you are to deliver a set of elements at LOD 350 to begin coordination. When coordination is complete, you have the

* Level of Development Specification © 2013 by BIMForum

BIM AND SPATIAL COORDINATION BASICS

option to generate elements at LOD 400 within your construction model, which can in turn, be utilized for component or assembly manufacture, fabrication, and installation.

The official definition of LOD 350 includes all of LOD 300 and adds some new information (emphasis added):

*The model element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location and orientation, **and interfaces with other building systems.** Non-graphical information may also be attached to the Model Element.**

The Coordination Team and Project Coordination Manager can expect that the LOD 350 model elements you have submitted to the first coordination meeting are ready to be federated into the coordination model. Your model must include enough detail for installation and cross-trade coordination.

The official definition of a LOD 400 model includes more detail than an LOD 350 model (emphasis added):

*The model element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation **with detailing, fabrication, assembly, and installation information.** Non-graphical information may also be attached to the Model Element.**

For MEP contractors, this model is equivalent to what are often considered as industry-standard shop drawings. You can use it as a construction submittal, declaring that it has completed the coordination process. You are ready to begin manufacturing, fabrication, and installation, upon sign-off and authorization.

*Level of Development Specification © 2013 by BIMForum

Chapter 3

BUILDING THE TEAM

As a senior executive of an MEP contractor, the responsibility for building a BIM spatial coordination program falls to you. The BIM Implementation Plan is the foundation. This plan identifies the skills, processes, and technologies you need to have to do the work successfully and a schedule for filling the gaps between what you have and what you need. This chapter focuses on the considerations for evaluating the skills and processes of your current operations. The technology issues are addressed in Chapter 9 [on page 129](#).

This chapter covers the following topics:

- **3.1. Building an Effective Spatial Coordination Program** [on page 19](#)
- **3.2. Preparing Your BIM Implementation Plan** [on page 20](#)
- **3.3 Roles and Responsibilities on the Coordination Team** [on page 21](#)
- **3.4 Internal Inventory of Skills** [on page 25](#)
- **3.5 Internal Communication Procedures** [on page 28](#)
- **3.6 Human Resource Requirements** [on page 32](#)
- **3.7. Outsourcing** [on page 33](#)
- **3.8 Working Within the Collaborative Process** [on page 37](#)

3.1. Building an Effective Spatial Coordination Program

Do not wait until you have been awarded a BIM and 3D modeling spatial coordination project to establish within your company the capabilities that you will need to perform the job accurately and effectively. Spatial coordination with 3D modeling is a valued capability of many MEP contracting firms and should be instrumental to your estimating and negotiating process for any project. When you find a requirement for spatial coordination, 3D modeling, or BIM in a Request for Proposal (RFP), you want to be prepared to add to the proposal a description of your company's unique capabilities to complete the job and fulfill the BIM special requirements of the project.

It is important to carefully review the spatial coordination or BIM requirements before your firm bids on any project. Your estimators should evaluate the costs of meeting the specification requirements, your operational personnel should review coordination and related construction schedules, your detailing or modeling manager should identify the special requirements and procedures related to this custom project, and your executives should analyze the contract terms and associated risk that might apply.

Do you have the trained personnel available to do this? Unfortunately, most contractors discover that they do not only after they have won the bid. They assume that the project requires a high-level detailing process, only to find that the BIM requirements demand much more time, resources, and expense than anyone had anticipated.

Once burned, smart MEP contractors are quick to adjust to the needs and demands of their clients and the industry in general. It takes a concerted effort to understand all the dynamic aspects of spatial coordination and Building Information Modeling and to recognize how Owners, General Contractors and Construction Managers, Architects, and design professionals are positioned to address technology's new influence in the construction process.

BUILDING THE TEAM

*Assembling your Project team***3.2. Preparing Your BIM Implementation Plan**

Projects vary in size, composition, and complexity, but your processes, protocols, and metrics should not. If you were to bid on a project that requires BIM coordination, do you know which aspects of your business can function as they do now? Or which departments or processes must transform to meet the new demands and expectations? Have your project teams identified and staffed all the functional areas required for a BIM project?

If you cannot answer these questions in the affirmative or you simply do not know, you need to begin work on a BIM Implementation Plan.

A BIM Implementation Plan is a business strategy document that outlines the resources your company needs to buy and to hire and identifies the changes to current internal processes that are required to fully support BIM projects. The first step in preparing this plan is to inventory the skills and equipment your firm currently has and analyze how your business data flows within the firm. The second step is to identify any gaps between what you have and what you need to meet the demands of current and future BIM projects. The third step is to prepare a schedule for your organization to evaluate, select, and incorporate the technologies you will need to adopt.

There are no standard templates for developing this plan; each one is unique. Because the BIM technologies can transform your company's processes, an executive with a broad view of all aspects of the company's capabilities and goals should oversee the work. That executive, in turn, needs to find the champions—the seasoned and

BUILDING THE TEAM

3.3 Roles and Responsibilities on the Coordination Team

respected individuals within your company who have the patience and persistence to keep your plan on task and still meet any immediate commitments or obligations for your firm.

These plans should describe the existing internal processes for planning and executing spatial coordination, including communication, data exchange, and how the information gleaned from the process is applied. The plan describes how you want these processes to change to meet new or desired expectations. The plan also makes note of future opportunities and of any data collection and reuse that might enhance your business practices. This plan should be prepared with the expectation that it will be revisited and evolve as the company's skills grow and to accommodate new technologies and tools.

If you are new to BIM and do not feel you have a good understanding of what the industry is demanding in your specific area of business, consider setting up formal discussions with your clients, your peers, your vendors and your technology providers. What you learn will help you see where your gaps are, and at the very least, what you need to meet your immediate needs.

The sections that follow include guidelines that you may want to use as starting points for various aspects of your Implementation Plan. They focus on the skills and processes that the Implementation Plan must address. The technology issues that the plan must address are covered in Chapter 9, [on page 129](#).

3.3 Roles and Responsibilities on the Coordination Team

Project specifications, BIM Execution Plans, or other project-specific BIM documents usually define the roles and responsibilities of Participants on the Coordination Team. External stakeholders include the Owner (and/or his designee), the Architect, the Construction Manager and General Contractor, the trade-specific engineers of record, Lead MEP contractors, and other trade-specific participants.

The first step for your Project Team members is to document the background and skills of each Participant on the Coordination Team. Who is taking on which role? What is each person responsible for? What experience do they have in the industry and with spatial coordination? What and how much authority do they have? Do they have the skills that will help everyone succeed?

This information is useful because the more experience your representatives on the Coordination Team have, the sooner they can recognize when critical roles are being performed properly. If they see shortcomings that will hamper progress, experienced team members should raise their concerns right away. Documenting such gaps is something that all prudent MEP contractors should be willing to do.

BUILDING THE TEAM

The three critical roles on the Coordination Team are the Project Coordination Manager, the Model Manager, and the Lead MEP Subcontractor. On some projects, one person performs more than one of these roles; on others, the roles are assigned to individuals employed by different firms. Their basic responsibilities do not change, but their responsibilities within the current project must be defined and understood. Their titles well may be different from those used here. There is also an authorized representative from each of the trades participating in coordination.

As the needs and expectations of spatial coordination have expanded, many stakeholders have looked to their MEP contractors to lead or manage some or all of their coordination efforts. MEP contractors are often asked to assemble initial drafts of BIM Execution Plans (see chapter 4 [on page 103](#)).



The Coordination Team leadership roles require field experience and computer skills

These are significant responsibilities. If you are willing to step into these roles, you should be confident that you have the resources, capabilities, and bench support for them. You should also be adequately compensated for the additional work and the risk you assume. Many qualified MEP contractors take on these responsibilities because they are compelled to by contract requirements, or choose to do so because they are best qualified to perform these functions, or want to have significant control over those factors critical to a successful project

BUILDING THE TEAM

The following sections describe the responsibilities of the basic roles on a Coordination Team.

3.3.1 Project Coordination Manager

The Project Coordination Manager (PCM) is generally responsible for the oversight and management of the spatial coordination process; another name for the role is MEP Coordinator. The General Contractor or Construction Manager generally assumes this role.

The Project Coordination Manager has these responsibilities:

- Managing the Coordination Team to ensure full participation and adherence to the BIM Execution Plan
- Creating coordination schedules that are based on the project schedule and agreed to by Project Participants; managing these schedules to keep them up to date and reconciled
- Obtaining and distributing all contract drawings and documents, design change drawings and documents, and all CAD and model files that the Coordination Team needs to create initial models
- Ensuring that all documents, drawings, files, and information from the design team are current
- Acting as liaison between the Coordination Team and the Architect, engineers, and Owner.
- Notifying appropriate parties and obtaining resolution from the Design Team when spatial coordination issues prevent the Coordination Team from achieving satisfactory coordination in accordance with the Design-Intent Model or with contract documents and drawings
- Acting as an arbitrator when members of the Coordination Team cannot agree to a mutually satisfactory solution to coordination issues.

3.3.2 Model Manager

The Model Manager is responsible for facilitating coordination meetings and managing the Model. This position may be specified in the BIM Execution Plan as a unique position; the responsibilities might also be incorporated into the roles of the Project Coordination Manager or Lead MEP Contractor. Either way, it is a critical role that must be defined. It can be filled by the Project Coordination Manager, the General Contractor or Construction Manager, the Lead MEP subcontractor, the Architect or Engineer, or an independent BIM specialty subcontractor.

The Model Manager is responsible for these tasks:

- Setting up and maintaining a secure online file-sharing site
- Assembling the initial master model

BUILDING THE TEAM

- Setting up the initial file structure of the model folders (also known as model directories) and establishing conventions for naming project files
- Establishing elevations and the point of origin (or insertion point) for all models
- Communicating information to the Coordination Team
- Confirming that the model files of all Project Participants align properly and can be inserted properly into the master model file
- Resolving any model alignment or coordination issues with all Project Participants
- Maintaining the model throughout the project
- Performing interference/clash-detection checks
- Generating clash detection reports
- Facilitating coordination meetings

It is a best practice for individual firms to generate their own clash-detection reports and resolve as many conflicts as possible prior to the coordination meetings. Coordination meetings should focus on major interferences or design restrictions, not minor, easily resolved interferences. If attempts to resolve clashes end in stalemate, the Project Coordination Manager should intercede.

3.3.3 Lead MEP Subcontractor

The responsibilities of the Lead MEP Subcontractor vary across projects, and the role might not be specified in the contract documents or the BIM Execution Plan. On some projects, the responsibilities of the Model Manager are assigned to this role. On others, the Lead MEP Subcontractor may coordinate the work of other MEP contractors on the team, modeling the major systems within the Lead MEP Subcontractor's scope first and providing that model to other Project Participants, who then model their own systems.

Any responsibilities assigned to this role must be clearly defined in the project's contract documents or BIM Execution Plan. When sequential modeling is specified, the systems with the greatest coordination impacts such as sloped piping and large duct work mains are modeled first; that model, preferably federated with the architectural and structural system models, is then provided as a "background" for the modeling of smaller, less bulky systems such as domestic water, electrical, and fire protection. Alternatively, the BIM Execution Plan might designate the Lead MEP Subcontractor as the Model Manager, MEP Coordinator, or MEP Spatial Coordinator.

BUILDING THE TEAM

Because these roles can be filled by a number of different individuals in different organizations, it is important that the Coordination Team sort out the details and agree to their responsibilities. It is highly recommended that you address these expectations during the bidding and procurement process because they have an impact on your financial commitment.

3.3.4 MEP Subcontractor

Each MEP contractor on the Coordination Team must have these responsibilities and authority:

- Collaborating with the Coordination Team about the requirements and guidelines of the Execution Plan and all applicable contract documents
- Modeling prescribed components at full scale, using the required units insertion points and project orientation, at required elevations, free from interferences with structure and their own components
- Capable of and authorized to make decisions regarding the placement and coordination of their components

3.4 Internal Inventory of Skills

The inventory of current skills can begin by constructing two organization charts, one that represents your current staffing and another designed to support the requirements or goals of your spatial coordination program. Then compare the charts. The differences should dictate what to include in your BIM Implementation Plan.

If your company is small to mid-sized, you may only need to assign a single individual the responsibility of upgrading the firm's CAD detailing department to support the required receivables and deliverables. If your company is large, you might include a thorough review of every department and how each could be improved to better support the cooperation and collaboration needed throughout the entire organization.

The requirements for successful spatial coordination are far more comprehensive and time-consuming than old-school detailing ever was. The skills inventory, especially for large contractors, should also consider when a shift to segmentation of steps or tasks may be prudent or necessary. The practice of assigning one individual to perform all tasks related to a specific project may need to change; assigning an individual to similar parts of many tasks is an alternative. This strategy requires stricter standardization processes, but permits a more focused use of any individual detailer's or coordinator's time and skill and allows for a more concentrated attention and improved efficiencies to each individual component.

BUILDING THE TEAM

To begin your inventory, consider the roles and responsibilities of an internal team that meets the common requirements for spatial coordination with 3D modeling.

3.4.1 BIM Manager

Most successful BIM Managers come from within the company and have a track record of successful construction management in one form or another. Additional training may be necessary, but having someone who has demonstrated a strong understanding of construction management is probably more important than someone with established CAD skills.

When looking outside the firm, a more likely prospect is a successful lead detailer or MEP coordinator. These skills and personal attributes are essential:

- Strong field experience, preferably in layout
- Trade knowledgeable
- Self-motivated, ambitious, hardworking, intelligent
- Computer literate
- Excellent social and communication skills

The BIM Manager typically reports directly to senior management and has these responsibilities:

- Managing the BIM process
- Supervising coordinators and detailers
- Working internally with estimators, project management, field personnel, fabrication facilities and externally with Architects, Engineers, General Contractors, Construction Managers, other trade contractors, and Owners
- Establishing schedules and budgets
- Monitoring the process to measure compliance with quality requirements and any other internal metrics established and defined by the organization
- Filtering clashes and evaluating clash reports prior to coordination meetings

3.4.2 Lead Detailers or Project Coordinators

Lead detailers require a strong knowledge of construction techniques and methods; they are often a tradesperson with long experience in laying out mechanical, electrical, or plumbing systems. Some good lead detailers also come from drafters and detailers with several years' experience. These candidates usually rise to the top as their abilities

BUILDING THE TEAM

and skills develop. If not familiar with your company's existing CAD platforms, the best candidate may also require specialized CAD training.

Also of great value is someone who has taken the lead role on multiple projects. These are people who can make or break a project, so their ability and willingness to accept a great deal of responsibility is essential.

A Lead Detailer or Project Coordinator has these responsibilities:

- Working with the Project Team
- Attending coordination meetings
- Coordinating the efforts of individual detailers assigned to the project
- Reviewing the status of these items with the Project Manager:
 - o Schedule
 - o Deliverables
 - o Submittals
 - o RFIs
 - o Design changes
 - o Cost impacts

3.4.3 Detailers

Many detailers, and indeed some of the most competent ones, come directly from the field. What they bring is a thorough understanding of the materials, equipment, and how systems and elements are connected and installed. Many capable organizations offer afternoon or early evening classes to their field personnel who are interested in making the switch.

Competent detailing candidates have also come from architectural or engineering firms. Entry-level candidates should have a two-year associate's degree or equivalent in CAD or BIM technology. Some construction management programs are offering minors in BIM technology and almost all are addressing BIM technology in one form or another. Your local MCAA, SMACNA, or NECA chapter or affiliate can often guide you to qualified candidates.

Detailers, also known as drafters, have these responsibilities:

- Detailing sections of the model
- Incorporating Design-Intent Models, contract documents and specifications, and the Project Team's requests and expectations into a virtual detailing model that represents the intended MEP installation for the building
- Understanding and interpreting architectural and structural details as they affect the MEP installations

BUILDING THE TEAM

- Identifying interferences with the architectural structural and other MEP elements
- Generating contract and internal company deliverables from the model. These deliverables include tagging, dimensioning, and generating fabrication spools and tickets.

In some companies, the senior detailers do the modeling and the junior detailers perform the tasks related to extracting deliverables from the model.

3.4.4 Technical/CAD Manager

This candidate requires a strong CAD and BIM background.

One other consideration, especially with a large department, is the option to establish a position for a technical manager or technical lead who works directly for the BIM Manager and takes on the full responsibility for these areas of the model:

- Implementation
- Management
- Troubleshooting
- Training others on the authoring software and related technologies

3.5 Internal Communication Procedures

Many of your existing workflows will have to accommodate the new communications, information exchange, and documentation requirements.

The most critical exchanges of data between the Coordination Team and company personnel fall in three areas:

- Field and shop personnel
- Project management staff
- Senior executives

The BIM Execution Plan (Chapter 4 [on page 39](#)) should help define your company's standards, protocols, and expectations of everyone involved in these communications. The rest of this section consists of checklists of the items to include in these standards for each area.

BUILDING THE TEAM

Internal Standard Practices Checklist

Has your company established exchange standards between the Project Team and the field and shop personnel? Consider using the following checklist to determine what standard practices need to be added.

- ☐ How to best manage internal questions
- ☐ Establish minimum standards for deliverables to the shop
- ☐ Planning of the coordination process (meetings, job reviews, participants, and so on.)
- ☐ Create and use a detailing/modeling checklist for intra-company deliverables
- ☐ Establish minimum standards for deliverables to the field forces
- ☐ Implement procedures for establishing the limits of the program on a job-by-job basis
- ☐ Obtain input from the field or shop staff before starting job-specific detailing
- ☐ Create default matrixes to use in the absence of approved submittals for commodity products
- ☐ Set expectations for routing and for systems optimization
- ☐ Obtain input and approval of field or shop staff after coordination
- ☐ Implement quality control protocols for detailing, completed models, and drawings
- ☐ Delivery and use of interim (not completely coordinated and signed-off) drawings or models
- ☐ Hold review meetings for project milestones; set expectations about what is to be delivered
- ☐ Follow up on status of material matrixes
- ☐ Establish post-coordination procurement procedures
- ☐ Identify prefabrication and modularization opportunities
- ☐ Establish the priority and desired sequencing of detailing and modeling efforts
- ☐ Provide access to documents (FTP or project-specific repositories)
- ☐ Installation tracking
- ☐ Establish procedures for “as-built”
- ☐ Establish procedures for communicating design changes or field directives

BUILDING THE TEAM

Internal Data Exchange Checklist

When establishing the exchange standards across all of your internal departments and between those departments and the Project Team members , consider the following issues:

- ☐ Roles and responsibilities, project-specific applications
- ☐ Contract reviews and communication of unique language or demands
 - Schedule creation and implementation expectations
- ☐ Budget reviews and cost coding
- ☐ Internal company receivables to the BIM/Spatial Coordination Teams
- ☐ Submittals
- ☐ Meeting attendance and recordkeeping
- ☐ Notification requirements
- ☐ Authority and authorization limitations (lines of instruction)
- ☐ The use and maintenance of logs (for example, Issues, RFIs)
- ☐ Red-Flagging
- ☐ Meetings and reviews
- ☐ Measuring and monitoring the process
- ☐ Addressing delays and impacts
- ☐ Training issues
- ☐ File management, file access, repository maintenance
- ☐ Client relations

BUILDING THE TEAM

Project Team to Management Team Inventory Checklist

It's important that the project team and the management team have the same understanding of these standards, resources, and events.

- ☐ Resource training
- ☐ Outsourcing
- ☐ IT standards – software and hardware platforms
- ☐ Infrastructure
- ☐ Database standards and security
- ☐ Company detailing standards
- ☐ Roles and responsibilities – company standards
- ☐ Internal malfunctions of the team
- ☐ Team meetings – timing and expectations

BUILDING THE TEAM

3.6 Human Resource Requirements

In any coordination process, one bad apple can spoil the team. A poorly performing Project Participant can delay the work and increase the costs for the rest of the team, along with generating numerous problems that migrate out to the field. When you staff your Project Team or review the existing Coordination Team, you must recognize that some detailers or coordinators lack the people skills necessary to collaborate effectively. Choosing an effective representative to be your company's spokesperson during coordination can go a long way toward gaining the cooperation of Project Participants.

A good BIM Implementation Plan should state the minimum experience requirements for team members and clearly define what the company expects of these representatives when they work on teams that include your clients. Team members should know their trade and be authorized and capable of making decisions.

Effective team members have these personal attributes:

- Are driven to meet their goals and commitments
- Understand the difference between spatial coordination and design or engineering
- Recognize the directions or adjustments to the scope of work that constitute extra work
- Know when to seek clear direction from your project managers or responsible authority
- Make it known when the coordination process is getting off track or is unproductive
- Document delays and wasted time

If you are not confident that your detailers or coordinators understand your company's expectations of behavior on the Coordination Team, lay it out in your BIM Implementation Plan.

BUILDING THE TEAM

3.6.1 Recruitment

Many MEP contractors, especially those who are new to spatial coordination, will at times find themselves shorthanded. In such situations, you must look for ways to recruit talent to meet those needs. Depending on the urgency to meet specific needs, various methods are available to source qualified candidates:

- Current employees who could quickly learn the skills they might lack
- Local trade unions, particularly those that might provide comprehensive detailing training for their active or retired members and apprentices
- Local colleges, community colleges, universities, and technical schools that have programs for your technical or engineering classifications
- Local temporary labor placement agencies
- National specialty placement firms that cater to your industry

Concentrating on these sources should not prevent you from advertising in local publications or web-based placement sites. You never know when you might come across someone who will fit your bill.

You, or your local trade association, may also want to consider teaming up with a local college to sponsor baseline training programs that might help provide the training to meet your future needs.

Regardless of where these new hires are sourced, never assume that these individuals are truly ready to meet your needs and adequately represent your firm despite the experience or qualifications they have. Test them when possible, and train them to understand your BIM processes.

3.7. Outsourcing

For contractors new to the BIM coordination process or for established BIM contractors who find their internal modeling resources spread too thin, outsourcing may be a viable option. This option should not be considered lightly. Special consideration must go to researching, selecting, and managing any qualified subcontractors.

One of your project management functions is to effectively manage the significant degree of responsibility and subsequent risk that you may be entrusting to another party. Many consultants will offer BIM coordination assistance for a fee, but most do not, or will not, accept the responsibility for it or the consequences of nonperformance. Approach such situations with caution. You will find that, in most cases, your team will still need to intensively monitor and manage these consultants or subcontractors, and be actively involved in the process.

BUILDING THE TEAM

3.7.1 Selecting an Outsource Firm

Researching and interviewing qualified firms or individuals is paramount. A lot of consultants will promise just about anything to make a sale. Qualified candidates should have solid industry-related references. They should have experience and specialized capabilities in your firm's area of expertise. Create a list of questions and expectations and present them to each firm or individual that you are considering. Look for how their work processes will handle both your internal requirements and those of the project, and record their responses.

Various types of CAD/BIM services available to the MEP industry:

- Individual CAD/BIM detailers. These are one-man shops typically suitable for smaller projects or supplementing your staff.
- CAD/BIM job shops. These are niche contractors that specialize in providing CAD/BIM services. Contractors in this category include both local firms and overseas firms. Local firms usually provide detailers that meet and work directly with the MEP contractor. Overseas firms typically provide a local contact who coordinates with detailers and modelers located overseas.
- Engineering firms. Some MEP engineering firms also offer CAD/BIM services.
- Specialty material or equipment vendors. Some MEP vendors sell packages that include CAD and modeling services along with packaged and sorted materials and/or fabricated skids or modules.
- Other MEP contractors. Established MEP contractors who are participating in the coordination process on a specific project are often willing to provide BIM coordination services to other MEP contractors.
- A peer-group company (that is if you belong to a peer group). A peer-group company that has established BIM/coordination capabilities may be one of the best options because a certain level of familiarity and trust is already established.

BUILDING THE TEAM

Qualifying design firms and setting project expectations

To screen a potential outsourcing firm, start with the list of questions here to develop your own list.

1. Do you provide coordination drawings only? _____

2. Do you attend coordination meetings and who represents your firm's interests in the process? _____

3. Does your firm require installation drawings, including deck, pad, insert and sleeve drawings? _____

4. Will the design firm generate material lists with a specific material scheme for sorting, bagging, and tagging material? _____

5. To what degree will prefabrication and 2D modeling be taken up in the process? Will deliverables include equipment, module, and spool drawings? _____

6. Will there be a deliverable to support and drive Total Station surveying equipment? _____

7. Does the design firm use the type of modeling software compatible with the project specs? _____

8. Who manages the submittal process and will the design firm produce the "as-builts"? _____

9. What previous spatial coordination projects has the design firm completed? _____

10. Are the design firm's insurance and bonding capabilities adequate for the project or does the MEP contractor provide it? _____

BUILDING THE TEAM

Some firms can meet your needs on small projects, but would be overwhelmed by large ones. Recognize that in most cases you are actually contracting with individuals, not firms, and these individuals must meet the requirements and qualifications that you have for your own employees.

Once you have chosen a firm or an individual, assign a small or simple project, or have them supplement your team's efforts on a current project so that your personnel can evaluate the work. Your staff needs to understand the work being delegated to subcontractors or consultants and to convey expectations for performing it. Putting all of this in writing, with schedules and standards, is important, particularly when some of the information needed is not available when the consultant joins the project. Accountability is important, and vigilance is key.

Establishing a relationship with multiple outsourcing firms is also something to consider. As with any other subcontractor, the more familiar you are with each other—your respective capabilities, strengths, and weaknesses—the more flexibility you have with developing the right approach for a particular job. By developing a strong relationship, your outsource firm can become nearly as integrated with your BIM structure as an in-house department. Having multiple options also allows for competitive balance in pricing. Oftentimes the smaller outsourcing contractors have a limited amount of work that they can take on at a given time. You do not want to have all of your eggs in one basket, only to find you have a major project and your outsourcing contractor is unavailable.

If you are an electrical contractor, keep in mind your unique circumstances if you are considering outsourcing 3D modeling and coordination work. The limitations of the typical electrical Design-Intent Model are often schematic; they do not show the connections between the primary electrical systems and other electrical elements that require power. Unlike the other trades, an electrical contractor must both model and provide a level of "pre-design." When this type of work is outsourced, you are potentially at the mercy of how the firm or individual you've hired approaches pre-design as part of the 3D modeling and coordination process. Before this contractor begins work, you should gather information from the field to prepare a set of directives for the contractor to follow and for your team to use when reviewing the contractor's work.

BUILDING THE TEAM

3.8 Working Within the Collaborative Process

Large-scale collaboration is the new normal. Your firm's Project Team is now working at various levels with parties who, just a few years ago, did not participate in the coordination process. These parties include the Owner, the Design Team, and many other trade contractors, all of whom have needs and agendas.

One of the primary responsibilities of the Coordination Team leaders (see Section 3.3 [on page 21](#)) and of your company's BIM Manager is to identify where projects are struggling or getting off-track. The coordination process can be derailed or adversely impacted in many ways. Many of these problems can surface quickly. A Coordination Team that includes qualified, experienced, and professional coordinators should be able to recognize such problems or symptoms and to bring any trends or upcoming issues to your attention. And, obviously, they should not be the cause of such problems or difficulties.

On some projects, the Coordination Team participates in team-building exercises before work begins. This approach can be especially effective when key Project Participants have not worked together before or when the project is large and complicated. Many clients hire facilitators to run these exercises and continuously energize such teams.

The collaboration is also reflected in the models that each contractor delivers. These models should reflect an awareness and understanding of the architectural elements, the structural elements, and other MEP elements. They should acknowledge the relationship between the subcontractor's model and the models and systems of other Project Participants. The models must also include the necessary amount of detail and be free from interference with structures while providing reasonable access to equipment and devices for maintenance—and coordinate all this while the other trades are competing for the same space. Collaboration, cooperation, and standardized building systems and modeling processes are truly needed to make this repeatable, job after job.

Chapter 4

BIM EXECUTION PLANS

The purpose of a BIM Execution Plan is to define and communicate the “rules of the road” to all participants in the coordination process. Having a complete and comprehensive Execution Plan, with allowances provided for input by the major participants, is often the difference between a successful coordination process and one that falls short.

The contents of a typical BIM Execution Plan are of value and importance to MEP contractors, relevant to the coordination process, and critical to the roles, standards, responsibilities, and rules for how the project will be managed and built. An MEP contractor needs to know where to look and what to look for in this pivotal construction document. A number of elements and variables in a BIM Execution Plan can impact your estimate, detailing and virtual coordination costs, and installation scheduling, procurement processes, and labor and resource planning.

This chapter describes what you, a senior executive or Project Manager, should expect to find in an Execution Plan and how to review it. Your review should allow you to evaluate whether it contains important data and addresses the critical elements of a successful spatial coordination process with BIM before you bid on it. Also, although many MEP contractors participated in the coordination process long before some of their Construction Managers, trade partners, and designers did, the responsibility for preparing Execution Plans has shifted to the Construction Managers. Some information about how to write one is available in section 4.5 [on page 62](#).

This chapter discusses these topics:

- **4.1 The Contents of a BIM Execution Plan** [on page 38](#)
- **4.2 Model Management Procedures** [on page 52](#)
- **4.3 Schedules** [on page 59](#)
- **4.4 Reviewing a BIM Execution Plan** [on page 61](#)
- **4.5 Red Flags in an Execution Plan** [on page 62](#)
- **4.6 Authoring a BIM Execution Plan** [on page 65](#)

4.1 The Contents of a BIM Execution Plan

The contents of any Execution Plan reflect the size, complexity, and schedule of the project and the contractual responsibilities, deliverables, and competence of the participating individuals and firms. For any coordination process, a comprehensive BIM Execution Plan should, at a minimum, cover the following issues:

- Overview of the Process [on page 40](#)
- Team goals and Objectives [on page 40](#)
- The Organizational Structure of the Coordination Process [on page 40](#)
- Project Meetings [on page 41](#)
- Document Management and Maintenance [on page 44](#)
- Collocation [on page 45](#)

BIM EXECUTION PLANS

- Receivables [on page 48](#)
- Deliverables [on page 49](#)
- Orders of Precedence and Space Allocation [on page 50](#)
- Temporary Power, Lighting, and Services [on page 52](#)

A BIM Execution Plan that is included in the specifications or Request for Proposal should be reviewed carefully to completely understand the information it provides and the consequences of accepting or taking exception to its language or requirements before you bid the project.

4.1.1 Overview of the Process

Most BIM Execution Plans clearly define their scope of activities. Many Owners will have their own Execution Plans or requirements for them; however, the Construction Managers currently author most of them.

4.1.2 Team Goals and Objectives

A BIM Execution Plan usually defines its goals as they relate to the project. These goals normally include the following:

- Improve communication between all stakeholders
- Reduce the cost of a project to the Owner
- Reduce the schedule of design and construction
- Improve field efficiencies
- Improve design efficiencies
- Increase productivity
- Increase accuracy

To this list, add any internal goals that are included in your company's BIM Implementation Plan.

4.1.3 The Organizational Structure of the Coordination Process

Every BIM Execution Plan must include an organizational structure for the coordination process.

Each Execution Plan should identify the Project Participants and indicate the expected degree of their involvement, including the anticipated starting and disengagement points during the process. It should also identify the nonactive participants who can or should be called upon as necessary. If you recognize, either when reviewing this Plan or during the kick-off meetings, that significant parties are not included or that they will not participate in the process until it is too late to avoid problems, this omission should be addressed as soon as possible.

BIM EXECUTION PLANS

Each Execution Plan must assign basic leadership roles to specific individuals and clearly describe their responsibilities and authority. These roles, although they may have different titles, are presented in section 3.3, “Roles and Responsibilities on the Coordination Team” [on page 21](#).

- The Project Coordination Manager
- The Project Model Manager
- The Lead MEP Coordinator
- The individual domain-specific and MEP Project Team leaders or managers

Note that these roles and any others included in the Execution Plan can be filled by one or more individuals, or several roles can be assigned to one person. Regarding these role assignments, it is important to understand the following:

- All the responsibilities assigned to the role
- Whether all important responsibilities have or have not been addressed
- Whether the individuals assigned to roles have the experience and credentials to perform them successfully

4.1.4 Project Meetings

The BIM Execution Plan should provide basic information about project meetings:

- Which meetings are required
- When and where these meetings will be held
- Who is expected to attend

Some of these meetings are held only once; others are held throughout the coordination process. Video conferencing software and web-based meeting applications make it possible to hold some of these meetings in cyberspace. This might become the standard practice or just an option to accommodate weather, travel schedules, or emergencies.

1. Kick-Off Meetings

A comprehensive kick-off meeting held before the Coordination Team begins work is an extremely good idea. To prepare for such a meeting, many best-in-class Construction Managers meet with the major contractors to preview their approach and obtain input on many of the subjects that will be addressed.

For most projects, each MEP contractor sends many representatives to the kick-off meeting. Successful projects invite representatives from the Owner, the Architect, and the Design Team. When the project

BIM EXECUTION PLANS

is large, complex, or of long duration, a collaboration facilitator often attends or leads the meeting. The BIM Implementation Plan should designate who attends this meeting, but at the minimum, your Project Manager and BIM/Spatial Coordination Manager should attend.

The agenda for this meeting should be provided in advance, giving each participant adequate time to review it and prepare.

Kick-off meetings often set the tone for collaboration and cooperation, and it is hard to get a second chance to make a first impression and establish credibility. Your company should be represented by experienced individuals who know the business, understand the expected processes, and can and will communicate concerns and issues effectively.

First impressions go both ways, and what you observe or learn in the kick-off meeting may raise concerns about the experience, competence, flexibility, or practicality of Project Participants or those in leadership roles, and other red flags. If you or your representatives recognize challenges ahead that were not addressed, you want to communicate your concerns to all the appropriate parties.

Document any critical details from these meetings that are included in the agenda or the hand-outs. Also, review the official minutes to ensure that any important verbal clarifications or instructions provided during the meeting are appropriately documented.

If a spatial planning meeting has not been included in either the Execution Plan or the agenda for the kick-off meeting, the kick-off meeting is the forum in which to request one.

2. Spatial Planning Meetings

The spatial planning meeting is the second meeting, or set of meetings, in the cycle. At this meeting, the members of the Coordination Team plan the process for the work ahead. Issues to be addressed include the conceptual routing of major MEP components and systems within the architectural spaces allocated for their installation. The primary goal of this meeting is to establish the ground rules that the detailers should follow when they begin drafting their systems routing and elevations so that the number of first-pass clash-detection conflicts is low. Some Participants may attempt to claim space, and the Coordination Team should resist this effort.

It is a good practice to include the facilities maintenance personnel in this meeting. They may have concerns about access or maintenance that are not incorporated into the design documents; they may have other prudent input that would best be addressed before coordination work begins. When the project is finished, you will hand off your work product to these individuals. Having them in the loop is good client relations.

BIM EXECUTION PLANS

This meeting is rarely included in a BIM Execution Plan; however, this exercise can unquestionably expedite the coordination process and is a proven best practice. If not mentioned during the kick-off meeting, your firm's representatives should vigorously request one.

3. Coordination Meetings

Spatial coordination is a meeting-intensive process, and the coordination meetings are where the bulk of the work is done. Chapter 5, "Managing the Process" [on page 67](#), covers much of this work and what needs to be in place for the Coordination Team to be successful.

The BIM Execution Plan should provide this information:

- The project schedule
- A list of attendees
- The time and location for the meetings

Your BIM Implementation Plan should indicate the roles and responsibilities of your personnel who attend these meetings. Your project management staff and your team's coordination leader should attend these meetings. If your Project Managers cannot attend every meeting, they should attend the first few as the project moves forward in order to understand the tone and context of how these meetings will run throughout the construction phase.

The trade-offs of physical versus virtual attendance are probably most important for coordination meetings. The early meetings may benefit from mandating physical attendance; once the Coordination Team has learned to work together effectively, virtual attendance can be just as effective and less burdensome.

4. Design Team Meetings

The BIM Execution Plan should acknowledge the occasional necessity for members of the Design Team to attend particular meetings. Ideally, the Design Team participates in the kick-off meeting and the spatial planning meeting.

For the coordination process to be successful, the Design Team must attend all meetings that address space allocation problems, missing design information, or issues that might change the performance of an engineered system. The old-school attitude of "submit a formal question and we will respond when we have to" runs absolutely counter to the practices of a successful coordination process. Follow-up confirmation documentation is a proven method for recording the decisions and instructions from Design Team members during any coordination meeting.

If the Project Coordination Manager is not responsible for creating and submitting such documentation, the BIM Execution Plan should specify the roles or the individuals who are.

BIM EXECUTION PLANS

Any confusion over what constitutes “normal and expected coordination” and what constitutes “design or redesign” can contribute to tension between the Coordination Team and the Design Team. Meeting with the Design Team early to discuss this subject contributes to good relations. Push to include a definition of “coordination means and methods” in your job scope and use it to determine when a change to the Design-Intent Model constitutes redesign or a design change that justifies the additional cost of change orders.

Make the Design Team aware of the coordination schedule and encourage them to make themselves available via online conferencing should the need arise.

Before coordination is complete, many MEP contractors have found it useful to offer the principal MEP Design Engineers a thorough fly-through of the MEP models (Figure 4.1 on page 44). This review provides these professionals with an understanding of the effort that has gone into the coordination process and serves to circumvent unnecessary punch lists or installation questions or critiques.

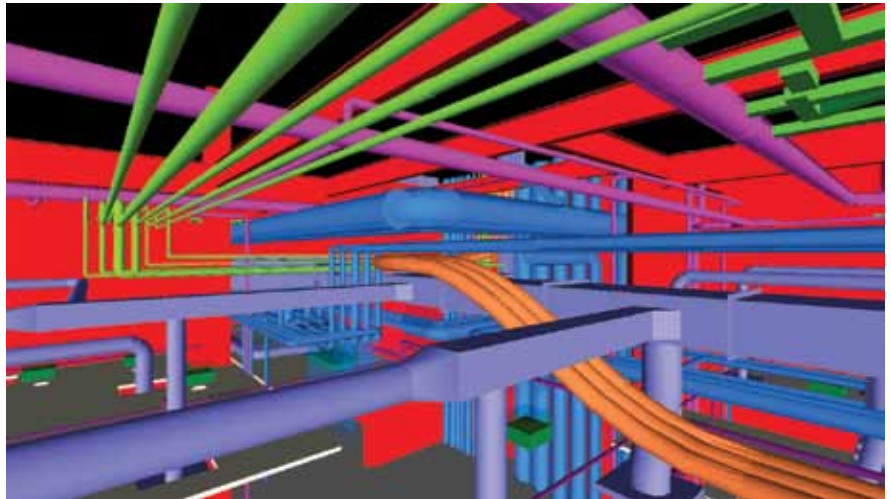


Figure 4.1 Fly-through of an MEP Model Before Sign-off

5. Sign-Off Meetings

Many, if not most, BIM Execution Plans establish sign-off protocols for the project. Most projects require interim partitioned area sign-offs of both models and drawings. After these models and drawings are approved, they should be “locked and archived within the Document Control system for the project. (For more details, see Chapter 5, “Managing the Process” on page 67)

4.1.5 Document Management and Maintenance

Most projects today use two separate document control systems; one stores BIM-related modeling and drawing data, and the other manages

BIM EXECUTION PLANS

other types of documents, such as submittals and RFIs. What information is stored in which system varies from project to project.

When working with coordination documents, every Project Participant needs to be working from the same set of common BIM-related documents, receive changes made to these documents as soon as the changes are available, and incorporate the changes into their own work.

The Project Coordination Manager has several responsibilities in this area:

- Fulfill any contractual obligations for Documents of Record, as described in Chapter 6 [on page 85](#).
- Promptly post or otherwise distribute all data pertinent to the goals of the BIM Execution Plan
- Provide notice and access to all updated documents and records to all participants
- Maintain complete, accurate, and current files and records of all version updates, data exchanges, issues and RFI logs, instructions, and communications and make this information available to all participants, as needed
- Maintain complete, accurate, and current files and records of all information provided during the process by all Project Participants
- Provide methodologies for all Participants to copy any Documents of Record needed to satisfy any company-specific or legal requirement that may be contained in these files and records

Regarding document management and maintenance, the BIM Execution Plan should clearly define these items:

- Who will actively manage and maintain all common files and records
- Where these files and records reside (FTP sites or other repositories)
- All access and security protocols

4.1.6 Collocation

Some BIM Execution Plans require that the members of the Coordination Team, along with personnel of the other major trade contractors, collocate in a common facility (often referred to as a “BIM cave”), usually at the construction site. The goal of collocation is to foster collaboration, promote direct communication, and accelerate the recognition and resolution of coordination issues.

MEP contractors rarely make the decision to collocate. They do so because it is usually imposed under the terms of the RFP or contract. Depending on the contract requirements, collocation can extend to every member of the Coordination Team involved with the project, to

BIM EXECUTION PLANS

some key members of the team only, or to a scheduled blending of both scenarios. The length of this arrangement is often left vague, defined as “until the coordination process is complete.”

Collocating your personnel can have a significant impact on your firm and its resources. The impact may be positive or negative, but it does need to be carefully studied before bidding the project and clarified as needed within the BIM Execution Plan. Limitations or restrictions that fall outside your normal business practices may be required.

New contracting types such as Integrated Project Delivery (IPD) are becoming popular. Most of these project delivery processes have clear expectations that certain key personnel are housed together to achieve their project goals (Figure 4.2 on page 46).



Figure 4.2 A Collocation Site

Before you agree to such an arrangement, consider the impact on your business.

Collocation can cost you significant control of your operations and your assigned staff. Construction Managers usually expect your collocated staff to work only on their project; therefore, they may not be available to work on other projects even when they have nothing to do on this one. If your ability to juggle tasks and projects to make the best use of your personnel on projects for other clients is compromised, can you still operate and meet your other commitments for the duration of this project?

BIM EXECUTION PLANS

Also, your collocated staff members may find themselves operating in a gray zone. Construction Managers may go directly to detailers with tasks, directions, or critiques that purposely or unintentionally circumvent your established chain of command. Who will supervise your collocated personnel?

Collocation also affects your personnel. Can the people who are not working on the project contact their colleagues with questions on other projects or for informal mentoring and guidance? Will you need to supplement your staff to fill the gaps? If so, how will the need to do more supervision affect the productivity of your remaining staff?

Also, special effort may be needed to provide adequate support to your collocated staff. For example, detailers can become isolated and removed from the resources and mentoring they get from working with the rest of your staff.

When you choose the personnel to send to the BIM cave, you need to consider the skills and personal attributes that will contribute to the success of the project.

- Can the individual adapt to a new organizational structure, work under new supervision, and maintain a proper chain of command both within the project and your company?
- Does the individual have the discipline to document their work, maintain adequate daily logs, and resist the distractions and the constant demands on their time that they may not be accustomed to in your firm's environment?
- Can the individual stay within the scope of the coordination process? Can the individual avoid two common areas of mission creep, namely, providing design-related solutions without the EOR's approval and providing more detail and development than required?

The cost of collocation can be determined more by time spent on site than the scope of your firm's contract. Your estimate may have to be based on the duration of collocation and required staffing rather than the multipliers you usually use to estimate project coordination. How will cost tracking and budget objectives be monitored and measured? Will the Engineers of Record also be collocated? Will they oversee all design and model developments, and author and sign off on all coordinated drawings and models?

The size, layout, and technical infrastructure at the collocation site are factors that impact an effective working environment. Although the collocation site is temporary, it needs to provide your personnel with the resources that support the level of productivity that is available in your office.

BIM EXECUTION PLANS

The site must provide each Project Participant a cool, comfortable, well-lit, and well-equipped individual workspace; it must also provide a separate space where the team meets for the clash-detection process. Avoid cramming people into one conference room or a spare office that is also used for team meetings.

As for the equipment required, keep in mind that detailers often need two large monitors for their design software and storage space for construction documents and other records. For clash-detection meetings, consideration should be given to the type of projector that the budget and the space can accommodate. A large wall-mounted monitor is recommended; a high-lumen projector (5,000+ lumens) is another option. Other equipment includes the infrastructure for remote access, printers, scanners, and other devices and networks that require shared access.

The management of the file-sharing server deserves attention. This includes equipment and policies, which are described more fully in Chapter 9, “BIM Technologies for an IT Infrastructure” [on page 129](#). These are the basic issues:

1. How it is to be managed?
2. Who is responsible for ensuring that seamless, shared, and easy access to digital documents is available 24x7 throughout the process?
3. How will the Coordination Team interact with the Design Team?
4. Will proper Documents of Record be kept?
5. Will you have remote access to the Documents of Record?
6. Will your company have copies of all final documents, including drawing and model revisions?

4.1.7 Receivables

Every BIM Execution Plan must start somewhere. Within the context of this Guide, the Execution Plan and the spatial coordination process that follows must begin with the information and documents that Project Participants receive before they begin work on the Coordination Team.

Most Execution Plans include a list of receivables that the Design Team provides to the Coordination Team. This information almost always includes these items:

- A list of drawings and their version dates
- Comprehensive specifications
- Sections of any Requests for Proposal
- Applicable references
- Copies of or links to appropriate Design-Intent Models

BIM EXECUTION PLANS

On a Design-Bid-Build project, any receivables from the Design Team that do not achieve the Level of Development that the Coordination Team expects should be clearly identified at the kick-off meeting so that appropriate schedule adjustments or scope-of-work issues are addressed. When Design Teams recognize that their Design-Intent Models may not satisfy the specified Level of Development or Level of Detail and fail to notify anyone of this condition early, the Coordination Team finds itself dragged into the coordination process under far more difficult circumstances.

4.1.8 Deliverables

Good BIM Execution Plans list or describe the deliverables expected from the Coordination Team and the format (or software platform) in which to produce them. These deliverables include the items described in the project specifications as deliverables to the Owner at the end of the process, and all documents, drawings, and models required during the procurement, prefabrication, construction, and commissioning phases of the project.

The Level of Development specified for domain-specific Deliverables and Receivables, which defines what you can expect to receive and then deliver in a LOD 350 and LOD 400 construction drawing, is an important component of a BIM Execution Plan. For example, an Owner might expect that the LOD 400 construction model delivered as a contract submittal includes ½" conduit, but electrical industry standards may exclude the modeling of conduits smaller than 2". Such a disconnection from the parties who are paying the bills can be a very unpleasant experience.

Another challenge arises when Construction Managers or outside authorities demand models or annotated drawings from the models that may never have been clearly described in any documents. Such demands introduce confusion, delay, and questions of responsibility into the process. All such deliverables should be clearly delineated in the BIM Execution Plan.

Each contractor may also have deliverables that, although not shared with the other participants, are needed for internal purposes, such as procurement, prefabrication, materials control, task management, and labor tracking. Some of this information will be derived from your firm's input into the coordinated model, and some of it will be derived from the input of other firms that contribute to this model. When reviewing a BIM Execution Plan, your staff should also be aware of these deliverables, particularly their scheduling requirements, and be willing to communicate your needs to the other members of the Coordination Team.

BIM EXECUTION PLANS

4.1.9 Order of Precedence and Space Allocation

Long before the advent of BIM, the industry wrestled with its need to establish some semblance of priority and order for space allocation on construction projects. The term “order of precedence” has peppered standards and specifications in the construction industry for years.

When spatial coordination was done with only 2D drawings, even when orders of precedence had been specified or defined, many problems arose from the misunderstandings or misinterpretations of engineers or trades relative to conflicts with hangers and support systems for higher priority components. It took some very skilled professionals to evaluate and work through such matters, with their best—and only—tool being a light table. The use of 3D modeling and BIM has made more details visible to many more stakeholders.

The necessity for ground rules carries over to the world of virtual construction. A good BIM Execution Plan recognizes and incorporates provisions for equitable space allocation and order of precedence, yet these provisions may not be exactly the same as those found in construction specifications.

Although the intent of most members of the Coordination Team is to be fair and reasonable with the rest of the Project Participants, there is a pecking order that is used to establish order of precedence. This installation sequence can vary from project to project and is affected by size, weight, importance of systems, maintenance requirements, and so on. This is a common sequence:

1. Structures
2. Major pieces of equipment
3. Reflected ceiling lighting and light fixtures
4. Gravity steam and plumbing lines
5. Major ductwork
6. Large piping mains
7. Large electrical conduit and cable trays
8. Pneumatic tubes
9. Water lines, plumbing vents, medical gas lines, sprinkler lines, other small bore piping
10. Small conduit, hangers and supports, and other small or incidental items

Most BIM Execution Plans that describe an order of precedence follow this sequence. Few Execution Plans recognize that these sequences also should be evaluated during the coordination process. Unique or unorthodox installation requirements or decisions can wreak

BIM EXECUTION PLANS

havoc later on if the Coordination Team encounters them after its own process is underway. Discussing these situations in detail during a spatial planning meeting can prove worthwhile and informative to everyone.

Having an established order of precedence should not be construed by any contractor as a right to claim space or exercise unilateral authority over the other Project Participants. It doesn't take a lot of experience to understand that common sense enhanced by technical knowledge offers the best approach to evaluating and resolving conflicts without imposing unreasonable costs or impacts on system performance.

Well-thought-out BIM Execution Plans may include several orders of precedence, each tailored to the requirements of different areas in the building. For example, installation sequence in a mechanical or electrical room is significantly different from that in an office or garage space.

Another consideration in determining order of precedence is the quantity and spatial usage of any particular trade that supplies material and equipment to a particular type of building. As illustrated in the LOD 350 model detailed by an electrical contractor in Figure 4.3 [on page 51](#), it makes perfect sense that the first contractor or precedence is the electrical contractor because the most significant amount of material and equipment is the electrical system. In Figure 4.4 [on page 52](#), the most significant amount of material and equipment comes from the mechanical contractor, who should expect that similar consideration to the proper order of precedence be given to the sheet metal contractor.

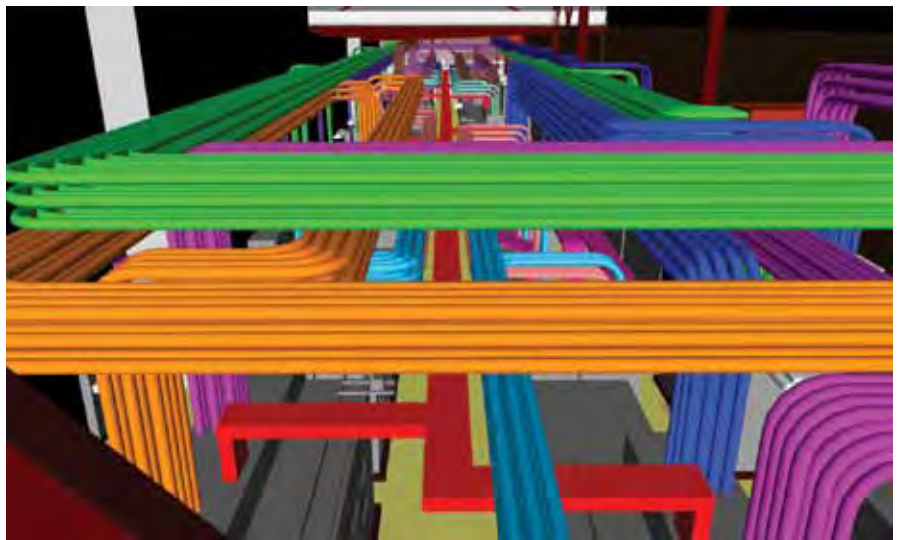


Figure 4.3 Electrical coordination-ready model at LOD 350

BIM EXECUTION PLANS



Figure 4.4 Mechanical coordination-ready model at LOD 350

4.1.10 Temporary Power, Lighting, and Services

The needs of temporary services, such as power and lighting, are frequently overlooked when establishing an order of precedence.

How to accommodate these temporary services, especially power, falls within the scope of the Coordination Team's work. Every contractor needs to know the locations of the penetrations, conduits, and raceways used for these temporary services; how long they will be needed during construction; and how much clear access is required to remove them.

Because most temporary systems are not indicated on any contract drawing and are never included in a Design-Intent Model, establishing this order of precedence in the BIM Execution Plan should prevent the Coordination Team from overlooking these systems or failing to give them appropriate level of consideration before the coordination process begins. Thinking this through before work begins avoids turmoil and installation sequence nightmares.

4.2 Model Management Procedures

The success and efficiency of the coordination process depends on how easily the team can submit, share, update, and merge electronic files.

4.2.1 File-Sharing and Posting Conventions

The BIM Execution Plan should establish policies and protocols for sharing project files. These policies include establishing the software platforms and versions that will be used to aggregate individual models from MEP contractors into the Model.

BIM EXECUTION PLANS

An acceptance of any file-sharing process is instrumental to the successful exchange of critical information. Although most Design-Intent Models indicate or stipulate the Design Team's preferred platform for the construction process, this choice is not always cast in concrete. The BIM Execution Plan should clearly establish the expectations for the project.

The BIM Execution Plan should define a repository for this exchange of data; details about how the data will be managed should be provided at the kick-off meeting. The MEP Coordinator is often the most qualified party to establish the most effective file-sharing practices and procedures.

The BIM Execution Plan should include the following standards or protocols. If this information is omitted, consider submitting an RFI to clarify any concerns.

- A clear statement of where shared project files are to be stored (repositories). If an FTP site is used, the account name and password details should be given to every authorized Project Participant. If a web-based cloud application is used, all location and access information should be provided.
- The naming conventions for files that are shared (see section 4.2.3 on page 55).
- A network path to the repositories and a notification mechanism to inform Project Participants when files that their models use have been updated. These practices contribute to efficiencies and process quality when sharing and exchanging this data.
- To maintain the integrity of working files, the PCM or MEP contractors should "scrub" a copy of any files they intend to use for this project. Scrubbing removes all external references and linked files from any shared files. (For details on scrubbing, see Appendix C on page 156.) One exception may be the equipment OEMs, which carry through to the software platform used for spatial coordination.
- Establish a schedule for uploading files. This schedule should allow adequate time before any coordination meeting for the Lead MEP Contractor to merge these files and for each contractor to prepare adequately for the next coordination meeting.
- Establish a protocol for responding to changes or revisions issued by the Design Team or Owner.

4.2.2 File Formats and Compatibility

The BIM Execution Plan should list the electronic file formats that will be supported.

BIM EXECUTION PLANS

Every software application creates files in a proprietary format that is described by the three-letter extension at the end of the file name. Generally, these files cannot be opened, viewed, or edited by other software applications unless the software publisher has released, licensed, or otherwise enabled the creation of data file viewers or converters.

This is an obvious problem for a business process that requires people to share electronic information. To address it, the publishers of most spatial coordination applications have negotiated with software manufacturers of BIM and 3D/CAD applications to incorporate technology that allows the spatial coordination applications to open files created in dozens of different proprietary software file formats and to view and possibly edit the data from those files once imported.

Be aware that this data-exchange “highway” is usually a narrow one-way street. The data imported into the spatial coordination application is a subset of the data in the original source file (typically, little more than the geometry), and it is rarely possible to export files from the spatial coordination applications back into their native file formats.

Nevertheless, the ability to import geometry from multiple proprietary file formats into the spatial coordination application is usually sufficient to allow the Coordination Team to collaborate, while allowing individual members to use the modeling application that they prefer. That said, the greater degree of compatibility among file formats on a specific project, the more easily information can be shared, and the richer the shared data set can be.

Another data-format compatibility option can be found in publicly available, open data standards, such as the IFC file format of the buildingSMART Alliance. Open data standards provide a neutral data exchange format between proprietary software applications. Software applications that support open data file standards typically allow users to import and export files in the open-standard format. In practice, this does not always work. It all depends upon whether the software applications support the open-standard file formats are compatible.

It is imperative that each Project Participant identify their native file format to the Model Manager, and cooperate in any testing that may be needed to confirm that their data files can be imported correctly into the spatial coordination application.

Some project specifications may be less flexible, requiring Project Participants to submit files in a specified format. If a proprietary file format is specified in the contract documents, be sure to resolve this issue during the bidding phase. Ignoring or dismissing this requirement can be a costly mistake (see Chapter 8, “Evaluating Spatial Coordination Contract Language” [on page 115](#)).

BIM EXECUTION PLANS

4.2.3 File-Naming Conventions

Although it is often overlooked or disregarded, a coherent, logical, and comprehensive file-naming convention for the project can greatly streamline the coordination process. These conventions should, whenever possible, be addressed in the BIM Execution Plan.

The importance of file-naming conventions to successful spatial coordination cannot be overstated. When files are named consistently, the Model can be updated easily and frequently, and all Project Participants can learn a great deal about the organization and status of the coordination effort simply by scanning the model file names.

When a file-naming convention does not exist or is not followed by even one team member, confusion reigns. Files may be accidentally deleted or overwritten, errors multiply, team members become frustrated with each other and the process itself, and productivity plummets.

The Model Manager uses the spatial coordination software selected for the project to merge the individual models into a single Federated Model or several submodels, and then performs clash detections on the Federated Model. This is an iterative process that is performed until the coordination process is completed.

If a file-naming convention is adhered to, the Model Manager should be able to automatically or semi-automatically update the Federated Model with every iteration of the native model files. If the files are inconsistently named, the update process can be extremely laborious and prone to error.

A data file name is more than just a name: it is vital part of efficient information management, greatly reducing the cycle time for the entire coordination process. Some modeling systems allow for model updates as frequently as the moment the model is saved, ensuring that all team members always have the most current information available. Taking full advantage of this powerful collaboration technology is possible only if the update process can be automated. A good file-naming convention has a very big payoff for a very small investment.

File-naming conventions should use easily recognizable abbreviations that accurately identify the content of the file. The use of underscores, rather than spaces, to separate words or abbreviations in file and folder names is strongly encouraged. This practice helps ensure that file and folder names are not inadvertently truncated during data transfer.

A good file-naming convention uses a standard nomenclature, with distinct words or abbreviations, representing distinct types of information that always appears in a specified order. The following are typical required elements of a file-naming convention:

BIM EXECUTION PLANS

- Project name or number
- Building or area
- Floor level
- Trade or discipline
- Additional elements can include:
- Company name

If files will be updated automatically, do not include the date and revision or version number in the naming conventions. Automatic updating involves overwriting existing files of the same name. If team members include any information other than what the updating script looks for, the automatic updating process fails; the date and time that a file is saved is recorded in a separate data field by the operating system, so including the date or revision number in the file name is not usually necessary. Also, most file-sharing websites have the ability to track revisions and pull them up, if necessary. This function has practically eliminated the need to add dates and revisions numbers to documents.

If the date and the revision or version number are required in the file name for some other reason, this information should appear at the end of the file name. This convention makes it easier for the Model Manager to identify and consistently remove this information before updating the Model.

Here's how a file-naming convention works. Consider the following information:

University Hospital; Area A1; Basement (Level 0); Electrical,
Ace Electric Company; 2012-07-24; Revision 1

The file that includes this information can be named this way:

UNHP_A1_L0_ELEC_AEC_2012-07-24_v1

When Model Manager truncates this file name to remove the date and the version number before updating the model, the file name is shortened to this:

UNHP_A1_L0_ELEC_AEC

Consider now the information in another file for this project:

An HVAC Model for Area 2, Fifth Floor, created by Northwest
Mechanical Contractors, Inc.

The file name for the same submission date and version is this:

UNHP_A2_L5_HVAC_MCI_2012-07-24_v1

BIM EXECUTION PLANS

As you can see from this example, a file-naming convention that is used consistently makes it possible for any team member to scan a list of files and identify the content and author without having to open a single file. An important element of a file-naming convention is that the number of characters (letters or numbers) in each part of the file name be consistent for all files. The example above uses four characters for the project name, two for the building area, two for the level, four for the trade or discipline, and three for the authoring company.

When this convention is followed, scripts can be run on large data sets of files, which is an extremely useful information management tool.

	Layer Name	JCC-ME		JCC-HP		JCC-RP	
		Layer Color	Layer Color	Layer Color	Layer Color	Layer Color	Layer Color
Administration	Sleeves & Cores	SLV	12	SLV	12	SLV	12
	Sleeving Dimensions	SLV-DIM	12	SLV-DIM	12	SLV-DIM	12
	Sleeving Text	SLV-TEXT	12	SLV-TEXT	12	SLV-TEXT	12
	Hangers	HANGER	0	HANGER	12	HANGER	12
	Equipment	EQUIP	0	EQUIP	0	EQUIP	0
	Equipment Pads	PADS	0	PADS	0	PADS	0
	Dimensions	DIM	Layer Specific	DIM	Layer Specific	DIM	Layer Specific
	Number Text (CAD-Mech)	TEXT	Layer Specific	TEXT	Layer Specific	TEXT	Layer Specific
	Size Text (CAD-Mech)	SIZE-TEXT	Layer Specific	SIZE-TEXT	Layer Specific	SIZE-TEXT	Layer Specific
	Level Text (CAD-Mech)	ELEV	Layer Specific	ELEV	Layer Specific	ELEV	Layer Specific
	General Text	TEXT	Layer Specific	TEXT	Layer Specific	TEXT	Layer Specific
	Conflict Notes	CONFLICT	Layer Specific	CONFLICT	Layer Specific	CONFLICT	Layer Specific
	Resolved Conflict Notes	CONFLICT-RES	Layer Specific	CONFLICT-RES	Layer Specific	CONFLICT-RES	Layer Specific
	Revision Notes	REV-DESC	Layer Specific	REV-DESC	Layer Specific	REV-DESC	Layer Specific
	Beam Penetrations	BP	Layer Specific	BP	Layer Specific	BP	Layer Specific
Medical/Lab Gases	Beam Elevations	BEAM-ELEV	Layer Specific	BEAM-ELEV	Layer Specific	BEAM-ELEV	Layer Specific
	Access Panels	AP	Layer Specific	AP	Layer Specific	AP	Layer Specific
	Room Numbers	RNA-NUM	Layer Specific	RNA-NUM	Layer Specific	RNA-NUM	Layer Specific
	Steel	Steel	1/2	Steel	1/2	Steel	1/2
	Insulation	INS	9	INS	9	INS	9
	Argon	AR	95	AR	4	AR	4
	Carbon Dioxide	CO2	20	CO2	4	CO2	4
	Carbon Monoxide	CO	24	CO	4	CO	4
	Oxygen	OX	105	OX	4	OX	4
	Nitrogen	NIT	33	NIT	4	NIT	4
Storm	Compressed Air	CA	142	CA	4	CA	4
	Medical Air	MA	4	MA	4	MA	4
	Vacuum	VAC	30	VAC	4	VAC	4
	Nitrous Oxide	NO	212	NO	4	NO	4
	Hydrogen	H2	37	H2	4	H2	4
	Helium	HE	126	HE	4	HE	4
	Instrument Air	IA	144	IA	4	IA	4
	Rain Water	RW	0	RW	4	RW	4
	Rain Water Pumped Drain	RWP-DR	0	RWP-DR	4	RWP-DR	4
	Siphonic Rain Water	RWSIPH	0	RWSIPH	4	RWSIPH	4
Underground	Domestic Water UG	DWA-UG	3	DWA-UG	4	DWA-UG	4
	Garage Drain UG	GD-UG	25	GD-UG	4	GD-UG	4
	Kitchen Waste UG	KW-UG	3	KW-UG	4	KW-UG	4
	Natural Gas UG	NG-UG	7	NG-UG	4	NG-UG	4
	Rain Water UG	RW-UG	0	RW-UG	4	RW-UG	4
	Sanitary UG	SAN-UG	5	SAN-UG	4	SAN-UG	4
	Underfloor Drainage	UFD	95	UFD	4	UFD	4
	Natural Gas	NG	6	NG	4	NG	4
	Chamber Vent	CV	11	CV	4	CV	4
	Garage Drain UG Vent	GD-UG-VENT	10	GD-UG-VENT	4	GD-UG-VENT	4
Mechanical Venting	Lab Vent	LAV-VENT	10	LAV-VENT	4	LAV-VENT	4
	Natural Gas Vent	NG-VENT	30	NG-VENT	4	NG-VENT	4
	Radon Vent	RADON	30	RADON	4	RADON	4
	Rain Water UG Vent	RW-UG-VENT	0	RW-UG-VENT	4	RW-UG-VENT	4
	Storm Water UG Vent	SW-UG-VENT	0	SW-UG-VENT	4	SW-UG-VENT	4

Figure 4.5 Project Layer Standard Document

4.2.4 Model Partitioning

When you start to model your systems, you need to consider how to partition your model to set a limit on file size. Smaller files can dramatically improve system performance, but other considerations may be in play. For example, you may need to deploy multiple resources

BIM EXECUTION PLANS

on a project. Because two people can't work in the same file simultaneously, you may need to partition the model based on the division of labor. A plumbing contractor could partition by splitting the medium-pressure duct from the low-pressure duct plumbing from piping systems, and even go as far to separate drainage systems from pressure plumbing. The trick is to keep the file size manageable, say less than 15 MB, while ensuring that the detailers who work in them can do so whenever they need to.

4.2.5 Drawing Sectioning and Key Plans

All construction projects need Drawing Sectioning and Key Plans. The Design Team usually provides these plans, which carry over, in some fashion, to the 2D deliverables from the coordination process. If there is a benefit to modifying the numbering, sectioning, or points of reference from the construction models for these drawings instead of using the Design Team's protocols, the kick-off meeting is a good forum to raise the issue.

The sectioning of drawings, breaking them into logical and manageable sections or areas, is often determined by the Design Team's drafting criteria, for example, how much area a typical 1/8" or 1/4" scale drawing covers. Designers may divide their drawings by structural grid lines or concrete expansion joint locations. Complex areas may be sectioned into smaller parts when detailed drawings are needed, for example, for mechanical or electrical rooms.

All sectioned drawings also require the imposition of a point of reference, usually North arrows.

4.2.6 Default Standards and Tolerances

Detailing and coordination efforts on a project should have pre-established standards and tolerances by which all participants on that project should abide. These standards and tolerances should be discussed and agreed upon during the project's kick-off meeting. An example of a common standard for is the layer document in Figure 4.5 [on page 57](#). Examples of common tolerances frequently found on MEP projects include a set of minimum clearances to be maintained whenever possible between objects of different systems or structures, steel fireproofing tolerances, dimensions for areas of influences for hangers and inserts, "no-dig" zones for foundation areas of repose, electrical panel clearances, and supplemental clearances for fire-sprinkler inspection. Annotations for elevations and dimensions are usually defined to be within 1/8" tolerance, except for underground, which is not typically at the 1/8" level of precision.

BIM EXECUTION PLANS

4.3 Schedules

Many BIM Execution Plans include coordination schedules, some only make reference to schedules included under different areas of the specifications or contracts, and some simply assume that the coordination process will stay ahead of the actual project construction schedule.

If schedules are included in the Execution Plan, it is imperative that your entire estimating, operations management, and coordination staff are aware of this and review these schedules very carefully. If the major subcontracting community, especially the MEP trades, have not been given the opportunity to have input into such a schedule, then the earlier you are able to provide input, the better your chances to make the Execution Plan a useful and mutually effective document.

In the preliminary planning phase of a construction project, Construction Managers often make serious errors when assembling their spatial coordination schedules. These errors are the most common:

- Attempting to start the coordination process before all prerequisite components or information for a given area is available. Less-experienced Construction Managers often fail to consider that MEP coordination components are integral parts of the building's systems; trying to coordinate particular systems before the adjoining systems have been locked down can invalidate any coordination work that is done too soon. One example of this problem is trying to coordinate under-slab plumbing piping before walls or equipment locations are locked down on the slab above. Such synchronization problems can arise in particular types of projects, such as health care facilities, and in specific domains; electrical contractors in particular, often find themselves in a position of starting coordination long before they anticipated. In this respect, it may be prudent to anticipate the need for additional resources and time in your budget and planning process. In addition, some Construction Managers and General Contractors may require that you to begin coordination before you can get approved submittals or finalize value engineering options. This could become an issue. Equipment is typically larger than shown; if a placeholder piece of equipment is used for coordination, when the equipment is purchased and installed, there is a strong possibility that, in a cascading and problematic way, connections on equipment, piping, electrical, duct, and fire protection systems all have to move. Coordination before approved submittals is almost a guarantee of rework.
- Disconnecting the coordination schedule from the construction installation schedule. The primary purpose of the coordination process is to assist the construction process. Certain drivers of the deliverables from the coordination process are critical to its success. Among these are dates for sleeving and inserting decks, equipment and long-lead

BIM EXECUTION PLANS

procurement release dates, and fabrication release dates. A good coordination schedule should start from these important milestones and work backward, making the adjustments required to benefit the entire construction project. Rarely can this be done without significant MEP input into a schedule.

- Assuming that the coordination process and model partitioning must follow, in lock step, the concrete pour sectioning. For MEP contractors, this can be very difficult if you are working to an aggressive coordination schedule that has no float available. Some building systems cannot be coordinated accurately if the starting point is the middle or the wrong end, for example, coordinating ductwork branches and mains before knowing where and how the duct risers fit.
- Assuming that no construction in an area can start until the coordination process is complete. One of the first elements of a model that the construction process needs (sleeves and inserts) is the last thing that is typically added to the Model. Every effort should be made to coordinate and complete this piece of the Model before construction starts.
- Tying construction-related coordination schedules to a permit approval process. This coupling may be necessary for a few elements, such as seismic or FM (Factory Mutual) approvals, but making direct links between these activities should be discouraged.

4.3.1 Phasing

Some BIM/Execution Plans lay out a coordination phasing process that is different from yours or from that of the local construction industry's normal detailing and coordinating process. Such phasing plans can dictate the population of the components and/or intelligence into your MEP models in a fashion that is inconsistent with your standard sequencing. This inconsistency can impact your process in a number of ways:

- Increasing the number of coordination passes or iterations to finalize an area. Simply by definition, a three- or four-pass process can require five or more passes just to follow a phasing plan.
- Inserting components into your models at a different point time than normal, thus requiring additional detailing passes through your internal models.
- Frustrating your experienced detailers. They know that everything they produce in an early phase will change because they know what must happen in a later phase, for example, coordinating duct mains before the king-studs for doors are in place. Morale can drop when dealing with professionals under such situations.

BIM EXECUTION PLANS

4.3.2 Scheduling and Sequencing of Construction

Some BIM Execution Plans stipulate what and how the Models developed by the Coordination Team are to be used for construction sequencing or scheduling. BIM is an extremely powerful tool for visualizing construction sequencing. The more that construction superintendents and trades supervisors use BIM, the higher the payoff for everyone involved.

Some Execution Plans, usually those authored by consultants, go so far as to attempt to merge the spatial coordination process into a dynamic CPM scheduling process. Although a good CPM is critical to the success of any large construction project, tying two dynamic processes to each other can become far more of a project than the construction itself. MEP contractors are well advised to avoid becoming entangled in such programs, if possible.

4.4 Reviewing a BIM Execution Plan

Any BIM Execution Plan must be reviewed carefully by individuals within your firm who understand the coordination process, estimates, schedules, budgets, contracts, and risks. Originally intended to assist the Coordination Team in guiding their work, many of these plans have evolved into detailed contract specifications or requirements with full legal and financial implications.

There are a number of expectations delineated in certain BIM Execution Plans that MEP contractors should keep an eye out for. How to effectively recognize, address, and respond to any of these issues is solely a business decision; however, the sooner any contentious issue is seen, the better the chance is to resolve it. You may even find language in a BIM Execution Plan that precludes you or other prudent contractors from bidding a project.

It is not an uncommon practice for certain stakeholders to use industry-standard procurement processes to force or attempt to force unreasonable terms onto unsuspecting bidders. Building an appropriate evaluation of any BIM-related RFP requirements into the discipline of your bidding program can help avoid such complications. Submitting RFIs to the owner before preparing a bid is one method of raising and addressing your concerns and may bring these issues to the attention of other prudent competitors.

Be leery of any Execution Plan that appears to have been copied out of a book or contains any gross misunderstanding of a spatial coordination process. Some of the potential red flags are listed in the next section.

BIM EXECUTION PLANS

4.5 Red Flags in an Execution Plan

Most MEP contractors have their own methods of determining what might constitute a red flag for their business. Language found in contracts, specifications, drawing notes, RFPs, and other documents have for years kept MEP contractors actively and vigilantly searching for any new, unexpected duties that may be pushed into their scope. BIM Execution Plans are no different.

Any red-flag issue or problem that your firm might encounter in a BIM Execution Plan is far better addressed early in the process than after the issue becomes potentially contentious.

The red flags that the spatial coordination process with BIM has unveiled over the past few years are described below.

1. Requiring an Integrated Model instead of a Federated Model

This is a serious issue. For an Integrated Model, all stakeholders (usually designers and contractors) involved in the coordination process are using the same software platform to create their model input. Architects or Owners are the parties that might most often make this request. As noted in Chapter 9 [on page 129](#), commercial MEP contractors rarely perform their detailing and coordination process on the same platform as Architects do. If this model is a requirement, your firm has four options: change software platforms; create your input with the tools you have and have the files converted for use on the required platform on an ongoing basis or at the end of the project; find another solution; not bid for the project.

2. Providing an Integrated Deliverable from the Construction Coordination Process

Even if MEP contractors use their standard software platform for the coordination process, some Execution Plans require a single-platform deliverable at the end of the project. Which stakeholder is responsible for converting the Federated Model information for an Integrated Model created at the end of the project is not always clear. It is most often assumed that, if the Design Team originated the Model and are updating that Model as the coordination process progresses, that they are also responsible for scrubbing the MEP Federated Models and integrating them into the Model. If it is unclear who handles this conversion, it should be clarified in the kick-off meeting.

3. Providing an integrated or useful facilities maintenance model

Requirements such as this one can be misleading and costly. If such deliverables are requested, make sure that you can identify detailed specifications as to the content, format, software platforms, and so on that must be provided.

BIM EXECUTION PLANS

4. Adequate time is not allowed for the actual coordination process

BIM is usually squeezed into the coordination process and often, adequate time is not allowed to complete the process effectively.

5. The coordination model must be “clash free”

Every project has some exposed clashes. There are situations where the standard layering protocols and standard detailing process always clash, for example, at connection points for equipment and piping. Minor clashes often indicate insulation wrapping conflicts or maintenance clearance intrusions that are a product of the BIM tool and irrelevant to the actual construction program. Therefore, it is not reasonable to require or expect that the final coordination model is “clash free.” (See Chapter 5, “Managing the Process” on page 67.) This is also a great opportunity for the MEP Participant on the Coordination Team to bridge the gap between poorly applied technology requirements and the reality of how valued BIM construction is done in the field.

6. Composite drawings

Creating multi-trade, overlaid, 2D deliverables from the coordination process is a time-consuming process. Additionally, most 2D deliverables presented in such a manner are far too cluttered to be useful. Often structural engineers will find a way to insist that the construction team deliver such documents for review. The entire Coordination Team needs to be well aware of any requirement for composite drawings, and the approval procedures related thereto before any coordination process begins.

7. Incorporating all changes and modifications during the coordination process

Any language that imposes an unlimited number of coordination passes and restricts reimbursement or recovery of the costs beyond the standard and acceptable industry practice should be questioned and removed. Attempting to place such a requirement on an MEP contractor does not differ from the imposition of construction-related unforeseen circumstances in any appreciable way.

8. Unlimited spatial coordination meetings

Any language that imposes an unlimited number of coordination meetings and restricts reimbursement or recovery of the costs beyond the standard and acceptable industry practice should be questioned and removed. Attempting to place such a duty on MEP contractors does not differ from the imposition of construction-related unforeseen circumstances in any appreciable way.

BIM EXECUTION PLANS

9. Imposition of any team roles and responsibilities beyond your contracted scope

If your firm is expected or willing to accept any roles and responsibilities relating to the coordination process for the entire project, you should document clear definitions, expectations, and limitations.

10. Imposition of Design responsibilities

Any language in a BIM Execution Plan that potentially shifts the lines of authorship or responsibility for design-related activities should be avoided. For MEP contractors, by definition, the standard and acceptable industry practice involves fitting construction components into allocated spaces, not stepping into any design responsibilities. (See Chapter 5, “Managing the Process” [on page 67.](#))

11. Access to original source files

Some BIM Execution Plans include a requirement for MEP contractors to turn over their source files for the discretionary use of the Owner and sometimes the Construction Managers. Many of the source files that MEP contractors use contain proprietary information that your firm derives from these files, as well as specialized components that your firm may have spent considerable funds to develop. If such source files are requested to be delivered from this process, clarify the amount of information you are willing to provide. In addition, your company should have a rigorous scrubbing protocol in place and run any source files that may include proprietary information before handing them over. (For more information about scrubbing model files, see Appendix C [on page 156.](#))

12. Continuous postings and updating

A BIM Execution Plan that stipulates continuous, daily updating is an indication of problems to come. Except in extreme situations, updated models should be posted on a published schedule. Keeping the Coordination Team focused on meeting their expected commitments and maintaining the sanity of the process is usually far more important than having a continuous stream of updates. Collecting the appropriate Documents of Record for such practices can also become unmanageable. Some Execution Plans have gone so far as to require continuous participation in the coordination process, whether or not your personnel are colocated. Such requirements don’t recognize that actually performing detailing and clash resolution is still an effort by professionals who must have the time and space to think through any system placements or modifications.

BIM EXECUTION PLANS

4.6 Authoring a BIM Execution Plan

An MEP firm that has skilled BIM talent capable of authoring a BIM Execution Plan for a project certainly has many advantages. If your company has not prepared an Execution Plan, many resources and references are currently available online to assist you.

The best, most comprehensive resource is the BIM Project Execution Planning Guide and templates published by the Computer Integrated Construction Research Program of the Pennsylvania State University Department of Architectural Engineering. It is available at no cost at <http://bim.psu.edu/>. That document is a reference resource, intended to encompass every conceivable workflow and information flow for every conceivable construction project.

Because of its comprehensive nature, the material that does not apply to your project may be greater than the material that does. Fortunately, you do not need to read the entire book to get started. The book includes a Microsoft Word template for a BIM Execution Plan. Fill out the sections of this template that apply to your project or organization, and refer to the guidelines as needed; the guidelines will make a lot more sense to you this way. This approach—deleting from a master template—is always easier and faster than trying to write a document from scratch. You will increase your knowledge of BIM execution planning and your skill in completing a BIM Execution Plan on an as-needed basis, gradually acquiring more knowledge as the number and complexity of projects that you plan increases. Because you will have the guidelines and the original template available for reference, you don't have to worry about leaving something out. If you have deleted something from your Execution Plan that turns out to be important, you can always put that section back in.

Chapter 5

MANAGING THE PROCESS

Complex commercial construction projects depend on the timely and unfettered exchange of information within a Coordination Team. If you have any management role on a project, establishing the environment in which this can happen is your first—and most important—job.

At the start of a project, the work required to set expectations, norms, and schedules is best done collaboratively. Participants on the Coordination Team get a chance to work together on issues that will make a difference to the work they do. As they learn from each other—and to be frank, size up the team and the state of the project—they can begin to build productive working relationships. This chapter is particularly useful if you are an MEP Project Manager, Construction Manager, or a senior executive.

Pulling this off successfully requires experience, collaboration skills, and flexibility from all Project Participants and the firm and focused management and leadership from the Project Coordination Manager, the Model Manager, and the Lead MEP Subcontractor. A successful collaboration empowers everyone who participates. Striking the balance between cooperation and vigilance over the process will demand the constant attention and energies of the Project Team Leader.

This chapter describes issues that should prompt a Project Participant to speak up when necessary. It specifically covers the following tasks that both promote and require collaboration:

- **5.1 Establishing Norms for the Project** [on page 67](#)
- **5.2 Setting Up the Project Environment** [on page 70](#)
- **5.3 Clash Detection** [on page 75](#)
- **5.4 Red Flags from the Coordination Process** [on page 83](#)

5.1 Establishing Norms for the Project

The best foundation for coordinating a project is a BIM Execution Plan (see Chapter 4 [on page 39](#)). By spelling out the work to be done and who is responsible for doing it, nothing significant will need to be done on the fly. The assumption for this chapter is that when you're ready to begin work, your team will know what's expected of them.

5.1.1 Agreement on Spatial Coordination

Your management task will be much easier if everyone on the Coordination Team has a common understanding of what constitutes spatial coordination. The three major North American MEP Contractor Associations—the Sheet Metal and Air Conditioning National Association (SMACNA), the National Electrical Contractors Association (NECA), and the Mechanical Contractors Association of America (MCAA) have issued a definition of the traditional MEP coordination process referenced in the National BIM Standards. This definition is reproduced below.

MANAGING THE PROCESS

- a. Standard and acceptable industry practice for spatial coordination performed under the contract documents is a collaborative process executed between the primary installation contractors and overseen by the general contractor or construction manager. This practice for spatial coordination seeks to integrate objects, systems, and components into spaces allocated in the contract documents. Standard and acceptable industry practice for coordination does not include adding pipe, ductwork, fittings, conduits, cable tray, junction boxes, or other appurtenances to remedy spatial constraints. Such work falls beyond the scope of what is considered standard and acceptable industry practice for coordination and will be performed as expressly directed pursuant to the terms of the contract. Achievement of spatial coordination under the contract documents that represents standard and acceptable practice in the industry assumes:

 - o The contract drawings have been fully designed and coordinated by the owner and/or its design professionals such that, if installed as shown on the contract drawings, the finished product will result in systems operating as designed by the owner and/or its design professionals.*
 - o Systems fit within the spaces allocated on the contract drawings as qualified below.**
- b. Spatial coordination that is standard and acceptable practice in the construction industry does not include relocating systems from their allotted spaces as shown on the contract drawings when such relocations require added materials, shop or field labor, or coordination time. Any such relocations or alterations of components and/or systems may compromise the integrity and/or the planned performance of the system(s) as designed by the owner and/or its design professionals. Responsibility for the integrity and/or planned performance of the relocated systems will remain the sole responsibility of the owner and/or its design professionals.*
- c. Depending on the complexity of the project, from one to three iterations each of clash identification and attempts at clash resolution are considered standard and acceptable industry practice for coordination. Further iterations fall beyond the scope of what is considered standard and acceptable industry practice for coordination.*
- d. The physical spaces for electrical, mechanical, sheet metal and plumbing equipment rooms must be adequate to allow for the installation of equipment as shown on the contract drawings. All designed spaces must include clearances in and around equipment as required by the contract documents, applicable codes and the equipment manufacturer's specifications. Adequate spaces must be*

MANAGING THE PROCESS

included in the design to accommodate incoming and outgoing services to and from the equipment and for maintenance as required by the contract documents.

Summary: *Spatial coordination is a cooperative and collaborative effort between the design professional, owner, general contractor or construction manager, and the trade contractors. Normal and expected spatial coordination performed by the trade contractors after the execution of a contract is not design. Rather, it is the reflection of the design in a three dimensional model. Trade contractors rely on complete and accurate designs when bidding projects in order to provide accurate bid pricing. In return, trade contractors, such as those represented by the MCAA, SMACNA, and NECA, using that design, are able to produce reliable models by which the project can be constructed in a more efficient, timely and cost effective manner.⁴*

But, to take your task one step further, you should make sure that your Project Participant colleagues also agree with this definition. Most unsuccessful projects fail because communication breaks down. Gaining an understanding of and agreement on the recommendations and practices in this joint definition is a great starting point for open communications, which in turn, are based on shared expectations and a common approach.

5.1.2 Consequences for Dilatory Participation or Refusal to Participate

The success of the coordination process can often depend on the weakest link. The consequences for parties who are critical to the success of the coordination effort but do not participate, who are understaffed, or who are otherwise unable to keep up with the other Participants should be clearly laid out in the BIM Execution Plan.

If Participants are not active in the coordination process, you need to understand that this will be a major issue for the project. You want to make it clear to your senior management as early as possible what the consequences will be. If the Participants had the opportunity to contribute to the scheduling of the coordination process but did not do so, the consequences for holding up the other Participants should include penalties up to their removal from and replacement on the project. In areas where the clash-detection tasks have been completed without their participation, these parties should either model and install their components around the finalized systems or be expected to reimburse the other contractors their added costs to revisit and re-coordinate the completed areas impacted by their lack of involvement.

⁴National Institute of Building Sciences buildingSMART alliance, *The National BIM Standard--United States, V2*, National Institute of Building Sciences, www.nationalbimstandard.org, section 5.5.1, accessed April 18, 2013.

MANAGING THE PROCESS

5.2 Setting Up the Project Environment

Your first task is to collaborate with the Coordination Team to make some decisions about technical issues and administrative policies (listed below) that are pivotal to the project work. You also want to build a relationship with the Design Team and open the door to collaboration.

- Points of Reference [on page 70](#)
- Deviations from Established Points of Reference [on page 71](#)
- Partitioning the Models [on page 71](#)
- Coordination Schedules [on page 72](#)
- Meeting Schedules [on page 73](#)
- The Design Team [on page 75](#)

5.2.1 Points of Reference

Points of Reference (PORs) are a necessary element of any spatial coordination process. Without mutually shared reference points, each Project Participant would create only those references that are advantageous to their operations; this approach creates problems when other contractors use references, dimensions, elevations, or starting points that are different yet have similar names. Communication among designers and contractors, inspectors and installers, fabricators, and vendors can become unnecessarily troublesome if these points are not established before the coordination process begins.

Design Teams, which are usually headed by an Architect of Record (AOR), will as standard practice, provide the Coordination Team with their chosen PORs. These PORs are often based on an established local civil monument (also known as “Northing & Easting”) and may incorporate some or all elevations from sea level. AORs rotate their project layout and 2D drawings to “square up” the building to facilitate their drafting process and to illustrate “True North” on their drawings and Key plans. AORs may also establish what they perceive as proper control lines for a project, such as grids and numbering designations, as well as what they consider to be 3D starting or insertion points, such as 0,0,0 and X,Y,Z coordinates.

This does not mean that the Coordination Team must adopt the Design Team’s references, but they usually do. The Coordination Team should carefully review these established PORs and determine whether to follow them, to modify some, or to use different PORs.

The Coordination Team should also recognize that structural designers and contractors, many of whom do not actively participate in the coordination process, often have PORs that are different from both the AOR’s points and the Coordination Team’s points.

MANAGING THE PROCESS

5.2.2 Deviations from Established Points of Reference

The use of alternative PORs by construction stakeholders does not remove their obligation to comply with the PORs used for coordination. The means and methods of construction often dictate that PORs for installers must be different from the PORs used for coordination. At times, installers do not take the time to “true up” their physical layouts with the primary PORs used for coordination purposes.

Examples of this failure to use the coordination PORs include framing contractors who use wall centerlines instead of the AOR’s PORs, bathroom fixture installers who guess at final floor elevations or use door frame locations to determine the elevation of their equipment, and contractors who shift their inserts and hangers slightly to facilitate their installation activities. Contractors who choose to “wing it” disrupt or seriously diminish the value of participation in the coordination process, cause considerable problems and consternation with field personnel, and cost many Participants money.

The Project Coordination Manager should ensure that those contractors who participate and comply with this program have precedence over those contractors who do not, or will not, install their products in accordance with the coordinated models.

5.2.3 Partitioning the Models

If the BIM Execution Plan has not established a milestone for it, one of the first tasks for the Coordination Team is to establish how to partition The Model. This process may seem simple, but if it has not been well thought out, it can create nightmares for Participants when their models have been populated with significant amounts of “intelligence.”

More often than not, Construction Managers want to partition the models used for clash detection along simple grid lines or along concrete expansion-joint locations. This approach can be difficult for MEP contractors because risers and gravity systems do not always work well under these lines of demarcation. Having the major Participants help develop these lines is an early opportunity to build a collaborative environment.

Inexperienced Project Coordination Managers may not understand that the size of the models has a great impact on the speed and efficiency of the clash-detection process. This is one of the main reasons why it is important that any Design-Intent Models received from the design team should be scrubbed before they are used in the coordination process. (See Appendix C, “Scrubbing a Design Model” [on page 156.](#))

As a rule of thumb, model partitions for a standard commercial project should not represent an area larger than 50,000 square feet.

MANAGING THE PROCESS

Hospitals, laboratories, and other heavily concentrated facilities may require smaller partitions.

Another consideration, specific to the size and partitioning of the Model has to do with the degree of 3D modeling object representation used in the process. The specificity of modeling detail should be visited before partitioning a model for efficiency. Not only is this important for the usability of the Model, but depending on the specific elements required to be included (such as hangers, bolts, nuts) the requirement may have a huge impact on load times.

5.2.4 Coordination Schedules

Realistic coordination schedules that are coupled with the construction schedule are critical. These schedules should be prepared by the Construction Manager and the Coordination Team.

Most major construction projects require the partitioning of their models into manageable sizes to keep the programs from getting too large for the hardware or software being used, and for setting priorities. Actual construction installation schedules also require such partitioning. The coordination and construction installation packages may or may not be completely aligned. Creating reasonable coordination schedules that stay ahead of actual construction, yet allow for enough time to systematically perform coordination, is often what separates the best construction managers and Project Teams from their competition.

Any workable clash-detection schedule must provide adequate time for all major participants to perform, at a minimum, these tasks:

- Hold a kick-off meeting and a subsequent spatial planning meeting for the project
- Obtain and process (scrub) any receivables from the Design Team
- Obtain, process and receive approval on all required submittals
- Evaluate and make a rough-detail model of their systems and products. This step can require considerable time for MEP contractors because the nature of their components obliges them to evaluate entire systems, not just area-by-area sections.
- Run a first-pass clash detection (to bring the initial installation routings under the guidelines detailed in the LOD 350 specification)
- Modify or correct models for conflicts discovered during the first pass
- Supplement these updated models with support systems
- Run a second-pass clash detection (acknowledge resolution of first-pass conflicts and review newly added support systems)
- Modify and correct models for conflicts discovered during the second pass

MANAGING THE PROCESS

- Supplement updated models for structural and seismic input (where applicable)
- Supplement updated models for final model approvals
- Run a third-pass pass clash detection
- Annotate or create Documents of Record for sign-offs
- Submit sign-off Documents of Record for engineer's review and approval

These schedules must also take into account some tasks that are not related to clash detection yet can drive the process because of actual construction schedules or conditions:

- Specialty contractors who need to create fabrication documents
- Creation of installation drawings and details (2D deliverables) for construction purposes
- Reviews and approvals from governing authorities
- Integration of shop drawings from other entities (for example, millwork, OFE, kitchen equipment)

You may need to include some “float” to provide the time to discover, communicate, and resolve any deficiencies in the design-related receivables or gaps of information that might create unexpected conflicts and problems.

These schedules may only be as good as the least-involved contributor. You must hold each participant accountable for their piece of the exercise. However, such accountability can become a major issue if any of the major Participants were not given the opportunity to provide input for these schedules. An inexperienced Construction Manager could assign a leadership role on the Coordination Team to a computer-savvy individual who is technically proficient but lacks the knowledge to understand the amount of work or effort that certain trades, especially MEP trades, must exert to manufacture their product and accommodate the process.

5.2.5 Meeting Schedules

Any coordination process is meeting intensive. The BIM Execution Plan should include a schedule of the meetings to be held throughout the project. These focused meetings include weekly coordination and clash-detection meetings, but may also involve separate or combined meetings for design resolution, scheduling, change implementation, permit-related issues or milestones, and so on. Such meetings can be scheduled as separate meetings or rolled into a larger meeting with a fixed agenda. On many projects, the initial schedule assumes that many

MANAGING THE PROCESS

issues can be addressed in one large meeting; however, later developments require separate meetings with a narrow focus to keep the team effective.

Coordination Meetings

Holding coordination meetings is the norm for the industry. When they commence and how often they are held will depend on many factors, but weekly meetings are the common practice. The general purpose of these gatherings is to perform clash detection on the Federated Model and to review the status of the many processes associated with it. This review includes Issues and RFI logs, the coordination schedule, communications, additions or changes to the scope, problems, commitments, and so on. These meetings should be scheduled and led by the Project Coordination Manager. Each meeting should follow a fixed agenda, which would include old issues and action items, new issues and action items, and provide ample opportunity to document any communications, commitments, and concerns raised during these meetings.

It is a standard practice to hold coordination meetings on the same day and time so that all participants can prepare for them well in advance. The venue should be established in the BIM Execution Plan. The Project Coordination Manager should confirm that the venue has adequate infrastructure for both physical and virtual participation for the duration of the project.

As communication technology has developed, the necessity for all participants to be present physically has diminished. The initial and early meetings on a project may benefit from mandating this personal presence, but once a Coordination Team has learned to work together effectively, allowing Project Participants to attend through video-conferencing and web-based meeting sites can be just as effective and less burdensome.

Clash-Detection Meetings

Parties who are interested primarily in the clash-detection section of the coordination meeting may or may not have participated in the coordination meetings. Establishing who is expected to participate in clash detection and their roles in that process, and addressing their specific issues and concerns can run parallel to the Coordination Meeting agenda, but should be recognized as a separate program that requires attention from your firm's leadership and the Project Coordination Manager.

MANAGING THE PROCESS

5.2.6 The Design Team

It is of great benefit to everyone for the Design Team to be represented in the initial Coordination Team meetings. These meetings can set the tone for true collaboration, in particular, establishing with the designers that the scope of Coordination Team's work specifically excludes design or redesign. What is shared in these meetings can also alert smart designers and construction managers to potential problems, risks, or delays to the project.

Your meeting with the Design Team should cover these items:

- Introduce all the participants
- Have all parties understand schedules and expectations of the coordination process
- Establish lines of communication
- Discuss expectations from each team
- Discuss how to handle and document any suggestions and recommendations
- Explain the use and format of the coordination Issues Logs and the RFI Logs
- Establish a protocol to prioritize issue resolutions

Without the consistent representation of the Design Team in the coordination meetings, the Project Coordination Manager may want to ask the designers or engineers to participate periodically, to insist they join ongoing meetings upon request, or to establish a series of meetings to review current items in the Issues and RFI logs.

5.3 Clash Detection

The objective of clash detection is to find all the actual or potential spatial conflicts and provide the abilities and procedures to resolve them before they manifest in the actual construction. Clash detection is the focus of most of the Coordination Team's work, and it demands practical protocols, realistic expectations, achievable schedules, and standard documentation from all participants.

Before starting a clash-detection process, the Coordination Team should examine the Models that come from the Design Team. There is a certain degree of spatial coordination that contractors and the industry expect to be performed during the development of Design-Intent Models. For Design-Bid-Build projects, most MEP contractors expect the Design Team to provide a Model that contains a complete set of MEP elements specific to their respective domains that reflect full compliance with the LOD 300 specification. This is the baseline from which you begin your coordination work. Keep in mind

MANAGING THE PROCESS

that you must always refer back to the BIM Execution Plan to identify contractually what you can expect to receive from the Design-Intent Model being delivered from the Design Team. Each Design-Intent Model needs to be assessed individually for the MEP elements it contains and whether they are at a LOD 300 or not.

There have been and will continue to be situations when a Design Team presents the Owner and Architect with an LOD 300 Model that they claim was coordinated within their Design Team and that allows additional space for LOD 350 and LOD 400 MEP construction modeling. This is not always the case; the state of the Model should be confirmed, and if deficient, be raised as an issue as soon as it becomes apparent. Many coordination projects are derailed, delayed, or overwhelmed when the Design Team has not allocated sufficient space to accommodate the MEP systems that are designated for the architectural space provided for them.

5.3.1 When to Start the Clash Detection Process

Starting clash detection too soon creates different problems from starting too late, but both waste time and money.

Work should not begin until all major participants are on board and engaged, until all models are at LOD 350, and until significant information is available or decisions have been made (for example, underground plumbing drainage systems must wait until wall locations and dimensions are locked down). Starting too soon sentences the Coordination Team to multiple clash-detection passes with no time off for good behavior.

On the other hand, construction schedules that do not provide adequate time to perform all the necessary activities often mean that shortcuts must be taken. Areas may have to be skipped, coordination may have to be piecemeal or not performed systematically, which can be far more difficult for contractors who install systems than for those who install components.

When all major participants contribute to the clash-detection schedule, the results are better—and far less expensive—for everyone.

5.3.2 Coordination Protocols

Clash detection can begin when all requirements of the Execution Plan have been developed, reviewed, and acknowledged by the Coordination Team, and a schedule for this program is developed and agreed upon.

Comprehensive logic diagrams of this process can be developed for any project. On large projects with long construction schedules, creating these diagrams in collaboration with all major Participants

MANAGING THE PROCESS

can be of significant value, especially in communicating procedures for inexperienced parties or Participants who have yet to join the team.

5.3.3 Document Control and Maintenance

Among the many responsibilities of the Project Coordination Manager is to communicate expectations and document important actions during clash detection.

Certain aspects of Document Control are of high importance, in particular, the use and maintenance of Issues and RFI Logs, version control of models and drawings and the common use thereof, authorizations and directives, and change orders. The maintenance and updating of the models that the construction team uses can be onerous and time consuming. These are important functions, and performing them is a serious and significant responsibility.

The Coordination Team has a duty to ensure that responsible parties are fulfilling their obligations. Often, a Project Participant will notice that accurate documentation or maintenance is not being adequately managed, or that the Model Manager has become cavalier about maintaining the necessary records, updates, or justification for changes and alterations to design documents related to clash detection. These lapses can become very serious problems for your firm. If such situations arise, your team should know how to raise the issue and with whom, both within your firm and within the Coordination Team. It is also important that your Project Team knows how to keep records for those activities that directly impact the scope of your work.

Another concern arises when the Project Coordination Manager is crossing the line between design and coordination. Sometimes, even when alerted to the risk, a PCM may not follow proper channels to get the design professionals' sign-offs. As questionable as it might sound, many Construction Managers place individuals who are not trained to understand the difference or who don't concern themselves about the potential consequences of coordination morphing into design into roles where they have that very responsibility.

5.3.4 The Process of Clash Detection

After all Project Participants have had adequate time to evaluate and process the receivables from the design team and have generated their first model within the first partitioned area, they should submit to the Project Coordination Manager an initial "desired" or "individually optimized" LOD 350 model of their system.

From this point on, the Coordination Team performs a series of clash-detection passes to identify and resolve most significant clashes and conflicts.

MANAGING THE PROCESS

Prerequisites

Each Project Participant has an obligation to run clash detections before any clash detection meeting to identify and resolve the problems within their own control, with unmovable structures, and with any component or system that was addressed during previous clash-detection meetings. Failure to do this seriously slows the entire process, ensuring that collective frustration levels will rise, and quickly.

Prioritization

As the Coordination Team becomes more experienced in performing clash detections, Participants learn which work products to include and exclude from their first-pass models.

Best practices stipulate that the clash-detection process for commercial facilities begin by resolving gross conflicts and work its way to minor conflicts. Nonmovable systems, large-volume components (such as duct mains), and gravity systems normally take precedence in space-claiming and in clash resolution.

Areas that are unusually complex, of high density, or where significant design problems arise may need to be separated from the regular clash-detection program and be managed independently of the balance of these areas and their associated schedules.

The construction schedule or installation means and methods can change the clash detection or installation priorities causing the acceleration or delay of an area. Large equipment installations or deferred approval components might have this impact. When the clash detection process is affected, or gets behind, regardless of the reasons, a careful evaluation of the impact of the various costs of deviating from any standard protocols should be made.

Conflicts

Conflicts will always arise. An initial clash-detection exercise generates literally thousands of conflicts in an area. This is to be expected, especially when members of the Coordination Team have not worked together before, or simply lack the experience to populate their models in a sequence that will allow them to effectively coordinate with other stakeholders.

Coordination Teams often recognize conflicts within the Design-Intent Models received at the start of a project. Even elementary but serious conflicts such as gravity systems and structures may be presented and described as LOD 300 elements. If the systems as designed, but before any contractor coordination efforts begin, do not fit within the allocated ceiling space or if the walls are not wide enough to accommodate riser

MANAGING THE PROCESS

pipe or conduits, such issues often indicate that adequate design coordination did not take place or was not a serious concern of the Design Team. Again, establishing with the Design Team at the outset that the purpose of clash-detection is not to complete the design should help establish the ground rules of all stakeholders to perform to the level expected.

One method of minimizing conflicts is to spend extra time “planning the planning.” Have the Coordination Team commit to baseline space allocation, routing, and rules set forth in the BIM Execution Plan. These preliminary meetings also help new participants to recognize that spatial coordination encompasses more than product-to-product clash resolution, but extends to product-to-access clearances, code spaces, hanger locations, and so on.

Planning-the-planning exercises often help everyone to agree upon certain default situations (fireproofing tolerances, common PORs, and so on) and work as a team from a common starting point.

5.3.5 The Process of Clash Resolution

Resolving “clashes” should be a team effort, making adjustments to the benefit of the construction project and all parties to it. Although the BIM Execution Plan should clearly establish a baseline order of precedence for component installation, a certain level of give-and-take is required of all Project Participants. Common sense should always prevail in any clash-resolution process. It is unreasonable to expect a 40"x20" duct to be offset around a 1" water line. On the other hand, that same 40"x20" duct may need to move to accommodate a 10" gravity storm drain pipe that needs slope to drain.

Should any individual participant or firm decide to adjust to clashes only when it works to their advantage, the Project Coordination Manager or the Construction Manager may need to become involved. You should also be wary of those who might attempt to stand on preapprovals of governing agencies, such as for sprinkler systems, to justify their unwillingness to modify or change their routing. If they submit their plan for agency approval before the coordination process is complete, they may have to resubmit a modified plan. This is not unusual; changes in scope constitute similar considerations.

If consensus cannot be reached during these meetings, the Project Coordination Manager may be called upon to exercise the authority to resolve the issue. If the impacts of these resolutions are significant enough, you should follow your company's procedures for elevating the issue.

MANAGING THE PROCESS

Clash reports can be generated within the virtual design coordination software and distributed to the Coordination Team to track the responsibility for resolution of trade work where residual clashes are present.

Clash reports should be generated before and after clash detection meetings; however this process should not begin until after the second pass. Restraint is prudent because of the extremely large number of conflicts and clashes that are usually encountered before the official clash detection process is underway.

The process of clash resolution can very easily become the point where contractors extend their efforts across the line that separates coordination from design. Spatial solutions can be visualized, but system impacts are harder to define. When these circumstances arise, it is always better to have the Design Team ready and willing to participate. The Coordination Team does not need to wait while designers go through various what-if scenarios; instead, it has the authority to approve spatial modifications with the expectation to re-evaluate any calculations or system performance criteria used initially and confirm this conflict does not impact those calculations or criteria.

The Project Coordination Manager should keep the minutes of these meetings and post or distribute the resolutions of all major conflicts. Resolution of major clashes should be documented and tracked in a manner that is consistent with the required Documents of Record and that can be audited.

“Clash Free”

Inexperienced Project Participants and Project Coordination Managers can get bogged down with the number of clashes and can lose focus on resolving the large and critical clashes that must be remedied first. Some insist on models that are completely “clash free.”

Attempts to create truly clash-free coordination models are, in most cases, a waste of time. Minimum insulation overlaps, minor challenges to access zones, and similar conflicts are costly to correct and irrelevant to the use of the Model. The primary use of coordination models is to be a tool to assist in construction.

5.3.6 The Number of Clash Detection Passes or Coordination Iterations

The number of area coordination iterations that a contractor must participate in has a direct and significant effect on the costs and time required to perform clash detection and complete the coordination process.

A rule of thumb that contractors use in commercial Design-Bid-Build projects is that they should be able to complete the coordination process in approximately three passes per partitioned area. Certain

MANAGING THE PROCESS

types of projects may require a few more, but even these should be recognized and acknowledged in an RFP or a kick-off meeting.

The scope of each pass is as follows:

- The first pass identifies gross initial conflicts
- The second pass identifies remaining conflicts, new conflicts created by the addition of new support or seismic components into the model or non-resolved conflicts from the initial pass
- The third pass identifies remaining conflicts, and their resolution will permit the publication and sign-off of the construction model.

On Design-Bid-Build projects, there exists an expectation that the Design-Intent Model received by the Coordination Team has already undergone adequate design coordination and is presented at an LOD 300 standard. Projects delivered on a Design-Assist or Design-Build basis may require more or fewer passes, but neither should be open ended or left to someone's guess.

Too Many Passes or Iterations

When more than three passes are required or demanded, the Coordination Team should investigate, as early as possible, the reasons for these additional iterations.

The reasons vary, but these are the common ones:

- A major participant or stakeholder is not participating in the process, and the entire team must revisit areas to eventually coordinate these additional systems. There can be innumerable reasons for this, including starting the coordination phase too early.
- Design issues are encountered and the Design Team does not participate in the coordination process with any sense of urgency.
- The status of the Design-Intent Model or design documents received from the Design Team, despite what might have been communicated, is not at the expected Level of Development. The coordination by the Design Team has not been completed to the degree that all products or systems required will actually fit into the spaces allocated. Such a situation may require that construction trade coordination must wait until design conflicts are recognized, communicated, and resolved.
- The Lead MEP Subcontractor, or a specific representative, is not adequately experienced or trained to manage the coordination process at a predictable or reasonable pace.
- The information required to perform the coordination is not available when coordination begins. The procurement process or the product or equipment approval process is behind the coordination process

MANAGING THE PROCESS

- The information that MEP contractors are working from, such as structural steel drawings, are design drawings, not the final fabrication shop drawings. This can require revisiting coordinated areas after receipt.
- The process is bogged down in revisions or changes of scope. Often the cost of re-coordinating an area is greater than the cost to make the modification itself.
- Deferred approvals by governing agencies force certain systems, such as seismic restraint systems, to follow an additional path that is separate from the coordination process. (This is not an excuse for nonparticipation.)

Regardless of the cause, every Project Participant should recognize that too many passes can and will add cost and time to their efforts. Contractually stipulated documentation and notification requirements may easily apply under such circumstances.

5.3.7 Communication and Collaboration Among the Trades

Every Project Participant should actively work with the other Participants, both during and outside regular meetings, to resolve actual or potential clashes. Without this collaboration, a coordination process can be seriously delayed or impeded. Although your firm may not be directly contracted with these other participants, and you may not have the ability to obtain or demand their cooperation, most trade contractors are willing to work together when they feel that they are being treated fairly.

The pertinent information can be exchanged in person, via email, telephone calls, or other methods. Every contractor involved should train their personnel to recognize which adjustments made during these communications are necessary to document and which are not.

The style of some Construction Managers is to demand that all communications relative to any project be directed through them. This behavior is counter to what contributes to the success of a coordination process; no such restriction on the flow of information should be instigated.

MANAGING THE PROCESS

5.4 Red Flags from the Coordination Process

There are various indicators that experienced Project Participants recognize in the early coordination process that may signal problems ahead.

1. No BIM Execution Plan for project**2. Scheduling issues:**

- a. Coordination schedules were created without input from the Coordination Team.
- b. Coordination and construction schedules are decoupled.
- c. Schedules are unreasonable, unachievable, or poorly thought out

3. Design issues:

- a. The model element receivables from the Design Team are not at LOD 300
- b. Design Team resists or refuses to participate when asked or needed
- c. Resolution of design issues takes far too long
- d. Lack of real collaboration with Design Team
- e. Changes to the design drawings are not documented with revision clouds

4. An absence of a systematic issues-resolution process**5. Project Management issues:**

- a. PCM has little or no experience in the role
- b. PCM has little construction knowledge
- c. PCM does not understand Levels of Development in the models
- d. PCM does not have adequate authority
- e. PCM is reluctant to or resists taking issues to the Design Team
- f. PCM tends to permit coordination to morph into design
- g. PCM makes decisions without appropriate authority or Design Team confirmation
- h. Nonstandard coordination standards used
- i. PCM forbids free communications between participants
- j. Disorganization of processes and documents: no meeting agendas or minutes, documents of record
- k. PCM makes offline exceptions to MEP contractors or other smaller subcontractors

MANAGING THE PROCESS

6. Clash-detection issues:

- a. Clashes run during the meetings instead of beforehand
- b. Focus is on number of clashes instead of worthwhile solutions
- c. Expectations of clash-free models
- d. No interaction between trades between meetings
- e. Even one participant who does not own all necessary project software

7. Project Participant issues:

- a. Major contractor refuses to participate
- b. Feckless participants: come to the meetings not prepared, have not run internal clashes, haven't executed past issue resolutions, are tardy or prone to miss meetings
- c. Indecisive or lack adequate authority
- d. Cannot obtain information or submittals in adequate time

A company's BIM Implementation Plan may stipulate what needs to be done when any of these situations arise. If your project management staff participates in coordination meetings, they should also be expected to know what action to take.

Chapter 6

DOCUMENTS OF RECORD

All construction projects have Documents of Record, which range from contracts to daily time sheets. Coordination programs use and generate Documents of Record that are necessary to meet a variety of obligations that all MEP contractors have.

A project's specifications usually list or reference most of the Documents of Record that a contractor receives from an Owner or Design Team at the start of the project. However, many critical documents are used during the coordination process, and other recognized Documents of Record are generated and delivered from this program.

This chapter highlights the important Document of Record and describes their place in the MEP contractor's operations. This information is useful if you are a senior executive, Project Manager, or Construction Manager responsible for these Documents of Record.

- **6.1 Working with Documents of Record** [on page 85](#)
- **6.2 Receivables from the Design Team** [on page 86](#)
- **6.3 Internal Receivables from Your Project Team** [on page 90](#)
- **6.4 Inter-Trade Receivables** [on page 91](#)
- **6.5 Other Receivables** [on page 93](#)
- **6.6 Deliverables** [on page 93](#)
- **6.7 Communication with the Design Team** [on page 98](#)
- **6.8 Managing Documents During the Coordination Process** [on page 100](#)

6.1 Working with Documents of Record

Some of the pertinent Documents of Record are easy to find in an RFP package, while others may be scattered or difficult to identify from the volume of information that is often provided. Many of your clients require you to use their unique forms and documents during the coordination process.

Rules and definitions surrounding any documents that are to be delivered as part of the coordination process may be significantly different from project to project and may include a greater number of stakeholders, including departments in your company.

By no means do all Documents of Record relate to the coordination process, but many important ones do. These documents are usually the contractual baseline for all coordination efforts.

The success of any coordination process requires disciplined management of project documents. The documentation processes require someone with authority to manage, provide clear and appropriate instructions, and push resolution of issues and to define and document problems, changes, and impacts caused by or to the coordination process.

DOCUMENTS OF RECORD

6.2 Receivables from the Design Team

Before coordination can commence, the Coordination Team needs to identify, acquire, organize, “scrub,” log, file, and archive a wide range of information. During the course of coordination and construction, many new documents are received and must be managed in the same standard process. It is critical that all Project Participants have and use the correct and most current version of all information. For information about “scrubbing” a Design-Intent Model, see Appendix C [on page 156](#).

6.2.1 Contract Drawings

Most projects and contracts still defer to 2D drawings as the contractual baseline for all work to be performed. Such bid drawings, permit drawings, and addendum drawings are necessary and should be available for any coordination effort. Most contracts include a list of all applicable drawings and the versions thereof. Many drawings or specifications describe these documents as “diagrammatical in nature” or have other disclaimer language imprinted on them; members of your Project Team should understand your company’s standards and expectations with respect to such language.

6.2.2 Schematic Documents

If the contract documents are not truly past the design development phase, schematic documents from the MEP engineers are required to assist in the development of the MEP systems and the coordination. At a minimum, these documents should reflect how the MEP Engineers of Record want the plumbing, hydronic, air, power, and control systems to be sized and distributed within a building.

Some projects may have drawing receivables in a schematic format, which by definition means the drawings do not comply with LOD 300. In the interest of meeting a schedule, a Design Team can issue what it considers ready-for-construction LOD 300 model elements that lack complete technical trade deliverables. Exceptions to normal and accepted industry standards, which exclude this work from the scope of commercial Design Team LOD 300 coordination efforts, do arise, for example, low-voltage wiring routing.

That said, if the Design Team delivers schematic or single-line drawings instead of fully developed drawings that show the location and volume of each MEP systems, the Coordination Team can conclude that the expected level of spatial coordination has not been performed.

The schematic nature of certain contract documents presents a unique prerequisite condition, more often impacting the electrical contractor that requires an additional design layout effort before coordination begins. This is the work referred to as “pre-design” in section 3.7.1 [on page 34](#).

DOCUMENTS OF RECORD

6.2.3 Design-Intent Models

Many Architects and Design Teams provide a Model that is ready to begin the construction phase. This Design-Intent Model is included in the package of information given to the contractors to start construction. This Model is typically used by the Design Team to “architecturally coordinate” the contents of a building. Design-Intent Models are usually good starting points for any coordination effort.

Such Models should contain information such as architectural layouts, wall locations, structural steel size and location, concrete details, floor and ceiling layouts and details, and exterior wall details. These Models may be either the source of the contract drawings or derived from the contract drawings provided to the Coordination Team.

Although the design community has worked hard to develop industry standards (Levels of Development) for Design-Intent Models, some Models received from the Design Team may fall short, slightly or significantly, of meeting those requirements. Heated arguments, delays, and frustrations may ensue, particularly when these shortcomings are not recognized and addressed before construction starts. Depending on the significance of the omitted LOD elements, it may be important to raise the issue with the full Coordination Team.

Individual contractors or the Coordination Team may find it necessary to re-create much of the information expected in these Design-Intent Models. The Models do not include the information needed to prefabricate and install comprehensive mechanical systems.

Processing Design-Intent Models

If you receive a Design-Intent Model from the Architect or an MEP Engineer before the Coordination Team begins work, you will need to process this Model before you can use it. You may need to convert the files to a format that works with the software your team uses. Some elements within the Model, such as furniture, may not be required for coordination and these elements can be “scrubbed.” (See Appendix C on page 156.)

Removing the layers that you do not need makes the files smaller, which in turn makes it easier to manage them. The Coordination Team requires 2D architectural floor plans and reflected ceiling plans, and these drawings can be extracted from these processed files.

Disclaimers in the Design-Intent Model

Many of these Models include a disclaimer that disavows the accuracy of the information within them and warns that you are using them at your own risk. Such language is a legacy from the period when models

DOCUMENTS OF RECORD

were created after the 2D drawings were completed; however, at times this language is used because the Models provided by the Design Team are either more current than the drawings provided or vice versa. Look to the BIM Execution Plan for clarifications regarding the ability to rely upon any Design-Intent Model.

6.2.4 Fabrication Models

Having the Design Team's Design-Intent Models available at the start of the coordination process is good; having actual fabrication and erection drawings from the actual suppliers of certain building systems or components is better. Some trades (for example, structural steel) may have been released for fabrication before coordination begins. These trades rarely participate in any coordination efforts and the other trades are often obligated to work around their drawings. However, the trades that do not participate often have comprehensive fabrication models; obtaining and using these models instead of the respective Design-Intent Models allows better and more accurate coordination.

Maintaining open communication and cooperation with these fabrication and erection contractors benefits the Coordination Team. Although they may not be flexible with their plans and drawings after fabrication is completed, before fabrication is finished they are often willing to work with the Coordination Team and to make desired changes in the same manner as other trade contractors do.

When these trades do not provide their fabrication models or drawings in a timely fashion and the Coordination Team begins work from the structural Design-Intent Models and drawings that are available, a quality control or re-coordination effort may be required to review and respond to actual fabricated conditions. This review may require additional coordination passes through complete and coordinated areas, which can become expensive.

6.2.5 Piping and Instrumentation Diagrams

Often, coordination efforts must begin with only general layouts and piping and instrumentation diagrams (P&IDs) available (Figure 6.1 on page 89). This situation is far more common on industrial projects than commercial projects.

Although stand-alone P&IDs do not meet the requirements of an LOD 300 receivable, they should reflect all the piping, including the physical sequence of branches, reducers, valves, equipment, instrumentation, and control interlocks. The P&ID may be used to operate the process system.

DOCUMENTS OF RECORD

A comprehensive P&ID should include this information:

- Instrumentation and designations
- Mechanical equipment with names and numbers
- All valves and their identifications
- Process piping, sizes, and identification
- Miscellaneous—vents, drains, special fittings, sampling lines, reducers, increasers and swaggers
- Permanent start-up and flush lines
- Flow directions
- Interconnections references
- Control inputs and outputs, interlocks
- Interfaces for class changes
- Seismic category
- Quality level
- Annunciation inputs
- Computer control system input
- Vendor and contractor interfaces
- Identification of components and subsystems delivered by others
- Intended physical sequence of the equipment
- Equipment rating or capacity

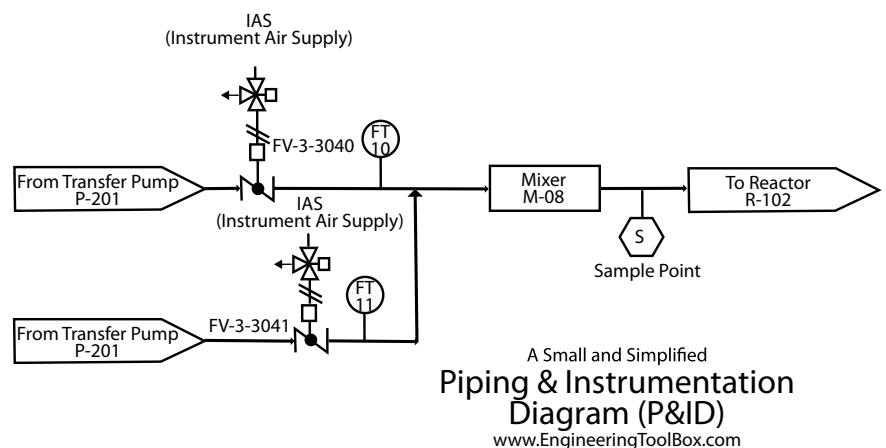


Figure 6.1 A small and simplified P&ID

DOCUMENTS OF RECORD

A P&ID does not include this information:

- Instrument root valves
- Control relays
- Manual switches
- Primary instrument tubing and valves
- Pressure temperature and flow data
- Elbow, tees and similar standard fittings
- Extensive explanatory notes

Although P&IDs are most common in industrial projects, many MEP contractors have their engineers create P&ID diagrams for plumbing, piping, and air systems before their detailing and coordination process begins. This step provides an internal quality control check for what are often perceived to be “simple” systems.

6.3 Internal Receivables from Your Project Team

Your Project Team needs a significant amount of information from other individuals or departments within your company. Active participation of your Project Manager is crucial to ensuring that receivables from your firm are accurate and delivered to vendors and the Coordination Team on schedule or as needed.

6.3.1 Submittals and Equipment

Submittal sheets for equipment, materials, specialty products, and the like, whether furnished by your firm or by others, may be needed for your Project Team to create intelligent objects or to start the coordination process.

Approved submittals are preferred, but often the coordination process must begin before these submittals have made their way through the assembly, submission, and approval process. You want to have a policy and procedures for working from non-approved data, particularly to identify who is responsible for reviewing the approved documents and validating any possible coordination changes.

If adequate submittal information is not available, your firm should consider implementing a matrix of default materials or components that your detailer can draw and coordinate to. This can minimize multiple detailers duplicating time researching every project specifications or making “difficult to reverse” decisions on what products you might be expected to purchase to avoid re-drawing or re-coordinating.

Often, equipment suppliers and material vendors have created models that are formatted to work with, or interface with, the software you are using. If you can obtain these models, and not have to create custom objects, you can save time.

DOCUMENTS OF RECORD

Whenever possible, this submittal data should be uploaded and maintained at the Coordination Team's file-sharing location. Other trade contractors often need valuable data that can be derived only from your firm's internal deliverables.

6.3.2 Certified Drawings

The critical nature of the dimensions and weight of certain pieces of equipment may be integral to the success of an MEP coordination effort. This equipment may be furnished by the contractors or other parties. Often manufacturers have purchase-order language, or boilerplate terms, that permits them to deviate from the information they might provide during the normal course of any product approval process. When there is a need for such information to be absolutely accurate, you can request or require your vendors to provide certified drawings.

Certified drawings should include all details of the equipment including exact connection information for all piping, duct, and electrical connections. Some manufacturers will provide a 3D model for this, also.

6.4 Inter-Trade Receivables

Although it is expected that all major stakeholders will participate on the Coordination Team, certain trades have been slow or reluctant to do so. If or when some trades do not participate, it becomes imperative that all appropriate information for their scope of work is recognized and included in the process.

6.4.1 Structural Steel Fabricators/Erectors

Structural steel drawings and models received from the specialty trade subcontractor do provide, more often than not, far more complete and accurate information than that included in the Design Team's documents. These components of a commercial building are often considered immovable, and all contractors must work around them after they are released for fabrication.

Even if these drawings are not received before the Coordination Team has finalized a partitioned area, someone on your Project Team should perform at least a trade-specific review of these documents when they arrive. If they are received before the partitioned area is coordinated, these documents and the equipment contained within should still be considered immovable objects in the sense that all trades complete their internal clash detection with these components before submitting their models for coordination (see section 5.3 [on page 75](#)).

If these new documents indicate conflicts that did not exist when the applicable area was coordinated, an all-trades re-coordination pass may be necessary, and new clashes may affect one or more of the

DOCUMENTS OF RECORD

coordinated trades. Obtaining this important data early can truly expedite the coordination process.

6.4.2 Wall and Ceiling Framing

Having the details for the interior finishes is helpful for any complete or comprehensive commercial model. Interior finish contractors can now create accurate models of all elements of their construction, including wall and ceiling details, supports, and bracing. This information is needed to coordinate wall openings and the placement of ceiling-mounted items.

When the coordinated MEP models are properly used to communicate construction scheduling and sequencing, including the complete framing details in them also enhances the ability of all affected parties to distinguish priority installation walls from the walls that follow MEP overhead installations, to accurately reflect soffit framing requirements, to indicate king-stud supports and clearances, and to indicate other critical means and methods of installation. When the framing contractors have not participated in the coordination process and the renderings and details from the Design Team are the only information available during the process, considerable rework and re-coordination is required.

The participation of the specialty subcontractors should be the same as all other participating parties; the precedence of their installations, their claim to or allocation of space, and the proper sequence of populating their models should be addressed in the BIM Execution Plan.

6.4.3 Curtain Wall

Manufacturers and installing contractors of curtain walls are now providing object models for the elements of curtain walls, including specific bracing and connection details. This information is often needed to adequately model or coordinate overhead rough-ins or exterior wall risers. Also, the bracing and framing of curtain walls is sometimes not accounted for adequately in the Design-Intent Model. This information can be very helpful for coordination.

6.4.4 Interior Finishes

Many commercial projects have custom millwork, casework, or furniture-like items that can impact the layout and placement of MEP rough-ins and services. Having fabrication or erection shop drawings available for the coordination efforts is preferred, but this information is rarely available during the early phases of the coordination process. If the design documents are not adequately followed, a review and re-coordination effort might be required.

DOCUMENTS OF RECORD

6.5 Other Receivables

People who are not Project Participants will give you input to which you need to respond.

6.5.1 Equipment or Products Furnished by the Owner or Others

Owners or other parties who are not actively participating in the coordination process may furnish equipment or systems that require coordination over and above the information furnished by the Design Team. Such equipment includes, but is not limited to, the following:

- Kitchen equipment
- Medical equipment
- Laboratory equipment and furniture
- Kitchen equipment
- Process equipment

Again, having the wrong or incorrect design information to adequately coordinate the MEP rough-ins or systems can require re-coordination.

6.5.2 Facilities Management Input

Obtaining input into the construction coordination efforts from the Facilities Maintenance personnel before starting the coordination process can be very useful. Knowing what these clients expect and incorporating some of their standards for access and work space, or simply knowing how they might be using your completed model after turnover can help avoid frustrations and problems at the end of a project.

6.6 Deliverables

Deliverables are the models, documents, and other information that are derived from or delivered after the coordination process is completed. These documents are contractually required, expected by specific industry stakeholders, or needed for your company's internal operations. The specific details, the schedule, and which parties will use these deliverables and for what purposes should be stipulated in the BIM Execution Plan or contract documents.

Common deliverables include the following:

- Sign-off documents
- Complete and coordinated construction models
- Coordinated 2D shop drawings
- Hanger and insert drawings
- Sleeve and block-out drawings
- Pad or foundation drawings
- Point load drawings

DOCUMENTS OF RECORD

- Composite access layouts
- GPS/Laser scanning data
- Fabrication details and drawings
- Turnover packages
- As-Built construction models
- Facilities Maintenance interface information

A list or matrix of any contractually required deliverables should be created and maintained by the Project Coordination Manager.

6.6.1 Schedules for Deliverables

Outside of the project construction schedule or even the Project Team's coordination schedule, you need to maintain an in-house schedule to meet project milestones and commitments. These items can include prefabrication schedules and procurement lead times. Identifying all deliverables required from your firm to the Coordination Team is critical to obtaining the benefits of participation and is often required to meet your budgets. (See Chapter 5, "Managing the Process" on page 67.)

6.6.2 MEP Coordination Sign-Off Documentation

When the work of the Coordination Team is complete, each trade should provide a fully annotated orthographic shop drawing of its system in a PDF file for signature sign-off and submission to the Architect and Engineer of Record for review and approval.

Any sign-off documents created from the digital model should be considered Documents of Record, and electronic record copies should be retained on the project file-sharing site. Printed sign-off drawings are typically a formally required submittal; these should be scanned and stored on the project file-sharing site with the original electronic files.

When sign-off documentation is submitted to the EOR for review and approval, you should ask the EOR to review any changes of sizes, routings, or configurations that were made by the Coordination Team to ensure that these modifications do not adversely impact the design intent. If the Engineer or Architect of Record refuses to do this, you may want to consider having the Owner insist on compliance with this request. It will benefit everyone in the long run. (See Chapter 8, "Contract Language" on page 115.)

In some instances the construction manager may require a digital sign-off of a coordination model through a third-party cloud-based electronic signature service. In these cases, all relevant stakeholders in the coordination process must request that a locked model file be created and stored for future reference.

DOCUMENTS OF RECORD

6.6.3 Complete and Coordinated Construction Models

The coordinated model should unquestionably be used for construction purposes. If contractors are not required to “build to the model,” much of the coordination effort would be in vain. Old-school construction superintendents have been known to bypass the process and build projects as they have always done. Your managers should be vigilant in making sure that this doesn’t happen or if it does, that it is addressed properly and corrected.

6.6.4 Coordinated 2D Shop Drawings

Installers still use 2D documents to install products on construction projects. The coordination and modeling efforts, at completion, must deliver useful 2D drawings. Typically, these drawings accurately reflect routing, sizing, elevations, tagging, and other such important information. Creating these drawings often requires considerable work after the coordination process is complete to include for such information as dimensional annotations, assembly details, and access plans.

6.6.5 Annotation

Annotation is the final step in preparing plans derived from coordinated models for field use. This should be done when all coordination is completed. Unfortunately, for a variety of reasons, MEP contractors must often create incomplete 2D documents on an interim basis simply to stay ahead of construction activities. Your Project Team may need to provide pipe and duct sizes, layout dimensions and elevations, installation details, clearances, tagging, and special instructions concurrently with ongoing project coordination efforts. All of these activities demand the time and concentration of skilled personnel. Any interim or not completely coordinated and signed-off drawings should be tagged or stamped accordingly.

Having a simple disclaimer such as the following on MEP 2D shops is very helpful in averting design liability:

The annotated shop drawings’ information and data embodied in this document reflect the result of the current BIM coordination efforts on this project. Electrical Engineer needs to confirm that the conductor size and length associated with the coordinated systems still fall within their design parameters used to meet the equipment selections and sound criteria for this project. All information, illustrations, screen shots, and data contained herein Copyright © your company name 2013, all rights reserved.

DOCUMENTS OF RECORD

6.6.6 Hanger and Insert Drawings

Hanger and insert drawings can be in the form of Total Station files to be loaded into the Total Station machine and used for field layout. Or, they can be completely dimensioned and tagged hanger drawings used to lay out and install hangers and inserts. They may be accompanied by spreadsheets to be used for prefabricating and packaging the hangers, hanger racks, and supplemental steel.

6.6.7 Sleeve and Block-Out Approval Documents

Information from the coordinated model is used to create layout drawings for all sleeves and block-outs required for wall and floors. These drawings are needed for accurate layout of these items. These drawings may also be required to be submitted to the Architect for approval before the placing of the work.

6.6.8 Pad or Foundation Drawings

Drawings created to establish pad location, depth, supporting miscellaneous steel, and other related information can be generated from the coordinated Model. These Models can also be utilized for generating points used in conjunction with Total Station equipment.

6.6.9 Point Loading Drawings

Point loading is the effect that the weight of an object has on the building structure and the hanger or seismic restraining method. Each point has an “area of influence” surrounding its attachment location to the structure. The size of the area of influence is based on the type of structure and the hanger method. These drawings may also be required to be submitted to the Architect for approval before the placing of the work. Again these Models can also be used for generating points used in conjunction with Total Station equipment.

6.6.10 Composite Access Layouts

Access layouts to accommodate equipment servicing needs, valves, and other items requiring access can be established within a Model and coordinated with other trade elements. Rules for access and maintenance clearances should be established in the BIM Execution Plan.

Composite Overlay Drawings

It is not uncommon for the Design Team or structural engineers to require a submission of composite overlay drawings for items such as deck inserts. These drawings are usually derived from the federated construction model and indicate the exact location of inserts and many times the “area of influence” of these inserts. Because these drawings

DOCUMENTS OF RECORD

are derived from multiple sources, the Project Coordination Manager should be the party assembling and submitting these to the structural engineers for their review and approval.

6.6.11 Total Station

Robotic style layout equipment is now being used for MEP layout operations. This equipment can also be used for sleeves, hangers, concrete pads, and underground piping systems. There are innumerable uses of precise layout information derived from the coordinated models. This system of layout is commonly known as Total Station. Information from a coordinated model is used to identify layout points such as hangers. These points are identified and numbered, and carry specific information such as hanger insert type and diameter. The robotic system is set up on the job site, and control points are established. The identified points are then established using a laser pointing system delivered by the robotic unit; when the point is identified, the specific hanger can be set. The goal is to set all sleeves, hangers, and other items on decks before concrete pours. When a crew is proficient in using this type of equipment, several hundred items can be set in one day. Items can be set before a concrete pour or afterward, and then transposed up and installed using drilling and setting methods. Setting items before concrete pours is the preferred method.

6.6.12 Bills of Materials

Bills of Materials (BOMs) can be extracted from the model throughout the process. Although the software processes makes it easy to create many of these BOMs, they should be reviewed before they are released. These BOMs can be used for accurate purchasing, tagging, packaging, estimating, creating look-ahead task estimates, estimate validation, labor tracking, and many other purposes.

6.6.13 Fabrication Drawings and Details

When coordination is complete, your model is signed-off, and you receive authorization to begin manufacturing, fabrication, and installation; your construction model is now considered to be at LOD 400. Fabrication drawings can take various forms and may include single spools, multiple spools, spool maps, equipment skids, plumbing in wall batteries, and hangers and hanger racks. A complete list of prefabrication deliverables should be made available to the team at the spatial planning meeting. This is an area where involving the skilled trades in determining what and how to prefabricate is absolutely essential to its success.

6.6.14 Turnover Packages

Deliverables to be “turned over” at the end of the project are normally defined in the project specifications. Some of the documents required for these packages relate to the spatial coordination process:

DOCUMENTS OF RECORD

- As-built construction models
- Coordinated 2D shop drawings, as built
- Facilities Management interface information

6.6.15 As-Built Construction Models

An as-built construction model may be required for use by the Owner post-construction. This should be the final, coordinated model from the coordination process, plus any field modifications made after the model was closed. It may include all the elements required for the construction model or just some of that information. Your project manager and Project Coordination Manager should be aware of any such deliverable before the coordination process is underway. Otherwise, what is needed for construction modeling may not be adequate to meet any as-built deliverable.

Submittal data plus operation and maintenance data may be required to be attached to the different items of equipment and other elements within the model for use by the owner.

6.6.16 Facilities Maintenance Interface Information

Turnover package deliverables for use by an owner's Facilities Maintenance personnel are becoming more common. You should read and understand the information to be included before you begin the coordination process.

6.7 Communication with the Design Team

It is extremely important that your detailers and modelers recognize the difference between coordination and design (see section 5.1.1 on [page 67](#)). All members of your Project Team should understand your company policies and expectations for handling situations that may cross this line.

Changes in routing or configuration of MEP systems very often change pressure drops, velocities, and other critical engineering calculations that affect the performance of these systems. It is common for detailers, especially trained craftsmen, to provide fixes for issues encountered in the coordination process and not obtain the proper agreement, approval, or instructions from the Architect or EOR. This "shortcut" can create huge problems for contractors and should be avoided where ever possible.

Any coordination process should require Project Participants to use the Issues and RFI Logs created by the Project Coordination Manager. These logs track open design-related issues, resolution thereof by the proper Design Team members, and appropriate follow-up instructions and documentation.

DOCUMENTS OF RECORD

6.7.1 Requests for Information

Requests for Information (RFIs) are submitted to obtain and record missing information and to record any resolutions, clarifications, or instructions from the appropriate design professionals. Many RFIs are generated by the Coordination Team.

Any critical information that is missing or incomplete and any problems caused by space limitations should be documented. Each RFI should convey all information that the Design Team needs to understand the problem, understand when an answer is needed, and, when applicable, point out potential resolutions.

All problems or issues uncovered during the coordination process should be properly documented and routed from your Project Team to your Project Manager. Detailers should not proceed with changes to any Documents of Record or with instructions from the Design Team without clear instructions from your Project Manager.

6.7.2 RFI Logs

A time-sensitive log of all RFIs should be maintained for all outgoing and incoming requests when the coordination process begins.

In addition to your Project Team's logs, your Project Manager should also keep and maintain a complete copy of all RFIs that your team members submitted and any other RFIs that have, or may have, a serious impact on your abilities to complete your obligations on time.

Use these logs to communicate with the Design Team and compel timely responses. When responses to RFIs are late or inadequate and are affecting the coordination process, you should follow the notification for delay procedures defined in your contract.

6.7.3 Issues Logs

An Issues Log is used to describe, track, and expedite any issues (including RFIs) that are, or soon will, affect the coordination process. Use these logs to document such issues as the absence of adequate information, instructions, and delay in responses. These logs are often used to advise critical parties, to prioritize outstanding issues, and to record delays, instructions, and directives. Often, these logs reflect the causes and need for multiple coordination passes.

6.7.4 Changes in Scope or Schedule

At some point, the coordination process has an impact on the scope of your work or your schedule. Changes to your installation quantities, system performance, inserting, or fabrication efforts can be introduced as the Coordination Team strives to create workable coordinated models. You must have both the processes in place and the personnel trained to recognize when such changes are being made.

DOCUMENTS OF RECORD

Your Project Team must also recognize that participating in the coordination process does not remove or replace any contractually imposed notification requirements.

6.7.5 Archiving Documents

You want to establish a system for capturing and filing the receivables for any project.

Long after a project's Document Control program has closed, you may have a need to retrieve all the information pertaining to receivables, deliverables, and other important Documents of Record. Every contractor who participates in the coordination process should obtain the project files at the end of the project.

6.7.6 Archiving Models

Give special attention to capturing and archiving any models received, created, or delivered from the Coordination Team. Modeling hardware continues to improve, and software programs are updated regularly, often more than once per calendar year. Newly published versions of software do not always fully support earlier versions.

The march of progress can also wreak havoc on any program used to archive or maintain the models used on large or long-term projects. Attempts to access models created even five years earlier can often be stymied because current hardware or software cannot open or modify them.

In addition to internal storage of these files, which can be extremely large, maintain hard copies also. If you believe that a project's model files have considerable future value, consider archiving the computers that currently run these programs.

6.8 Managing Documents During the Coordination Process

New and critical pieces of information arrive, often daily, during the course of a normal coordination process. These documents may include drawings, sketches, RFIs, and addendums. You should be prepared at the outset to properly manage the documentation and data files. Management includes providing timely notification of updates and new information and providing access to this data to all Project Participants.

6.8.2 Web-Based Document Control Programs

Most large projects use web-based document control software that is usually managed by the Construction Management firm. These programs can be simple or very sophisticated. These programs need to be organized and managed effectively, otherwise participants can be overwhelmed by the sheer volume of information that they are expected to review; they may not be able to find information they need,

DOCUMENTS OF RECORD

miss important updates, or be working from outdated or erroneous information.

The receipt, logging, input, maintenance, notification, distribution, and overall management of those documents used for spatial coordination is typically the responsibility of the construction management firm. Each Project Participant involved in document management should be provided the appropriate level of security access and trained to properly use the software.

At the end of each project, it is good practice to download or receive a copy of the final documents maintained on any web-based software program.

Because clients use different document control programs, it's a good practice to maintain your own documents in a software program of your choosing and feed documents to each coordination project from it. This practice permits you to maintain consistency within your organization for document control, manage your needs and requirements independently, and have access to the information long after your client's website for the project is taken down.

6.8.3 Model Files

As coordination progresses, the Model is changed and updated many, many times. Your Project Team should capture or save each rendition of the Model, at a minimum, after each coordination meeting. Computer or disk storage space is cheap compared to not having a history of the changes.

All collaborative modeling applications provide a mechanism for taking a snapshot of the Model at a particular point in time that cannot be subsequently edited, but can be opened and reviewed to see the state of the Model at any specific point in time, which interferences or clashes had been identified or unresolved, and what actions had been agreed upon to correct them (provided that information was incorporated into the Model before the snapshot was taken). A record snapshot also should be taken and saved at the time of coordination sign-off.

6.8.4 Drawing Logs

A complete log of drawings and sketches received, and for which the Coordination Team has proper authorization to include in the coordination process, with revisions, versions, and dates issued, should be vigorously maintained, and readily available, to your project team.

On most projects, these drawings are delivered on a continuing basis, and these logs require constant and expeditious management. When appropriate, these logs should be available and managed on any web-based document control system used for the project. Depending

DOCUMENTS OF RECORD

on your setup, hyperlinks can go a long way toward simplifying searches for the most current information.

6.8.5 Meeting Minutes

Accurate minutes of all spatial coordination meetings should be kept. The Project Coordination Manager should maintain the official set of minutes, and distribute them to the team for review and approval. All matters requiring action should be documented with applicable due dates indicated.

You are well served to maintain your own minutes and notes. This practice permits an internal reminder to distribute the action items and changes to those individuals within their organization that may be affected by issues broached during these meetings. Having the Project Manager or his trained representative participate in all coordination meetings is advantageous because many detailers and/or modelers are not usually trained to keep adequate notes or to recognize issues that might involve additional costs or time.

Chapter 7

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

Once you commit to implementing spatial coordination and 3D modeling, the volumes of digital data that are a by-product of the process become available to your organization to improve your operations.

Beyond the geometrical information about MEP objects, the coordinated model contains information about each object's exact location in the building, its item name, a long and short description, weight, warranty information, special maintenance requirements, manufacturer, order number, labor factor, price, location, dimensions, material type, and type of connection. Almost every CAD authoring tool provides functionality to append attributes to these objects, extending the possibilities for sharing data to support facilities management and future space renovation.

This data costs nothing, but to use it you need to learn where to find it, how to collect it, and most importantly, how best to manage and apply it. Once you've gained experience using and managing data, you will wonder how your firm ever got by without it.

This chapter describes the uses of this new resource and is of particular interest to senior operational managers and Project Managers.

- **7.1 By-Products of Spatial Coordination Data** [on page 103](#)
- **7.2 Improving Project Management** [on page 107](#)
- **7.3 Aligning Company Databases** [on page 112](#)

7.1 By-Products of Spatial Coordination Data

The data that you receive and deliver for spatial coordination creates by-products that are useful to your operations. You need some of the data that arrives with the Design-Intent Model to design your systems, and you can direct some of it to drive fabrication. Also, the data from which you prepared your estimate can be used to measure productivity in the field.

7.1.1 Data for Fabrication

The most common examples of the by-products from spatial coordination concern the data extracted from the coordinated construction model for use as input into MEP trade-specific, prefabrication and fabrication processes. For example, the electrical or the piping and plumbing contractor produces shop drawings (also called cut sheets or spool sheets). Shop drawings represent an accurate geometric description of an object, component, or assembly taken directly from the coordinated model with all of the details and instructions to manufacture the element in a controlled shop environment. An HVAC contractor can use the data for direct fabrication. The HVAC detailer or the shop's ticketing manager initiates a "take-off" of fittings and ducts from the coordinated model and downloads the output file directly to the CAM (computer-aided manufacturing) application which, in turn,

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

drives the shop's plasma cutting table and coil lines for manufacturing the objects. There are many other types of fabrication that are generated from the process of spatial coordination, such as plumbing fixture batteries, piping main racks, hangers, equipment hook-ups, pipe cuts, and hanger points for robotic layout.

In each case, an MEP contractor can use the data by-product to automate a unique prefabrication or fabrication process, eliminating potential human error, reducing manual input, and gaining greater manufacturing efficiency. For more information about using this data for fabrication, many tutorials, articles, and papers are available on the Internet and through MCAA, SMACNA, and NECA. (See Appendix D [on page 160](#) for contact and reference information.)

7.1.2 Data from the Design-Intent Model

When you begin any project, you have two originating sources of digital data: the project's Design-Intent Model and your firm's estimate. The Design-Intent Model arrives either as part of the bid documentation or, once you've won the job, as part of the contract documentation. Typically, the Model arrives after the bid was awarded in the form of a Level of Development 300 model. (For details on LOD, see section 2.3 on page 15).

The Design-Intent Model is created in one of a handful of industry software packages, including Autodesk's Revit MEP, Bentley's AECOSim, or Graphisoft's ArchiCAD. These MEP design platforms provide functionality that allows you to collect pertinent MEP object and system services data directly from the document. (See Appendix C, "Scrubbing the Design Model" [on page 156](#).)

Many MEP contractors lack both the software to open this model and the skills to extract from it the project data that they need. Instead, they invest hours in creating and assembling this data, and because this process is largely manual, opportunities for introducing errors abound, and corrections or revisions take more time than they have to.

This is a common mistake, though an understandable one. Historically, these platforms have yielded little value to MEP contractors, who had no incentive to invest any time or money in them. But Design Teams now use them to create higher quality models, which gives you more reasons than ever to develop basic competency with these design platforms. The skills needed to extract MEP object data to assist estimating (for quantity and material take-off) or to populate your virtual design and project management process can be acquired in a few days. The value of having personnel on your project team who can collect data is significant, particularly with respect to many of the initial requirements and tasks of the Project Manager.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

7.1.3 Data from the Estimate

More than likely, your estimating department created this estimate based on 2D schematic design drawings, specification documentation, industry-standard metrics, and historical labor data and cost metrics based on your company's standard WBS (work breakdown structure). Once you've been awarded the project, the estimate data is often filed away and rarely, if ever, repurposed or reviewed. Exceptions occur, for example, if a major design change requires you to re-estimate a portion of the project.

Failure to recognize the value of reusing the data from the estimate is another common mistake that MEP firms make. The estimate data is a valuable baseline for monitoring costs and schedules through the project lifecycle. Incorporating it into your project workflow should be a standard practice. At a minimum, reviewing this data should be part of the team's analysis of every completed project. This review would identify aspects of the estimating design and construction phases to improve future projects.

To incorporate the data from these two sources into your existing workflow, all members of your internal project team must understand the inherent value of this process to the company and be prepared to use the data. If the company is not fully ready when the project starts, or if you do not have the backing of the department personnel, your firm will be playing catch-up through the entire project and may be unable to benefit from the information that you generate and collect during your initial learning curve. And that is the final common mistake.

The rest of this chapter covers other valuable approaches to take with the data to improve your operations. The matrix in Table 7.1 on [page 104](#) summarizes some useful by-products of your spatial coordination data.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

Type	When is it created	Who created it	How is it used
Construction Schedules (No. 1. Structural and concrete No. 2. MEP build-out)	No. 1 is often times completed prior to your involvement and No. 2 is one of the result sets that are generated through the coordination process	General Contractor, Project Coordination Manager, and other subcontractors (that is, concrete, structural, and so forth)	To define major milestone construction dates and order of precedence
Estimate data	After project is awarded	Your estimating team	As input into the PM estimate described in section 7.2 on page 107 and for post mortem reviews of the project
Quantities of equipment and materials	During the estimating process but also generated as a critical element of sales and estimating passing the project, once awarded to the PM. This will also be generated in the MTO process, once a LOD 400 set of elements in a drawing has been submitted and received authorization to begin manufacturing and installation	There are two stages: first, during the estimating process and further defined during the RFQ process with your supply chain and second, at MTO for procurement and manufacturing	Estimating, Project managing, detailing, procurement, shop and field productivity measures
Labor estimate requirements	Estimating department and PM Estimate	Estimating department and PM	Shop and field productivity measures
Initial Equipment and materials RFQ to supply chain	Estimating department	Estimating department	To sharpen estimate and win bid
MEP construction coordination schedules	During coordination with Project Coordination Manager and other domain Project Participants	The Coordination Team and Project Coordination Manager	To define major milestone construction dates and order of precedence
Major systems and equipment location (from Design-Intent Model)	When Design-Intent Model is received (which may or may not contain LOD 300 elements)	Detailer with software skills to scrub Design-Intent Model	To begin the process of detailing construction model and as input into Project Manager's equipment procurement process
Hanger point location	After completion and sign off of model	Virtual Design Team	To site superintendent for installation
Procurement schedule for equipment and materials	As early as post bid and as late as LOD 350, but prior to LOD 400 submittals	Project Manager	To provide the purchasing department with adequate amount of time to procure within a "best-buy" framework all equipment and materials within a JIT framework.
Prefabrication 2D models	When the model elements are extended and compliant with LOD 400	Virtual Design Team	<ol style="list-style-type: none"> 1. To provide and accurate MTO and data for procurement to ensure that all of the materials are readied to be used in the prefabrication process. 2. To provide prefabrication shop team with precise assembly details in shop drawings to construct assemblies and then ship to site for installation
Fabrication downloads to CNC cutting machines	When model receives LOD 400 authorization from project stakeholders	Virtual Design Team	To provide automated downloading of sheet metal of pipe to CNC machines in shop
Shipping and on-site delivery Schedules	Any time after LOD 350 of the construction model and as a direct outcome of weekly project team meetings	Virtual Design Team, Shop Operations Manager, and Project Team	For purchasing department, shop operations, shipping manager, and site superintendent for improved materials handling and JIT delivery
Weekly site field labor reports	As soon as manufacturing and or installation commences	Project Manager and site superintendent	To better manage the manufacturing and installation process by tracking productivity compared against estimated and expected results
Turnover package	Begins as soon as the project is won and the Phase 1 meeting between sales, estimating and the PM. It continues through the lifecycle of the project	Project Manager	As an iterative process, when data, spec sheets of equipment and other turnover information is created and available it should be aggregated in preparation for the final turnover package

Table 7.1 Data Available from a Coordinated Project Model

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

7.2 Improving Project Management

It should come as no surprise that by the time your firm has been awarded a project, it is already behind schedule.

The person most responsible for getting the company and the project on schedule is the MEP Project Manager. In that role, you are in the position to know everything about the project, and when you don't have a particular answer, you know where to find it or who to get it from. You are also continually thinking about the variety of tasks and project deliverables that need to arrive on time if they are to be useful. In both areas, no one knows better than you the value of having access to dependable information and data to make the right decision. Much of the collecting, collating, and report generation falls to you in whatever time you have left in the day.

You also understand that by collecting data from the spatial coordination process, you can have critical project data when you need it. Some of this data must be gathered from members of the Project Team. However, new technologies that support automated access to project data are becoming available. It won't be long before you and your entire Project Team will be able to access current project data whenever and in whatever format you need it in to support timely and better decision making.

7.2.1 Aligning the Project Schedule with Available Resources

The coordination and construction scheduling process begins immediately after you are awarded the job. The kick-off meeting is already scheduled and referenced in your contract documentation or in the BIM Execution Plan. Before you attend, you should hold two other meetings.

Your first meeting (the Phase 1 Meeting in Figure 7.1 [on page 106](#)) is with key individuals in your company; at a minimum, this meeting should include the sales manager, estimating manager, virtual CAD manager, and site superintendent. It's not critical that all four meet at the same time, but is important for the sales and estimating managers meet with you in tandem to transfer their combined knowledge about the project. The meeting with the CAD manager and site superintendent helps to identify resource and schedule requirements of the project and to determine, with their input, how well that aligns with the available project resources and other project schedules within their departments.

You should have a clear understanding of the scope of the project and a realistic view of available internal resources. You are ready to schedule the second meeting, a face-to-face meeting with the Construction Manager. Your goal at this meeting is to review, discover, discuss, and negotiate any initial issues or inconsistencies found within the BIM Execution Plan or the contract documents with an authorized participant

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

on the project and who is in the position to do something about whatever may need to be altered or changed.

Recognizing that the project has been in motion for months, you want to discuss is construction schedule first. A common mistake that first-time or inexperienced Project Managers make is to agree to a construction schedule that is not aligned with what your firm's resources could possibly accomplish within that timeframe. Therefore, before you agree to any milestone in the construction schedule, you must have confidence that your Project Team has the time and resources to meet them.

Many experienced MEP contractors suggest that the initial focus in this meeting should be on the concrete pour schedule. Keep in mind that the Construction Manager, the General Contractor, and the concrete subcontractor are on the same page regarding the schedule, a schedule that was more than likely created without input from you or the other MEP trades. Ensuring that your virtual CAD department has enough time to complete your hanger points and project model before the scheduled pour date is a great advantage in cost and labor savings. If you aren't able to complete and receive sign-off of your coordinated hanger model in time, you will be forced to drill each hanger point after the pour at greater expense and labor. If there is even a slight chance that your detailers will not complete their coordinated hanger points schedule in time, this meeting is the only opportunity you have to address it with the Construction Manager before the kick-off meeting.

The general philosophy that guides spatial coordination with 3D modeling is the expectation that all participants are willing to work collaboratively. This point is worth emphasizing during your meeting with the Construction Manager if it doesn't appear that you can meet the concrete pour schedule. There may be a way to negotiate a later date, allowing your CAD detailers to complete the hanger points in time. If no relief is available and the schedule cannot be extended, there is value in knowing that this issue exists and that you may have other options. One option, if you can present information to establish that the pour date is unreasonable within a normal virtual design process, your firm might be in a position to issue an RFI, and potentially seek monetary compensation. Another option, if the Coordination Team is falling behind the pour schedule, is to skip an area, especially if it has numerous design issues delaying coordination sign-off, and come back to it later using traditional installation methods. This will allow you to get ahead of the pour rather than staying behind it for the entire project.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

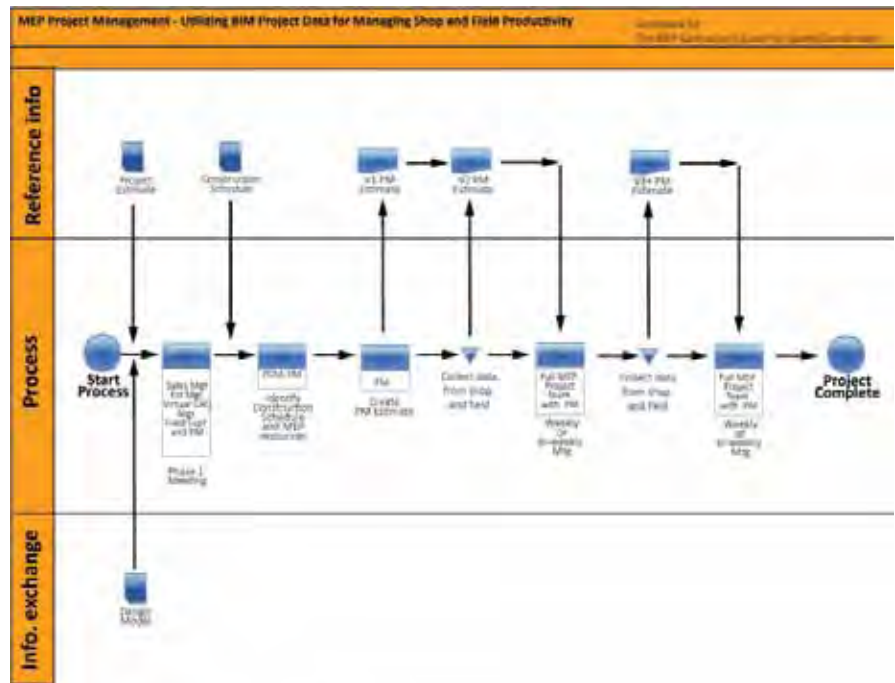


Figure 7.1 Project Manager Process Flow

7.2.2 Measuring Field Productivity

You now understand the assumptions and data that your firm used to calculate the projected costs and margins for your winning bid: the labor, materials, and equipment that you will manage through to completion. If your MEP business is sheet metal, you'll know how much lineal footage of duct work, pounds, and number of pieces that the estimate represents. You'll receive construction documentation detailing major equipment and materials, system specifications, projected labor (based on labor factors and difficulty factors for each unique zone in the job.)

The next step is to break the original estimate into manageable pieces of the project to create the PM Estimate. The PM Estimate is typically set up in a standard spreadsheet application. The primary benefit of the PM Estimate is to help you and your Project Team, organize the project into a manageable process flow that is easy to understand and is repeatable, reproducible, logical, and linear.

Figure 7.2 on page 110 is an example of a PM Estimate for a sheet metal contractor.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

Emerson Hospital Annex					
Project Code: 303-2014					
Date: 11/3/2013					
CODE	DESCRIPTION	LABOR	HOURS	RATE/HR	TOTAL
Shop FAB Codes					
1-301	1st floor and underground duct	SHOP	98	\$ 45.00	\$ 4,410.00
1-502	2nd floor duct	SHOP	85	\$ 45.00	\$ 3,825.00
1-503	3rd floor duct	SHOP	74	\$ 45.00	\$ 3,330.00
1-904	4th floor duct	SHOP	72	\$ 45.00	\$ 3,240.00
1-505	Shaft/exhaust duct - curb caps	SHOP	358	\$ 45.00	\$ 16,110.00
1-506	Mechanical Room & plenums	SHOP	25	\$ 45.00	\$ 1,125.00
SHOP SUBTOTALS			712		\$ 32,040.00
Field FAB Codes					
2-501	1st floor and underground duct	FIELD	226	\$ 39.50	\$ 8,927.00
2-502	2nd floor duct	FIELD	198	\$ 39.50	\$ 7,821.00
2-503	3rd floor duct	FIELD	215	\$ 39.50	\$ 8,492.50
2-504	4th floor duct	FIELD	201	\$ 39.50	\$ 7,939.50
2-505	Shaft/exhaust duct - curb caps	FIELD	478	\$ 39.50	\$ 18,881.00
2-506	Mechanical Room & plenums	FIELD	15	\$ 39.50	\$ 592.50
Other Field FAB Codes					
2-801	GRD's	FIELD	75	\$ 39.50	\$ 2,962.50
2-602	Equipment	FIELD	63	\$ 39.50	\$ 2,488.50
2-603	Plenum's / curb caps	FIELD	47	\$ 39.50	\$ 1,856.50
2-604	Material handling	FIELD	356	\$ 39.50	\$ 14,062.00
FIELD SUBTOTALS			1874		\$ 74,023.00
Detailing Labor Codes					
2-700	General Detailing Labor	DET	50	\$ 54.25	\$ 2,712.50
2-701	1st floor and underground duct	DET	24	\$ 54.25	\$ 1,302.00
2-702	2nd floor duct	DET	44	\$ 54.25	\$ 2,387.00
2-703	3rd floor duct	DET	39	\$ 54.25	\$ 2,115.75
2-704	4th floor duct	DET	35	\$ 54.25	\$ 1,898.75
2-705	Shaft/exhaust duct - curb caps	DET	55	\$ 54.25	\$ 2,983.75
2-706	Mechanical Room & plenums	DET	4	\$ 54.25	\$ 217.00
DETAILING SUBTOTALS			251		\$ 13,616.75

Figure 7.2 PM Estimate for a Sheet Metal Contractor

As you can see in Figure 7.2 on page 110, the Emerson Hospital Annex project drawings are named 1st Floor & Underground, 2nd Floor, and so on. In addition, each drawing has its own worksheet. On the 1st Floor & Underground worksheet (not shown), you populate the cells with data from your estimate: field hours, lineal footage of duct work, pieces of duct work, shop hours (in man hours), pounds of duct work, and material cost. The data categories are organized in the columns within each worksheet, representing when the data was collected; that is, one column contains the estimate and another column references the data that will be added when work begins on system design, manufacturing, or installation.

Each category of data is tracked from the original estimate, to the coordinated model, to manufacturing, to shipping, and finally to field installation. When the process of updating this PM Estimate with project data begins, every member of your Project Team must understand this process and believe that it is of value to their departments, to the

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

company, and to the entire project. The Project Team member closest to the data is responsible for adding it to the worksheet accurately as it becomes available. (For more information about tools and technologies that can help facilitate this process, see Chapter 9 [on page 129](#).)

When you have received sign-off authorization to begin manufacturing, you now have a real lineal footage of ductwork, total pounds, number of fittings, and number of hours projected for the job. You can use that data to calculate a metric of “average lineal feet per hour” for the project per space, per zone, per drawing. If you collect and review data every two weeks, you will understand where you are with respect to costs and schedule. Specifically, you’ll be able to measure your performance in important areas:

- Track productivity of your firm’s field installation teams against what was planned
- Determine whether any mitigating outside circumstances (perhaps created by another party or by an internal company conflict) contributed to less-than-expected results
- Gauge the health of your portion of the project at any time
- Determine whether additional steps need to be taken to minimize impact an issue in the field may have on the overall project results

When creating the template for these worksheets, be sure that all updated cells automatically populate any cells associated with and hyperlinked to them. This property supports expanded reporting and analysis. For example, it is useful to view a plotted graph that aggregates data taken from individual cells and worksheets and compares it with historical data from previous collections. In addition, use the data to populate a standard nongraphed contextual report with quantitative data generated from an algorithm that represents measured data, such as the total completed lineal feet during week 4 on the project for Installation Team One.

A one-stop software solution that automates all of the tasks required to manage a PM Estimate through the lifecycle of a project is currently not available. Technology and software publishers are targeting this need, and the first sets of tools are expected to enter the market soon. In the meantime, expect that inputting this data is a manual process and may take up to one man-day to collect, collate, and place into the worksheet for review. If you review progress every two weeks, this updating is needed less often than if you review it weekly.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

7.3 Aligning Company Databases

To sharpen this focus on data—where to find it and how to use it—the value of aligning your firm’s database systems deserves attention. These are the systems that store, manage, and report on real manufacturer MEP content data, the individual databases of your estimating, virtual CAD, purchasing, and back-office procurement departments. The goal is to have key company-wide databases using, referencing, and sharing the same building content and data. Most MEP firms today do not have this capability.

If your departments aren’t using software from the same publisher, this alignment might seem too daunting to attempt, but it can be done. Some of the leading MEP contractors who use different software publishers, and therefore have different database structures, are actively engaged in implementing this change. When you consider the benefits of integrating data and sharing it among departments, the future is compelling:

- The virtual CAD model is using the same information as that used in the original estimate.
- You can easily track your actual cost of labor, materials, and equipment against the costs used for the estimate.
- You can re-estimate the project quickly to accommodate a design change and make sure consideration is made regarding whether or not to issue an RFI.
- You eliminate errors that occur during when mapping activities manually between your virtual MEP project model, RFQs, and your purchasing department’s content database.
- You can incorporate your CAD department’s material take-off into the purchasing department, again eliminating the need to map activities manually, which gives your purchasing department more time to identify the best buy for the project.
- You can generate a single RFQ to your entire supply chain and receive, in turn, a standardized quote from each supplier, eliminating the need to resolve disparities in materials and equipment quoted.
- You can use Just-In-Time ordering and delivery of equipment and project materials.
- Cash flow improves because you can take advantage of favorable wholesale distributor terms for early payment.
- Cash flow improves from the Just-In-Time billing of the completed installation.

BENEFITS OF BIM BEYOND SPATIAL COORDINATION

Moving your firm away from fiddling with disparate departmental databases toward sharing and exchanging data with confidence requires technical skills and knowledge of the applications and their database structures. The best recommendation is to take small steps and to engage the assistance of your software publishers. Instead of tackling all of your databases at once, work to align your estimating software data with your virtual CAD content data. The many combinations of estimating software and CAD authoring software makes it impossible to explain how you might do that for the combination used in your firm. However, there are some basic rules to the process.

First, establish a unique identifier within each database that you will use to map and link the two database structures. There are two mechanical content aggregators who could provide identifiers that can be adopted to provide this map and link between application databases. The aggregators are Trade Service (Trimble) and its PIK code, and Harrison Publishing House with its HPH code. Appending any of these identifiers to the data in your existing databases provides a mechanism that your firm can use to align the content libraries of your applications with each another.

Second, consider how to update the content for both databases as an ongoing process. Setting this up is where the experience and skill of your application software publisher becomes invaluable because each application has its own methods for accommodating updates.

Managing this deluge of data requires significant changes in your operations. Yet, in so many ways, the benefits far outweigh the costs. If you step up to these challenges, you will have better managed, more efficient, and more successful projects. And that success should bring more opportunities and more projects.

Chapter 8

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

With increasing frequency, Project Participants such as Owners, Architects, General Contractors, and Construction Managers are shifting additional spatial coordination scope and responsibilities to the subcontracting community, especially MEP contractors. This shift may create additional risk for project costs and for new or unanticipated legal exposures.

The cost and effort of entering into the BIM process is substantial. If you are considering taking your company in that direction, you need to believe that it's worth it. When the MEP "pioneers" finished their BIM projects, they discovered how the all that they had invested pays off. They had replaced nonstandard practices and communication patterns with linear, repeatable operating procedures. They knew where to get the data they need from previous bids and projects and how to repurpose it. They knew how to recognize the unreasonable risks in vague language and which expectations to challenge. They had the skills they need to pursue and win new opportunities. They had strong companies that were running better than ever.

The goal of this guide is to establish an authoritative reference for acceptable practices and standards for MEP contractors who are working on their first BIM project that requires spatial coordination. The guide explains; how to review, use, and contribute to the many documents that establish the scope of that work; how to manage the BIM coordination process; and points out the red flags to look for and the best practices to adopt.

This chapter provides information and guidelines for any senior manager responsible for the firm's contract business. The contents will help you review project documents to identify potential risks and exposures. It also points you to some sources of contract language that can help you mitigate identified risks.

- **8.1 Reviewing Spatial Coordination Contractual Requirements**
on page 112
- **8.2 Specific Legal Considerations Concerning Spatial Coordination**
on page 118
- **8.3 Spatial Coordination Related Provisions for Consideration**
on page 122
- **8.4 Red Flags in Contract Language** on page 123
- **8.5 Other Important Industry Contract Reference Material:**
ConsensusDocs.org on page 127

8.1 Reviewing Spatial Coordination Contractual Requirements

All MEP contractors should be well aware that expectations and obligations with respect to any of their spatial coordination activities are first and foremost dictated by the contracts that they sign. These Guidelines are not intended to presume nor establish any precedence over any limitations, restrictions, expectations, or obligations between any contracting parties.

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

The information presented herein is for management guidance to inform MEP contractors about various issues that might apply to their contractual and professional obligations. It is not intended as legal or insurance advice applicable to specific circumstances and should not be construed as providing such. Before you apply or act on anything contained in or suggested by this material, consult your local legal and insurance counsel or other appropriate professional advisor.

To reduce the risk of unexpected costs and legal liability, first recognize and identify language in any proposed contract or RFP that is associated with spatial coordination. Such language needs to be assessed for its potential to impact the time and resources that you may have to allocate to meet relevant requirements. In addition, any language that might imply or impose legal obligations on your firm that arise from its spatial coordination efforts should be carefully evaluated. It is imperative that the responsible and knowledgeable individuals within your firm carefully read and understand any spatial coordination requirements that are introduced in an RFP, BIM Execution Plan, Specification, or contract.

8.1.1 Pre-bid Review

Before submitting a proposal for a potential new project, at a minimum, look for certain critical spatial coordination language or requirements that are commonly delineated in such documents. These are the basic items of interest:

- 1. The scope of the coordination work involved.** Note the resource demands it entails, the comprehensiveness of the program, and the responsibilities it pushes down to the participants.
- 2. The leadership of the program.** Look for which party will be leading the spatial coordination effort and the extent of the MEP contractor's participation and responsibilities, both internal and to the project team.
- 3. The schedule for performing the spatial coordination efforts.** Consider the availability of qualified resources and potential impact to ongoing business operations.
- 4. The contracting methodology of the project.** Of importance here is how the project may be divided by preconstruction and construction proposals, and therefore, contracts. Also, what is the potential for winning a preconstruction contract without winning the follow-up construction contract?
- 5. The location of the spatial coordination efforts.** Note where the work will be done. Look for expectations of your personnel how they participate—collocation, in-person, or video-conferencing—and the duration of associated commitments.

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

While the best BIM and spatial coordination requirements are prescriptive, detailed, and clear, you must always be on the lookout for vague or inconsistent requirements. Most, if not all, of the spatial coordination requirements can be communicated clearly. If any bidding information is unclear, you should not assume that the terms are unimportant or inconsequential. Instead, you should submit detailed questions to remove uncertainty during the pre-bid clarification period so that you can develop a sound approach to the bid. If the BIM or spatial coordination requirements cannot be clarified prior to bid submission, you may want to mitigate risks by qualifying your proposal accordingly. Similarly, if any of the requirements are clear, but inconsistent, you should seek to resolve the potential conflict or any misinterpretation through the pre-bid question period by submitting an RFI or other documentation vehicle.

Any subcontracts that potentially tie your duties and responsibilities to those contained within the prime contract between the Owner and the General Contractor should be assessed to ensure there are no inconsistencies. You should attempt to resolve any questions you have by submitting an RFI in the manner as noted above or by other appropriate means.

The failure to ensure a precise understanding of the coordination requirements may saddle your firm with additional or different obligations than those you thought you were agreeing to; in turn, the obligations that you actually undertake can give rise to added, unanticipated costs to meet the coordination requirements and increase your exposure to certain legal liabilities. MEP contractors who have not taken these steps have found themselves obligated to scope, process, or other requirements that they did not anticipate simply because they did not give the spatial coordination/BIM sections of an RFP adequate attention.

The ability to successfully and profitably bid and complete a project may depend on having clear and well-defined expectations for the spatial coordination requirements. To this end, your firm should provide pricing that is adequate and appropriate to meet the requirements, clarify expectations, or qualify the bid in the event of ambiguous or missing requirements.

8.1.2 Risks Associated with Vague or Inconsistent Contract Requirements

The quality and clarity of BIM and spatial coordination requirements can vary widely for many reasons. At times, the BIM/spatial coordination knowledge or proficiency of the author of such requirements becomes evident. Although the technology is no longer new, it is still unfamiliar

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

to many Owners, contract managers, and specification writers. Truly “standard” specifications or requirements for spatial coordination have yet to be developed and adopted industry-wide.

Beyond the Owner’s design or specification authoring team, requirements also can vary considerably between Construction Managers or General Contractors who each may have their own levels of BIM sophistication, style, preferences, and demands when it comes to spatial coordination. MEP contractors that work with various Owners and Construction Managers simultaneously often find themselves working under a multiplicity of rules, requirements, or expectations across different jobs on a daily basis. Understanding and managing all this can be quite a juggling act.

Sometimes the requirements for BIM or spatial coordination processes are scattered throughout the RFP documents or specifications and cannot be located easily. Under such circumstances, it is not uncommon to find contradictory or confusing language. A typical RFP may be the work of many people, each with their own particular area of expertise. The modeling and spatial coordination requirements may be written by a “BIM specialist” while the “boilerplate” coordination and submittal requirements may be written by a skilled, but traditional, building systems coordinator. These different perspectives can result in an RFP that contains inconsistent requirements that call for both traditional, paper-based, coordination submittals and BIM-based spatial coordination processes and submittals, leaving the contractor unsure of which obligation it must follow.

Other samples of confusing language may include using the terms “BIM” and “CAD” interchangeably, which can create a great deal of confusion, or require the MEP contractor to “use BIM” on the project without otherwise specifying why or how it is intended to be used.

These differences can result in spatial coordination requirements in bid or contract documents that are vague, contradictory, not coordinated, or inconsistent with other requirements. Such vague or inconsistent requirements create risk for bidders and require close attention to minimize exposure relative to costs, risks, and liability.

8.2 Specific Legal Considerations Concerning Spatial Coordination

While many of these issues noted in this chapter can increase your costs purely as a matter of the time and resources necessary to actually perform the obligations, it is critical to bear in mind that they also increase your legal exposure when framed in a contract for the work, and the related risk of added costs for such liability.

EVALUATING SPATIAL
COORDINATION CONTRACT LANGUAGE**8.2.1 Contract “Flow-Down” Provisions**

Inconsistencies may arise from the typical “flow-down” provision contained in subcontracts, which imposes on the MEP subcontractor all the terms of the prime contract that relate to the MEP subcontractor’s work. If the flow-down clause requires the MEP subcontractor to meet the BIM and spatial coordination requirements to which the General Contractor agreed in the prime contract, as they relate to the subcontractor’s scope of work, then those obligations may be different from the obligations specified in the MEP subcontract for coordination. Alternatively, the prime contractor may seek to impose greater coordination obligations on the MEP subcontractor through its subcontract, if that subcontractor is uniquely situated to provide such services. This situation may arise when an MEP subcontractor has an inordinate portion of the work or is otherwise more sophisticated in this area than others involved in the project.

MEP contractors should also remain mindful that the contracts between Owners and their Design Teams likely address Model reliance or Spatial Coordination issues, as well as allocation of risk and liability concerning such issues, and the Design Team’s obligations under such agreement may influence the quality of information received from the designer. For example, if a designer is liable for modeling or coordination issues pursuant to its contract, it has an incentive to provide as much reliable, quality information as possible, whereas another designer that is able to limit its exposure to these issues may not perceive the need to provide the same caliber of information. MEP contractors also should note that the Design Team’s contract may be made a part of the Contract Documents and, if so, and if the MEP’s subcontract flows down to it coordination obligations in the Contract Documents, the MEP contractor may have obligations similar to or the same as the designer with regard to the MEP’s scope of work, or limited recourse against the designer. Such obligations or limitations may influence many aspects of the construction spatial coordination efforts and should be addressed accordingly.

8.2.2 Time and Delay Risks

If a contract imposes liability on a MEP contractor (or subcontractor) for causing delay, the contractor must bear this in mind when assessing its coordination obligations. For example, if you also agree in the contract, unwittingly or otherwise, to provide 100% complete and clash-free modeling, but really expect to provide modeling only for core components, then you may be exposed to delay damages to the extent you have to delay the project while reworking and completing the model as agreed, and also for the time it takes all the other trades to then

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

remodel as well. Or, alternatively, you will have to absorb the cost of adding resources to accelerate the additional work to avoid delaying the project. These coordination requirements, when couched within the MEP contractor's larger contractual obligations, can significantly increase legal risk.

MEP contractors sometimes find that the terms of a contract between an Owner and the Design Team significantly influences the flow and the quality of information received from the Design Team, specifically, the amount of information, its LOD-defined elements, or how complete and reliable it is. Flow-down provisions from a MEP contractor's contract from a Construction Manager may also have flow-down references from the design contracts.

8.2.3 Coordination Morphing into Design

The lack of industry standards and precise definitions for spatial coordination tasks also increases legal risk because the ambiguity creates room for Owners, Construction Managers, and Designers to argue that the contractor's bid or the contractual language requires the MEP contractor to do more than the MEP contractor ultimately may be willing to do. One very important permutation of this issue arises when a party argues that the MEP contractor actually took on, or is responsible for, design work. Actual design work is well beyond spatial coordination, but the lines can get blurred with ease through the use of certain contract language or as "adjustments" are made in the course of a project.

You should always be aware of this issue because assuming responsibility for design imposes an array of additional and different obligations on your firm and increases risk. For example, engineers and design professionals generally must have a license, and also carry different insurance; your employees, in attempting to help coordinate a project, may accidentally venture into territories where insurance coverage does not extend. Your firm's failure to meet federal, state, or local design-related requirements may also violate certain laws, as well as your agreement in the contract to comply with these laws. These breaches and violations all can result in significant consequences for an unwary contractor.

To help distinguish coordination from design, the National Institute of Building Sciences has issued National BIM Standard V2, which notes that coordination is the implementation of design, but MEP contractors still must remain mindful that any conduct that trends toward design work greatly increases legal exposure. For example, some contracts may require the MEP contractor to provide "design assist" services, which is a nebulous concept that lurks somewhere between coordination

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

and actual design. Similarly, a request for “value engineering” pushes the contractor into another area of considerable concern and unclear boundaries. In an effort to win work, you also may be tempted to send proposals or scope documents that state your firm can help “to design” or “engineer” a project or a solution. The use of such words, however, can have unintended consequences later when a court is forced to assess what the parties intended when forming the agreement. In this regard, it is critical to choose your words carefully when addressing such issues, and make certain to describe tasks as coordination only and to stop short of hallmarks of true design work. Moreover, once integrated into the Design Team, you lose the “firewall” that usually exists between the Owner’s designers and the installing trade contractors, and it is much harder for you to argue that you installed all items properly and a defective condition or other issue is tied just to design.

At the very least, you should insist that your Engineers of Record be involved with, review, and approve any changes or modifications of the systems as designed that were made to accommodate the constraints imposed by the multi-trade construction spatial coordination process.

8.2.4 Accepting Contract Administration Responsibilities

Your firm also should seek to understand, before you sign the contract, whether the other trade contractors and the Construction Manager’s Project Coordination Manager on the project are knowledgeable in spatial coordination tasks and BIM. If they are not, this can slow down the process or cause repeated modeling efforts, which can cost you time and money.

But perhaps the greater risk of working with unsophisticated parties is that the more experienced contractor (often the MEP) is often asked or required to administer the spatial coordination effort for the entire project or a significant portion thereof. If the individual coordination leaders or others on the project are computer literate, but lack the actual trade or social skills necessary to manage an efficient coordination process, your firm may choose to accept this role and lead the MEP spatial coordination process for the entire team when you feel that, despite the added time required for this role, it will be more effective and efficient to have a streamlined and well-coordinated process.

Although this makes logical sense, you must bear in mind that taking on this role increases your exposure and legal risk because your firm has now essentially assumed an administrative role and responsibility for a portion or the entire spatial coordination product, and may therefore be liable for delays to or errors in the final product. Such an administrative role also may consume far more time and effort than anticipated if the other trades truly are unsophisticated or the project experiences a

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

large number of changes. The MEP contractor therefore needs to weigh these items carefully before taking a lead role in the spatial coordination process.

Often MEP contractors, by contract or by choice, undertake certain tasks that by definition encompass the work products of multiple trades, inclusive of parties not under contract to their firm. The assembly of composite drawings can be such a responsibility. MEP contractors should insist that, although they may take on these types of tasks the responsibility for the accuracy and completeness of the individual elements of these assemblies remains with the originators and that any risks associated with such actions remain with the individual contributing contractors and the General Contractor.

8.3 Spatial Coordination Related Provisions for Consideration

The absence of established, industry-wide norms for BIM spatial coordination criteria has caused (or enabled) Owners, Construction Managers, and design professionals to create individualized requirements and craft custom provisions, which they inject into their RFPs, often buried in pages of technical descriptions. Further refining the critical reviews noted above, your firm's representatives should take care to look for and assess the numerous, more specific, spatial coordination requirements that often appear in the contract documents.

Typical bidding or contract documents may include some of the following types of requirements. You should evaluate each of these for the potential impacts and obligations they impose upon your firm:

- Expectations of the Owner, Construction Manager, or General Contractor for the spatial coordination process
- Schedule requirements for spatial coordination
- A Project BIM Execution Plan (if one does or does not exist)
- Definition and assignment of spatial coordination roles and responsibilities
- A listing of trade contractors and others required to participate
- Spatial coordination meeting requirements
- Mandates for unrestricted quantities of meetings for the spatial coordination process
- Spatial coordination meeting locations
- Expected receivables from the design team, such as architectural/ structural models
- The Levels of Development of the Design Team's deliverable model elements (for example, LOD 0, 100, 200, or 300)

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

- Spatial coordination workflow and approval processes
- The Level of Development for spatial coordination model elements (for example, typically LOD 350)
- Submittal processes and sign-offs
- Location and management of a central project information repository
- File-sharing protocols or web-based repositories
- Software requirements
- Computer hardware, network, and Internet connectivity requirements
- Post-coordination deliverables
- Non-responsibility language from the design team associated with their deliverables

Each of these issues may have a significant impact on how, or even if, your firm may choose to pursue a contract for such a project. Moreover, careful reviews by qualified individuals are required. Estimators or individuals who are not intimately involved in the BIM or spatial coordination process may have difficulty understanding or comprehending the costs, time, and risks associated with these criteria and may overlook these important concerns.

8.4 Red Flags in Contract Language

In addition to the more general review requirements listed in the previous section, certain other contract requirements deserve a higher level of scrutiny before your firm accepts BIM spatial coordination language that may be presented. Each of these issues has the potential to significantly increase your costs, time, resources, or risks that may be associated with a project.

1. A deficient spatial coordination schedule. Often, certain stakeholders create coordination schedules that are unrealistic, unachievable, or seriously diminish the positive benefits or opportunities that a well-coordinated project should receive. Such deficient schedules are often created to make firms look better than competitors or may be developed by individuals who really don't understand the importance, effort, time consumption, or true intent of virtual coordination and construction. It is also not uncommon for these parties to use the "procurement process for MEP contractors" to get subcontractors to agree to such impractical schedules. To some extent, it is often a buyer beware situation. If the coordination schedule provided is not connected in any logical manner to the project construction schedule, then even a small project, if coordinated in too short a period of time, can cause very large and costly impacts to business operations.

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

2. Any requirement for utilization of a modeling software platform that differs from standards or industry norms. Some Owners or Clients are looking for an Integrated Model instead of a Federated Model for both the construction coordination efforts as well as for their project model deliverables. Most MEP contractors create models within their own specialized software, which permits their work product to be “federated” into a viewable model by other model review software. Having an “integrated model” requirement can impose significant challenges to how your models must be created, the internal value of such models and/or how these must be translated into a Client’s integrated platform.

3. Any language that stipulates that the cost of all materials and installation needed to accommodate spatial coordination adjustments be absorbed by the bidding contractors. In the usual Design-Bid-Build project, the general purpose of construction spatial coordination is to reduce trade interferences, eliminate rework, optimize construction sequencing, and enhance prefabrication and installation of components or systems. The obligation of any Project Participant should be limited to a requirement that it coordinate its system with those of all other Participant members in advance of installation.

Spatial coordination is not an acceptable vehicle to impose unreasonable or unfair duties upon the participants. A requirement such as that noted above does not differ in any significant way from a requirement that the MEP contractor accept the risk of unforeseen circumstances or actions beyond its control that occur during the construction process. If this type of language appears in any RFP or document, you should take appropriate actions to remove it, or at least draw a tight box around any financial exposures that might arise relative to its coordination efforts.

If the scope of work of any individual team member increases because of the spatial coordination process, then that person should be entitled to fair compensation under generally accepted practices and protocols. The MCAA, SMACNA, and NECA Industry Associations all publish manuals covering such matters.

4. Any requirement that imposes a duty that all project participants attend an unlimited or unspecified number of spatial coordination meetings at no additional cost, regardless of quantity or causation. As with any requirement to attend progress meetings of any kind, spatial coordination meetings should be limited in number unless the project team member has failed to meet the obligations for participating in the spatial coordination process. Having unlimited access to a MEP contractor’s spatial coordination and management time and resources, without regard to the cause or necessity to repeat the coordination process, is one of the major causes of cost and time budget overruns in a business.

EVALUATING SPATIAL
COORDINATION CONTRACT LANGUAGE

5. A requirement that every MEP contractor submit models that are “completely” or “100%” clash free. This is both an LOD and a “degree of coordination” issue. Even the best model-review software has built-in clashes where disconnected systems meet. In addition, certain inconsequential elements of building systems can be placed, and easily modified as needed, in the field without prior coordination. It is not practical to expend coordination time and resources modeling such loose, random, or minor items. The goal of spatial coordination using BIM is to identify, and eliminate or mitigate, physical interferences between building systems that would cause undue delay or rework during construction. A mandate for a “clash free” model can cause many project coordination programs to degenerate, focusing solely on getting to zero. Such mandates usually indicate the author’s inexperience or misunderstanding of how and why these efforts are being expended.

6. Any requirement for construction models to be delivered in a format for integration to the building’s facilities management systems.

Single-sentence requirements for this type of deliverable are written by people who may not understand what they are asking of the MEP contractor; unfortunately, they are becoming more common. Any requirement that as-built information be delivered for purposes other than recording the structure as actually constructed needs to be spelled out in very precise detail. There are numerous facilities management software applications but very few, if any, that are fully integrated with authoring or model-review software platforms. Placing intelligent components into MEP models so that facilities maintenance programs can be populated from the same data source can be an extremely complicated and time-consuming process. More often than not, achieving such integration is beyond the means and skills of most MEP detailers.

7. Any requirement for a MEP contractor to waive its rights to remedies for erroneous information delivered by the Design Team or third parties. Not long ago, design models were simple 3D renderings of 2D design drawings. Technology has reversed this process, and designers now create their drawings from their models. Design models are, in most cases, just advanced or more developed versions of the 2D design drawings provided to a contractor as a Document of Record for construction. There are certain industry-wide expectations for the LOD of the model elements, which can be found in both the AIA and BIM Forum references. On Design-Bid-Build projects, it should not have to be the obligation of the MEP contractor to validate that the drawings

EVALUATING SPATIAL COORDINATION CONTRACT LANGUAGE

received from the Design Team exactly match the design models that also are provided to coordinate the project. However, many specifications and contracts place the burden of such validation squarely upon the parties using these models. If there are differences between these documents, hopefully they are clearly identified in the RFP. Both the models and the drawings provided by the Design Team should, without question, be constructible.

A common-sense argument can be made here: if an Owner expects its project construction team members to engage in a collaborative process that will result in well-coordinated building systems prior to construction, then the installation contractors should be able to rely on the information provided by the Owner or the Design Team for that purpose. Additionally, spatial coordination is supposed to be a collaborative process; collaboration does not mean that the risks of one party's oversights, errors, or deficient control measures should be borne by another party.

8. Any requirement for bearing the cost of distribution of drawings to noncontracted parties. The cost of distribution of 2D drawings created post-coordination can be substantial on certain projects. Beyond being a financial burden, however, many times such language also implies an administrative duty to provide such a distribution in a timely manner and to all affected parties. This can become a very complex responsibility. If your firm has been assigned such duties in the project contract, you should obtain very clear instructions from your Client as to when, how often, and to whom these distributions should be delivered.

9. Any language that imposes a requirement to deliver proprietary information to the Owner, Construction Manager, or other third party. Many "source files" that MEP contractors use contain proprietary information that the MEP contractor derives from these files, as well as specialized component creations that it has spent considerable funds developing. If an Owner requires delivery of such source files, you should clarify early on the amount of information you are willing to provide. In addition, your firm should have a clear "scrubbing protocol" in place before handing over any source files that might contain such proprietary information. (For details on scrubbing source files, see Appendix C [on page 156](#).)

When reviewing project documents, take care to look for clauses that impose these requirements, and remove them from the contract, edit them to minimize such risks, or otherwise price the project accordingly.

EVALUATING SPATIAL
COORDINATION CONTRACT LANGUAGE**8.5 Other Important Industry Contract Reference Material:
ConsensusDocs.org**

Another industry organization, ConsensusDocs, has focused on collecting consensus of agreement in standard construction contracts and has made recommendations for contract language to refer to these industry acceptable practices. ConsensusDocs has been developed by a diverse coalition of 38 building associations with members from all stakeholders in the design and the construction industry. The associations represent Owners, contractors, subcontractors, designers, and sureties. ConsensusDocs contracts incorporate best practices and fairly allocate risk to help reduce costly contingencies and adversarial negotiations. The basis of ConsensusDocs is a philosophy that all parties in a construction project deserve to work under a fair contract. ConsensusDocs contracts protect the best interests of the project rather than a singular party, yielding better project results and fewer disputes.

Of particular interest and relative to spatial coordination and BIM Execution Plans are Consensus Contracts 202.2, 301, and 750.* (See Appendix D, “Industry References” for more information about these documents [on page 160](#).)

While ConsensusDocs is one model of Agreement, no Agreement addresses all of the issues or concerns raised in this Guide. All MEP contractors should carefully review any Contract or Agreement for obligations or expectations relating to your spatial coordination efforts.

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Chapter 9

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

You are a senior executive or perhaps a virtual detailing manager and are responsible for building an IT infrastructure. Your task is to support the requirements and work of your virtual detailing and construction project teams.

This chapter discusses where to begin and what to consider when you evaluate your options to make the best decisions. This discussion includes some tools to assist you in the process of identifying your teams' needs and the options you have for addressing their requirements.

The product of your research is an IT Implementation Plan, and its scope can range from solving immediate problems to long-range planning. This IT Implementation Plan is one of the components to your BIM Implementation Plan. (See Chapter 3, "Building the Team" [on page 19](#).)

The management and maintenance of the databases, drawing files, software, and hardware has a substantial, ongoing cost, but will yield increased profits if done correctly.

This chapter covers these topics:

- **9.1. What Is an IT Implementation Plan?** [on page 129](#)
- **9.2 Hardware Specifications** [on page 133](#)
- **9.3 Software Requirements** [on page 134](#)
- **9.4 Types of Software Used in Spatial Coordination** [on page 135](#)
- **9.5 Stand-alone vs. Network-Based Licensing** [on page 140](#)
- **9.6 Software Versioning and Upgrades** [on page 141](#)
- **9.7 Making the Right Decision for Your Firm** [on page 145](#)

9.1. What Is an IT Implementation Plan?

An IT (information technology) implementation plan describes what you need to have and to do to support spatial coordination projects. This infrastructure includes 3D virtual modeling computers and a variety of MEP software platforms and applications. It also includes many other components that are not used for spatial coordination, yet contribute to the IT computing environment, for example, wireless network hardware and services, interface devices, accounting and back office software applications. (For the purposes of this chapter, these other components are not addressed.)

The first step in building your plan is to identify exactly what your firm needs to upgrade or add to your existing computing infrastructure. The IT Inventory checklist in section 9.1.1 [on page 130](#) covers far more technologies than those needed for spatial coordination. If your company hasn't prepared such a checklist before, this is an excellent opportunity to identify what it may need.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

9.1.1 Preparing the IT Inventory

To prepare your firm to support spatial coordination with 3D modeling, you first need to know the capacity of the hardware and software that you currently have. The simple inventory presented in this section will give you the information you need to measure the gaps between what you have and what you need.

If you have the time and the resources, you can also expand the scope this inventory to include the items in section 9.1.2 [on page 130](#).

To begin, collect the information in Table 9.1 [on page 130](#) for each of your laptops, PCs, and servers.

Network ID (Main user)	Make and Model	OS	RAM	CPU Type	CPU Speed	Hard Drive Total/Free	Installed Applications

Table 9.1 Computer Hardware Inventory

Next, collect the information in Table 9.2 [on page 130](#) for all the software that is currently installed on your laptops, PCs, and servers.

Type of software	Application and version	Type of license	# Licenses/users
Detailing CAD			
Design Platform			
Collision Checking			
Communications			
File Exchange			
Office Productivity			
Project Management			
Email			
Other:			

Table 9.2 Software Inventory

9.1.2 Extending the IT Inventory

If you want to complete a more extensive inventory of your IT infrastructure, you can include information about the items listed here.

Physical Inventory

Gather this information for each piece of hardware; include the PCs, laptops, servers, monitors, printers:

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

- Manufacturer
- Purchase date
- Serial number
- Warranty expiration date
- Service level (same day, next day, on-site, or off-site)
- Support phone number

Software Inventory

Gather this information for each software application or package installed on the hardware:

- Application (for example, AutoCAD 2014, Navisworks Manage 2014, Microsoft Office 2010)
- License number (that is, registration and license details for managing subscriptions and service)
- Number of users that the license supports
- Support contract Information:
 - o Start and end dates
 - o Support phone number

Server Information

Gather this information for each server:

- Operating system
- Administrator login identity and password
- IP address
- Server-installed applications, (for example, Microsoft SQL, Microsoft Exchange, accounting software)
- Active Directory domain
- DHCP scope
- Drive/partition volume information

Network Information

Create an IP Map that includes this information:

- Static IP device assignments (usually printers)
- Router/firewall information along with user name and password
- For firewalls:
 - o Support contract information for updates
 - o Contact information for assistance

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

- Wiring diagram for the office
- Numbers assigned to each jack and patch panel

Internet Access Provider Information

Gather this information about your IAP:

- Type of technology (for example, cable modem, DSL, FiOS, T-1, Ethernet over copper, Ethernet provided by building owner)
- Name of provider (for example, Cablevision, Time Warner, Verizon)
- Whether IP address assignment is dynamic or static. If a Static IP block, number of IP addresses in block. Include IP addresses for sub-net, gateway, and domain name server

User Information

Gather this information about your users:

- User name
- Login information for each account that accesses the network resources (for example, a file server)
- For a small environment, password information, as applicable
- Name of computer used to access the network
- Network resources permitted to access (for example, directories on the server, printers, and software applications)

Email Information

- Primary and secondary domains
- Anti-spam and anti-virus software, if applicable
- Complete list of all email account addresses, including any generic addresses such as info@ or sales@ and whether they are configured as mail forwards or mail aliases.
- Type of mail server (for example, POP3, IMAP, Microsoft Exchange, Office365, Google Apps for Business)
- Name of Internet service provider
- Name of computer consultant
- Name of web hosting company
- Name and location of internal email system
- Name and location of local file server

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Website hosting information

Gather this information for each website:

- Domain registrar information, including account name and password
- Name of web hosting company (for example, 1and1, GoDaddy, local Internet service provider)
- Where site is hosted
- Appropriate account and contact information for host provider

9.2 Hardware Specifications

As technology continues to change, faster and more productive hardware becomes available. Any hardware specifications established to meet project requirements are going to change, too. Fortunately, the specifications in Table 9.3 [on page 134](#) should meet or exceed software application requirements for the foreseeable future and will easily satisfy the demands of your 3D model detailer.

The specifications recommended here reflect the experience from MEP detailing shops and, in effect, establish a current benchmark for a high-performance virtual design platform. Before you purchase new equipment, consider using these specifications as a basis for a conversation with the firm that your company purchases your hardware and computer from. Ask to speak with an application engineer/specialist instead of a salesperson. The specialists should be able to match the data in the table with their own offerings. If new technology is available in one component or another, specialists should be able to identify how to obtain even higher performance at a similar price.

One valuable recommendation comes from the shop floor and addresses the high demand placed on computers to draw 3D objects while maintaining multiple open windows of other applications: consider using computers designed for video gaming. Even though these are considered high-end computers, they are less expensive than industry detailing workstations and, in most cases, provide better performance. As a reference point, the components listed in Table 9.3 [on page 134](#) have been thoroughly tested with the spatial coordination software applications used in the industry and easily support their requirements.

Most spatial coordination projects do not directly specify minimum hardware requirements, such as the amount of RAM (computer core memory), which controls how fast the computer displays MEP objects. The rule of thumb is that the more core memory you have and the higher the speed of the processor, the faster the 3D model can be fully rendered on the computer screen. However, contract documents and BIM Execution Plans usually include a requirement that Project

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Participant must use computer hardware and equipment that both supports effective participation in the project and allows the contractor to adhere to the project schedule and coordination meetings. Some Execution Plans also require Project Participants to provide, set up, and maintain computer workstations on site for the duration of the project. An Execution Plan may also require Project Participants to attend coordination meetings with laptops capable of making changes or adjustments to their models during the meeting.

Meeting these requirements always costs more than it first appears, especially when you have similar requirements for multiple projects. But purchasing hardware components that meet only the minimum requirements may be a false economy; such equipment soon hampers the speed and effectiveness of the people who use it, and eventually, of the coordination process itself. If your IT budget has additional funds, spend them on the hardware; a PC or laptop that supports high-performance 3D modeling maximizes the productivity of your representative and the team.

Component	Desktop	Laptop
Processors	2nd Generation Intel® Core™ i7-3930K (12M)	3rd Generation Intel® Core™ i7-3840QM (8MB)
	Cache, Overclocked up to 4.1 GHz	Cache, Overclocked up to 3.8 GHz
Operating system	Windows® 7 Professional, 64Bit, English	Windows® 7 Professional, 64Bit, English
Memory	16GB Quad Channel DDR3 at 1600MHz	16GB Quad Channel DDR3 at 1600MHz
Video card	1.25GB GDDR5 NVIDIA® GeForce® GTX 560 Ti (OR SIMILAR)	2GB GDDR5 NVIDIA® GeForce® GTX 660M (OR SIMILAR)
Hard drive	256GB SATA 6Gb/s Solid State Drive	256GB SATA 6Gb/s Solid State Drive
Networking (server to client)	NIC (network interface card) 1Gbps (Gigabits per second)	NIC (network interface card) 1Gbps (Gigabits per second)

Table 9.3 Hardware Performance Specifications

9.3 Software Requirements

Selecting the right set of software applications may be a bit more daunting than selecting the right hardware. This difficulty is due primarily to the different types of software used on a spatial coordination projects and the number of choices available for each type.

But you often don't have to make a decision. Many projects make the decision for you by requiring Project Participants to use one or more standard software applications. These requirements turn up in the BIM Execution Plan (see Chapter 4 [on page 39](#)) or as part of the construction documentation. So the challenge may be to make sure that what you have purchased is current and meets the requirements of the project. New software applications and updates to previously released software applications are published every 6 to 12 months, rendering applications, publishers, product names, and versions out of date very quickly.

BIM TECHNOLOGIES FOR
AN IT INFRASTRUCTURE**9.4 Types of Software Used in Spatial Coordination**

To establish an effective IT infrastructure for spatial coordination projects, you will need one application from each of the five types of software applications, which are described in this section:

- **Design Platform Software** [on page 135](#)
- **Project Review Software** [on page 136](#)
- **Domain or Trade-Specific Software Applications** [on page 136](#)
- **IT servers and Communications Software** [on page 138](#)
- **Cloud Computing** [on page 138](#)

9.4.1 Design Platform Software

Design platform software supports the MEP engineering work specific to creating an LOD 300 design drawing and handover model to the MEP contractor. The type of software provides its users specialized analysis and design tools tailored to the needs of an MEP engineer or design consultant. As an MEP contractor, you may also have plug-in software installed on this platform that offers trade-specific detailing tools and database content, right out of the box.

Regardless of whether the particular design platform software is the exact software your MEP detailing team will use, at a minimum, you should develop internal resources with enough skill to open the design project model and collect the useful MEP object data (quantity and material take-off), again regardless of which virtual CAD authoring tool your firm uses. These are the more commonly used software design platforms:

- Autodesk's Revit MEP
- Bentley's AECOsim Building Designer
- Graphisoft's ArchiCAD
- AutoCAD
- AutoCAD MEP
- Architectural Desktop

Odds are that the commercial building project you were awarded was designed using one of these platforms; as a result, the Design-Intent Model contains the LOD 300 data and manufacturer specifications (for example, 2D schematics) that your estimating team used to win the bid.

Now your task is to retrieve the valuable MEP data in the Design-Intent Model that you can reuse for your phase of the project. To perform this task, you need at least one copy of the design software and someone in-house with skills to extract the data from the Model and organize it to assist in the firm's detailing and fabrication process.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Each MEP design is unique and created by individuals and design firms that deliver the work at different points along the spectrum of completeness. Some Design-Intent Models will contain a great deal of object data and other models will include very little. In recent years, design quality in North America has continued to improve, providing partners with more and more useful object data.

9.4.2 Project Review Software

One important feature of project review (or model review) software is the capability to aggregate the individual models designed with the preferred authoring software application of each Project Participant into a Federated Model. Once all of the models are aggregated, the Project Team can begin running clash detection across all domains and participant models. Each software platform of this type offers a unique set of additional functions. These are your primary options for project review software:

- Autodesk Navisworks
- Bentley Navigator
- Solibri
- Tekla BIMsightBIMsite

Even though the project and its clash-detection activities are driven by the Coordination Team and you provide your construction model to the team via your domain-specific CAD authoring tool, you will need, at a minimum, one copy of the project review software identified in the BIM Execution Plan. The purpose is to allow you to perform clash detection and model review outside the scheduled coordination meetings while using the same project review platform. The Project Coordination Manager assumes that you have completed preliminary clash detection before you submit your model. This practice allows you to identify and correct the easy and trivial clashes beforehand, leaving only the more difficult issues to be resolved at meetings. In addition to the software, you also need to make sure that your firm has an individual in-house who understands the aggregation process and the project review software. This individual should also have some experience with or the skills to manage documents and multiple models.

9.4.3 Domain- or Trade-Specific Software Applications

Unlike the other types of software, you can choose the applications specific to your trade, based on your needs and requirements and the functionality and capabilities the software provides. All that the Project Team requires is that your domain-specific software can be used in all of the Coordination Team software. These are the common domain authoring and estimating tools:

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

CAD Detailing and trade-specific authoring tools

- Autodesk Fabrication
- CADPipe – Gen2
- Drawtech
- EastCoast CAD/CAM
- Intergraph
- Intellicad
- MetaLab
- SYSque
- Trimble QuickPen Designer3D

Fire Protection

- AutoSprink
- Fireacad
- HydraCAD
- Sprinkcad

Estimating software (only)

- Autodesk CADest
- Highlands Construction Software
- Maxwell
- Quote Software
- Trimble QuickPen & Accubid estimating
- Wendes

Each domain or trade uses a set of software applications that offer a database and the detailing tools to support domain-specific virtual content. The quality of the application's database of virtual objects is measured by how well this data maps to the geometry and attribute set of the manufactured object. Each trade-specific publisher and its authoring tool plug-in offers an assortment of detailing tools, beyond just a library of virtual content, designed to support the detailer with greater efficiency and increased productivity. This type of software is typically installed inside of one of the design platforms described in section 9.4.1 [on page 135](#) and is often referred to as "plug-in software." It is worth noting that before the project starts, you may be required to satisfy the Project Coordination Manager that your software is with compatible with the design software or other trade contractor's software.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

9.4.4 IT Servers and Communications Software

Server and communications software is used to share, exchange, and annotate documents and models within the Coordination Team. These files are typically large (more than 15MB) and require a higher transmission speed than email supports. In addition, your organization's needs with respect to storage, security, document management, and configuration management (managing the volumes of similar documents while protecting multiple and different versions of each) need to be considered in your planning process.

There is an excellent chance that one or more of these applications is specified in the BIM Execution Plan, with the Model Manager responsible for its management. Some of these software tools offer unique capabilities that your firm alone may benefit from. You'll determine which tools are important to you as you acquire more experience and skills. Initially, however, you need someone on your team who is familiar with the primary set of the applications listed below, because you will be required to use at least one of them.

- Autodesk 360
- Autodesk Buzzsaw
- Bentley ProjectWise
- "Box" (Box.com)
- Dropbox
- Filezilla
- Fusionlive
- Google drive
- Newforma
- SkyDrive (Microsoft) Drive HQ
- Thru

9.4.5 Cloud Computing

The first use of cloud computing (also called SaaS—software as a service) by MEP contractors was online ordering between the field and the shop. This approach eliminated the process of faxes and phone calls. Within the past few years, these ordering applications have added pricing capabilities that assist MEP contractors to better manage field labor, orders, invoices, and reports. Additional tools such as time cards, phone directories, safety information, and policy and procedure handbooks are also available. More and more cloud-based software applications are entering the market because they make it easy to access current building and model data on-site without having to use jump drives that may or may not have the current model. This is particularly valuable to the Project Manager and site superintendent.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

There are two types of cloud-based software applications. The first type provides additional data storage and file backup services over the web and outside your company's network. The second type represents user-based applications that your company does not own or install. These applications provide one or more software services and run over a set of redundant servers owned by a service company that manages the application's delivery to you and to other users. One of the major benefits of this type of software is that you no longer keep your files on a jump drive or on any of the computers you use. The files are now stored and accessed from an Internet server and accessed through a browser window. The only part of the application that runs on your computer is through a browser, for example, Internet Explorer, Google Chrome, or Safari. The application runs exceptionally fast and is not constrained by the hardware configuration or limitations of your PC, laptop, or tablet. Typically, these applications are affordably priced and require minimal system administration, which is ideal for most small MEP companies.

This type of software offers many benefits:

- All of the system management functions such as software updates, backups, downtime, hardware issues are handled by the provider; the software runs in a redundant network of servers so if one server goes down another takes over with no loss of data.
- Less expensive because you pay only for what you use
- No downtime
- Access data from any location where you have an Internet connection
- Offers more collaboration functions and capabilities
- Supports multi-team and multi-site requirement
- Facilitates better communications between the field and the shop
- Centralized information distribution and sharing (specific to orders, archives, construction documentation, document management, time cards, delivery and construction schedules)
- Standardized ordering
- Many SaaS applications support full collaboration, in other words, multiple people can work on the same file at the same time (for example, Google Docs)
- Lower downtime and support costs
- Reduction of human errors via digital orders and invoices
- Better cash flow via faster and more accurate invoicing and costing
- Faster roll-out of new services and tools

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

The list that follows includes a few of the options you might consider for cloud applications. Some are exclusively used for storage and system management (backing up your critical models and files); others provide an array of collaboration and communications services. The most important benefit of these software applications is that users can get to whatever data they need anytime and anywhere (providing they have access to the Internet, which in some projects is not always the case.)

- a. BIM 360 glue
- b. BIM 360 field
- c. GlobalScape
- d. Gmail
- e. Google Docs
- f. Gotomeeting
- g. Hightail
- h. Microsoft Lync
- i. Microsoft OneNote
- j. Office 2010
- k. ShareFile
- l. SharePoint
- m. Webex

9.5 Stand-alone vs. Network-Based Licensing

Software applications are typically sold as a license (a one-time price) along with an annual subscription that entitles you to all updates released within a 12-month period from the date of purchase. The annual subscription should also include, at a minimum, telephone software support. While some publishers include training in their subscription, most publishers charge for training. Another form of licensing is a monthly or annual lease that includes the subscription. This is typically how SaaS (software as a service) is licensed.

Many software publishers offer suites and special packages that contain a variety of applications, some of which are critical and the others, you'll never use. The rationale behind most packaging schemes has to do less with the features that users favor or require and more to do with marketing and increased profits for the publisher. You should therefore, give special consideration to "suite" packaging. In some cases it is cost effective, in others not. You often pay for more software than you'll ever need, and you may find that it's cheaper to purchase only the software you need.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Do some careful analysis of the initial cost, associated annual subscription, and stand-alone versus network licensing. In terms of network licensing (more expensive) versus stand-alone licensing (less expensive), the general rule of thumb is that network licensing presents a better return on investment when you have a large number of users (more than 8) who use the application on a daily basis. This is the case because the number of total users who require access to the application on any specific day or time will never equal the total number of your firm's users and, therefore, you can purchase fewer network licenses. Another advantage of network licensing is that it makes system management and the software upgrading process much easier to manage.

9.6 Software Versioning and Upgrades

Managing versions of individual software tools and applications during the project lifecycle has to be done. You should know which versions of which applications are being used in conjunction with all of your project's construction documentation. When the upgrade process is not being managed or is not properly understood, you open yourself up to risk and all level of financial impact. When upgrades are done without careful consideration, you can expect all kinds of trouble. For example, if you are not prepared, someone could innocently update a noncritical software application that runs on the server that also provides the detailers their networked design platform application. Below is a summary of what happened—in the middle of an existing project—at a, mid-sized MEP firm that didn't pay attention to software versioning and the upgrade process.

A contributor, Fred, occasionally used an application that no one else used. Fred asked Joe, the local IT guru, to upgrade that application.

As the person that everyone went to for advice and help on IT issues, Joe was glad to help. He had never received any training and was self-taught and fairly good at it. But he had never been taught the value of managing versions and upgrades and all of the havoc it could raise if certain practices are not followed. Joe assumed that the upgrade would have no impact on anyone else or on any other application. He downloaded the upgrade from the web to the server and proceeded to install it.

A user interface pops up and asks him for the SQL Server Administrative password. Because Joe was the most experienced with computers, most of the project team members and the company relied on him to keep them online and moving forward. He finished the install and left for the evening.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Because he went home late (doing the install the evening before) he arrived at the office 30 minutes late in the morning. A circle of detailers were standing around the office of the Lead Detailer. Joe walked up and asked what the meeting was about. They all turned to him and said that when each of them opened their drawings that morning, the CAD authoring tool displayed a message: "Your SQL database has been updated, do you want the new database?" Each answered yes. The application repopulated the objects on their drawings and every single object had moved. When the Lead Detailer opened the current team Federated Model, the same thing happened. And no one could open up any of their old drawings. Two calendar days and seven days of actual work were lost. Weekly backups were scheduled to run the day the problem was discovered.

This has happened many times, with different applications and for different reasons, but it doesn't have to happen. There are measures and precautions that should be brought to the attention to the person responsible for IT. And this is first question: Do we need to upgrade the application?

The rule of thumb is never upgrade from a version of any software application in the middle of a project, unless you absolutely have to.

And yet, in some situations, an upgrade might be your best option.

- The new version includes functionality that will greatly reduce the burden, workload, or expense of at least one of your construction departments.
- The upgrade fixes a known bug that is contributing to errors and expense in your workflow, construction documentation, prefabrication and fabrication MTOs (material take-offs/BOMs) and downloads to CNC machines.
- The communication between you and others on the Project Team is broken and the upgrade will greatly improve collaboration, the sharing of models, and the exchange of data

There are a few other benefits to upgrading:

- The project will run more smoothly, with fewer system performance issues.
- There will be minimal to no disruption of service through the lifecycle of the project.
- The project team will have more confidence in project plans, schedules, and deliverables.
- You will have more confidence in your workflow and the quality of the finished product.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

At the beginning of a new project, if you are responsible for your firm's virtual detailing, make sure that when different departments (that is, plumbing, sheet metal, and so on) share the same domain-specific application that each department runs it separately. This allows you to update, or not, the software based on the benefits and need of each individual detailing department and this allows you to update the software application for one of your detailing departments while not creating a problem or issues for another. If this is the framework of your IT infrastructure, you are diversifying your risk. Each MEP domain in your business uses, to some degree, different aspects of the same software application. A great reason to upgrade for one department may create problems and risk for another. If each domain's software applications are separated, you are less exposed and better able to support the individual requirements of each of your MEP departments.

9.6.1 Preparing for an Upgrade

Begin with research. First, search the web for issues pertaining to the software you want to upgrade. These issues might be posted by the software publisher or by its users; many publishers provide blogs and free technical Q&A. Depending on the kind of license you have, you may be able to contact the software publisher directly for unlimited telephone support. Do both, but make sure you have current market knowledge of what to expect from the installation process and later, the interoperability with other software applications.

Next, test the upgrade independently, but not on the production server. Never install untested software on your firm's data, communication, or application server, all of which may be installed on the same machine. Instead, find a PC or workstation whose installed software environment represents the environment used by the team and take it off the network.

Make a "ghost" image of that environment on a drive. "Ghost" software is a disk-cloning application that's an excellent tool when you need to replicate complete running software environments. Building a clone testing system will save time if you have to re-create a copy of everything running on a computer. Now, install the upgrade and start testing.

What do you test for? You test the basic functions of every critical software tool that the Project Team uses to complete its work. You open files, add elements to them, or perform the operations of the tool you are upgrading. Save these files and close them; then open them. If you see what you expect to see and become confident that the upgrade will have no impact, install the upgrade on your production server.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

9.6.3 Scheduling an Upgrade During an Ongoing Project

Long-term projects evolve, and new people join the team and make new demands on the software. Some projects last for three or more years. Versions of software that worked quite well in early stages may no longer work with new tools or software platforms. So there may be no way to avoid an upgrade.

When and how do you upgrade?

You anticipate it, months in advance. Time it with a major submittal release that represents perhaps a level or a large zone in the project. The submittals have been signed off by the proper authorities, and it's time to send the MTOs and BOMs off to purchasing, the downloads to manufacturing, the spool sheets to pre-fab, and the 2D shop drawings to the field.

This is when you schedule the upgrade, based on team needs and requirements, and only after you've tested it. With respect to testing the software, note that these tests are often done on the fastest, most capable computer in the firm, yet the average worker uses a machine with half the horsepower. The results from testing on less capable, but representative machines may be so slow as to render the upgrade useless.

A submittal release is the right time to upgrade because everyone is ready to begin a new drawing with a new template that incorporates the upgrade.

There's always a need to restore an earlier version of the construction documentation and software environment. This, too, should be anticipated. The upgrade offers an excellent opportunity to use the "ghost" cloning software; one of the standard practices when upgrading your environment is to make a clone copy of the running system. A ghost clone of a previous environment can be brought up in less than 15 minutes. Re-creating the environment—finding and reinstalling all of the old versions of the software—might take all day.

Cloud-based SaaS tools and applications excel in this aspect of managing an IT infrastructure. Why? Because almost every mid-sized to large MEP contractor uses some form of this type of software, somewhere in their business. The upgrade process is managed entirely by the SaaS service bureau, behind the scenes, and there is nothing ever for you to worry about, except losing access to the Internet. The best part of all is that the service promises that you'll always be able to access and work with your application and documents, regardless of the upgrade.

SaaS for authoring tools is the next major goal that software publishers are focused on. Within a few years, more firms will be releasing their core application software as a service.

BIM TECHNOLOGIES FOR
AN IT INFRASTRUCTURE**9.7 Making the Right Decision for Your Firm**

Making the right decision about the software to purchase requires a team effort of due diligence, market research, and product evaluation specific to the needs of your firm. As you evaluate your options, consider also that the management and maintenance of the databases, drawing files, software and hardware has a substantial, ongoing cost, but will yield increased profits if done correctly.

To make it easier consider the following process:

Step 1: Build your firm's IT Implementation Plan.

Prepare your IT Implementation plan, including your IT inventory of hardware and software.

Step 2: Create a hardware RFQ based on what you and your 3D model detailers need for high-performing hardware.

Based on the plan, identify the additional hardware you will need; then contact your local or national computer provider to discuss your requirements and how they can assist you.

Step 3: Create a list of software applications currently not in-house and that require further research and evaluation.

Based on your software inventory and what you've learned about the software your firm needs along with the software requirements for spatial coordination, select the software applications within each type of software that you plan to research and evaluate.

Step 4: Conduct online software product demonstrations with the software publisher's application engineer or product expert.

Evaluate each based on your firm's requirements and needs. Contact a set of each publisher's references.

Contact the leading publishers of the applications selected in Step 3, to schedule an online, product demo. (See Section 9.4 [on page 135](#) for a list of the primary software publishers of each type of software.) Make sure that the person facilitating the demo is a technical application engineer, someone who is considered a product application expert.

Ask for details on pricing, packaging, and licensing. Of particular importance, make sure you request, from each software publisher that you are working with, five references of companies that are using their application. Contact every reference, or even better, contact someone you know and trust who uses the software and ask for their experiences with it and with the publisher, including the quality and timeliness of their technical support and training.

BIM TECHNOLOGIES FOR AN IT INFRASTRUCTURE

Step 5: Review all of the data and make a decision, acquire software and begin training.

Review what you learned from the product demonstration, from conversations with users, and comments in technology blogs about the product and the publisher. Determine how well the application matches your requirements and how accommodating the licensing and pricing is compared to other solutions. Then, choose the application that best fits your needs.

Acknowledgements

Funny thing about asking industry professionals to band together to create something that will literally help their industry become more skilled. While showcasing their personal professionalism, folks from competing companies gave this project time and devotion that I could never have obtained elsewhere. To say I thank these volunteers and honor them is an understatement. To say that the industry owes them a debt it can't repay is a humbling truth.

The most prodigious and active contributor from the start (long before me) to where we are today with the official release of the GUIDE and the person I owe the most appreciation to for the depth of his input and his draft editorial reviews of each chapter and for every one of the three major reviews is Steve Shirley, CEO of University Mechanical and Engineering Contractors in El Cajon, California. The Guide was originally envisioned by Steve as the Chair of the MCAA BIM committee more than two years ago. He has been one of the earliest MEP pioneers in the use of BIM and other technology-based solutions to enhance his company's operations and profitability.

The Mechanical Contractors Association of America (MCAA) fielded great professional team I received much help from Richard Anderson, John Attebury, Michael P. Cannistraro, Rod Foley, Mike Feutz, Dan Lovell, Pete Mackenzie, Frank D. Musica, Brian J. Muggy, Ian O'Doherty, Al Prowse, Steve Shirley, and Stacy Zerr.

To the powerhouse of professionals from the National Electrical Contractors Association (NECA), I am grateful to Josh Brill, Craig Clark, Denis St. Pierre, Adam Davis, Bryan Inghish, Dan Maimonis, and Joseph Vernice for casting helpful light in some of the dark corners of this subject.

Last, but not least (and they still take up the most LOD space) are the professionals from the Sheet Metal and Air Conditioning Contractors National Association (SMACNA). Paul J. Alexander, Matt Cramer, Richard Freeman and Steve Hunt shared their many lessons and best practices from their engagements with BIM.

The consistent dedication of three MEP contributors filled this Guide with many practical ideas. They spent countless hours in meetings with me and reviewing many drafts. Pete Mackenzie, a well-recognized trainer in BIM on behalf of MCAA, made significant contributions and was the only task force member who actively participated in almost every chapter committee meeting. On the electrical side (NECA), Josh Brill brought great insight and showed me how the concerns of his discipline are the same and also different. My debt to the sheet metal industry (SMACNA) for Steve Hunt and his willingness to help the industry take this giant leap forward, raising the awareness and capabilities of tradesmen, is probably larger than I can repay.

Special thanks to David Francis, MEP Chairman to the BIM Forum LOD Specification, for helping me understand how the LOD specification is being understood and used in the field and for his continued representation and support of the MEP contractor in all of his open standards efforts.

ACKNOWLEDGEMENTS

Joe Perraton at Pointone Media, who shared his many ideas for how cloud-based software applications can decrease MEP contractor expenses while improving collaborative processes, filled some large gaps in my knowledge.

My predecessor, Michael Tardiff, who started the project one year ago had other demands to meet, and he graciously passed the project me. His willingness to share all that he had learned (quite a lot) in the short time he spent with the project got me off on the right foot.

I also want to recognize the excellent work that the Guide's editor, Susan Hunziker, and the graphic designer, Cyndi Carr of Visual Persuasion, LLC, brought to the effort. Their unique skills and special touch helped to make this document a product the three MEP associations will be proud of.

I am deeply indebted to the association directors— Dennis Langley of MCAA, Tom Soles of SMACNA , and Dan Walter of NECA. Their unequivocal support and their unfettered access made this book possible and far better than it could have been. They made sure that I had direction, content, and examples from the top professionals in each of their associations.

Three organizations were willing to put their money where their mouths are. MCERF, The New Horizons Foundation, and the NECA believed in the need for this Guide and provided the funds to bring their shared vision to reality. I believe that in time, their desire to serve a greater good by raising the knowledge and skills of the entire MEP and specialty contractor segment of the construction industry will create new opportunities for all.

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The Appendixes

Appendix A: Examples of Internal Deliverables

- Some building systems lend themselves to prefabrication, and some subcontractors or suppliers may have model-to-fabrication capability, which means that they have the ability to fabricate and build components directly from a model.
- Some team members may have the ability to locate and place hangers in the field directly from a model using a Total Station, that is, surveying equipment with robotic laser point tracking systems.
- Because the precise location of incidental elements such as hangers, penetrations/sleeves, and control/expansion joints may have to be determined prior to fabrication, all building systems—and not merely those being prefabricated—may have to be modeled and coordinated to a higher level of detail and at an earlier stage in the construction schedule than would be required for conventional construction or installation methods.
- A clear understanding of what needs to be modeled should be one of the important references an MEP contractor should determine based on the BIM Execution Plan.

For example, here are some important things to identify within the BIM Execution Plan:

- Is the MEP contractor required to model hangers?

A note of caution regarding hangers and a sloping pan deck: Some BIM Execution Plans require precise modeling of hanger placement (that is, 100% accurate). Hangers can be greatly affected by the sloping of the pan deck; in addition, many times deck inserts are required to be in the top or bottom of the flute. The deflection of the deck and orientation of the deck flutes can turn well-intended hanger coordination into a total waste of time. There are some things that BIM cannot account for and this is one of the most significant

- Should pipe or conduit under 2" be modeled? If you do find a requirement for pipe 2" or higher to be modeled or for bundles of communication cables exceeding 1" in diameter, this is a red flag and perhaps something that might be worth issuing an RFI in order to address. In the example of communications cables (modeling 1"–2" conduit), this is easily and typically fabricated and coordinated in the field.
- Even when an assembly or portion of system is not required to be modeled, a best practice is that if you want to install something in a specific place, you should model it to save the space. If you had modeled it and brought it through the coordination process, should someone else install their equipment in your modeled space, they will have to move it. Also, if you don't model, you must first yield to

THE APPENDIXES

all those systems and components that have been modeled, you may not interfere or obstruct with the installation of modeled components, and after that it's first come, first served. In short, you have to get in around every system that was modeled.

THE APPENDIXES

Appendix B: An Outline for Developing a BIM Implementation Plan**A) Groundwork – set a foundation for your plan**

- 1) Determine your goals – Create two lists
 - a. What benefits to you expect to get from the BIM process?
 - b. What do you expect the BIM Implementation Plan to establish for your company
- 2) Do your homework, determine best resources for understanding the BIM process
- 3) Make a solid , fully budgeted commitment
- 4) Determine who's going to develop and implement the plan
- 5) Assess your options
 - a. Establish CAD/BIM capabilities in-house?
 - b. Outsource?

B) Create an Organizational Structure

- 1) Typical Personnel
 - a. CAD/BIM Manager
 - b. Lead Detailers/coordinators
 - c. Detailers/drafters
 - d. Define the required skills and responsibilities of each position

C) Evaluate and select software

- 1) Determine software needed
- 2) Establish a selection criteria checklist
- 3) Establish a list of do's and don'ts for selecting software
- 4) Obtain references from trusted sources

D) Select and schedule training

- 1) Determine needs based on current inventory of skills and identified weaknesses
- 2) Determine methods of training , select providers, create a schedule
- 3) Establish a comprehensive ongoing training program

E) Establish IT and Infrastructure

- 1) Determine specific hardware needs, create specifications and select hardware
- 2) Establish network folder structure for all CAD/BIM related documents and files
- 3) Establish secure backup procedure(s)

THE APPENDIXES

4) Establish security procedures and establish read/write permissions

5) Create a productive collaborative office layout

F) Create a budget for

1) Software

2) Hardware

3) Training

4) Office furnishings and equipment

G) Create company procedures for

1) BIM process workflow, the roadmap for BIM in your company

a. A reliable repeatable linear process from start to finish to be used on every project

b. Integrates all company aspects and departments into the BIM workflow

c. Establish communication protocols

2) CAD/modeling standards that:

a. Establish uniformity

b. Provides for increased drawing productivity

3) Quality control

a. Establish levels of quality control and applicable roles and responsibilities for

(1) First Line - Detailer

(2) Second Line – CAD/BIM Manager

(3) Third Line – Project Manager and Field Foreperson

4) Metrics and cost histories

a. Evaluate historical detailing/coordination cost information

b. Determine what data should be captured for future historical evaluations

c. Establish a standard default cost coding structure for timesheets

d. Establish monitoring of metrics protocols (weekly, monthly, milestones, etc.) and participants

H) Leading BIM Projects

1) Define possible roles and responsibilities you are willing to assume

2) Define scope you are willing to assume

3) Write a generic BIM Project Execution Plan

THE APPENDICES

- a. Apply and/or modify as needed for specific projects
- b. Establish well-defined rules of engagement and methods of recourse
- 4) Establish web hosting capabilities and protocols for storing, updating and maintaining the project BIM model

THE APPENDIXES

Appendix C: Scrubbing a Design-Intent Model

It is always a good practice to “scrub” the Design-Intent Models received from the Design Team to remove information that your trade does not need or care about. Scrubbing also makes the file much smaller, which makes it easier to update and share.

A Basic Approach to Scrubbing

This procedure is dependent on what design authoring platform the files were delivered. The “scrubbing” process may require more attention than these eight steps. At the end of the day, scrubbed files are most always used as background files.

1. Burst all blocks
2. Burst again
3. Highlight all
4. Override color by layer
5. Change layer color to 8
6. Purge
7. WBlock

A Detailed Approach to Scrubbing

1. Remove all xrefs.
 - a. Type the command **XREF**; press **Enter**.
 - b. Highlight all of the xrefs under the main drawing file
 - c. Right click any of the highlighted xrefs.
 - d. Detach the selected xrefs by clicking **Detach** on the right-click menu.
2. Make layer 0 (zero) the current layer.
 - a. Type the command **LAYER**; press **Enter**.
 - b. Double left-click on the layer 0 (zero)
 - c. A green checkmark will appear to the left of the layer 0 (zero).
3. Remove all layer filters.
 - a. Type the command **LAYER**; press **Enter**.
 - b. Highlight all the layer filters listed on the left except the filter **All** and **All Used Layers**. These cannot be deleted.
 - c. Right-click any highlighted layer filter.
 - d. Delete the selected layer filters by clicking **Delete** on the right-click menu.

THE APPENDIXES

4. Change layer lineweights.
 - a. Type the command **LAYER**; press **Enter**.
 - b. Highlight all the layers.
 - c. Click any one of the highlighted layers' lineweights.
 - d. Click the 0.25 mm lineweight in the Lineweight window.
 - e. Click **OK** to confirm.
5. Make all layers visible.
 - a. Type the command **LAYER**; press **Enter**.
 - b. Highlight all the layers.
 - c. Find layers that are turned off; turn them on by clicking the darkened light bulb.
 - d. Find layers that are frozen; thaw them by clicking the darkened snow flake.
 - e. Find layers that are locked; unlock them by clicking the darkened padlock.
 - f. Click the **X** in the upper left corner to exit the layer properties manager window.
6. Remove all layer states.
 - a. Type the command **LAYERSTATE**; press **Enter**.
 - b. Highlight all of the layer states listed.
 - c. Delete the selected layer states by clicking **Delete** on the right-click menu.
 - d. Click **Yes to All** to confirm.
 - e. Click Close.
7. Erase all layout tabs.
 - a. Click the first layout tab.
 - b. While holding down the **Shift** key on the keyboard, click the last layout tab.
 - c. Right-click any of the highlighted layout tabs.
 - d. Delete the selected layout tabs by clicking **Delete** on the right-click menu.
 - e. Click **OK** to confirm you want the tabs deleted.

THE APPENDIXES

8. Remove unnecessary information from model space drawing.
 - a. Erase all text that is not important for your needs (door types, wall types, room square footages, dimensions, notes, detail symbols, section symbols, etc.).
 - b. Erase all miscellaneous lines and objects that are not important for your needs (construction lines, dimension lines, detail lines, section lines, symbols, etc.).
 - c. Skip the rest of this step if the drawing is a 3D model.
 - d. Type the command **OVERKILL**; press **Enter**.
 - e. Type **ALL** to select all of the items in the drawing; press **Enter**.
 - f. Press **Enter** again and make sure all of the options under **Object comparison settings** are unchecked.
 - g. Make sure all the options under the **Lines, Arcs and Plines** are checked.
 - h. Click **OK** to execute the command.
9. Remove all named views.
 - a. Type the command **VIEW**; press **Enter**.
 - b. Highlight all of the named views under **Model Views** (on the left).
 - c. Delete the selected named views by clicking Delete on the right.
 - d. Click **OK** to exit the window.
10. Remove all scale lists.
 - a. Type the command **SCALELISTEDIT**; press **Enter**.
 - b. Click **Reset**.
 - c. Click the **Restore the Default List of Scales** option.
 - d. Click **OK** to exit the window.
11. Remove all regapps.
 - a. Type the command **-PU**; press **Enter**.
 - b. Type **R** for regapps; press **Enter**.
 - c. It will ask for the names to be purged; just press **Enter**.
 - d. It will then ask if you want to verify each name to be purged. Type **N** for no; press **Enter**.
12. Purge the drawing.
 - a. Type the command **PU** for purge; press **Enter**.
 - b. Click **Purge All** on the bottom. Click this button until you can no longer select it.
 - c. Click **Close** to exit the window.

THE APPENDICES

13. Set all color layers to **bylayer**.
 - a. Type the command **SETBYLAYER**; press **Enter**.
 - b. Click **BYLAYER**.
 - c. Click **OK** to exit the window.
14. Define the insertion point.
 - a. Type the command **INSBASE**; press **Enter**.
 - b. Type 0,0,0 and then press **Enter**.
15. Define linetype scales.
 - a. Type the command **LTS**; press **Enter**.
 - b. Type **1** to set the linetype scale to 1; press **Enter**.
 - c. Type the command **MSLTSCALE**; press **Enter**.
 - d. Type **1** to set the model space linetype scale to 1; press **Enter**.
 - e. Type the command **PSLTSCALE**; press **Enter**.
 - f. Type **1** to set the paper space linetype scale to 1; press **Enter**.
16. Change the annotation scale to 1/4"=1'-0".
 - a. In the lower right side of the CAD Screen, click **Annotation Scale**.
 - b. Click the 1/4"=1'-0" option.
17. Name and save drawing file.
 - a. Type the command **SAVEAS**; press **Enter**.
 - b. Browse to the appropriate location to save the file.
 - c. Type a new name next to the **File Name** heading. (Do not name the file the same as the original file.)
 - d. Click **Save** to save the file and exit the window.

Another Approach to Reducing the File Size of the Design Model

Another way to reduce the file size is to explode any bound external references down to the object level, unlock all of the layers and then copy and paste the visible objects into a new blank template file using 0,0,0 as a basepoint. After this step, then remove all irrelevant objects, scalelists, purge, etc. It is also recommend the use of the **AUDIT** command to fix any possible errors in the database.

THE APPENDICES

Appendix D: Industry References and Software

This appendix provides the web addresses for software publishers whose products are widely used in the MEP contracting industry and for various organizations that serve the MEP contracting segment of the construction industry.

Software publishers***Design Platform Software***

Autodesk— <http://www.autodesk.com>

AutoCAD

AutoCAD MEP

Architectural Desktop

Revit MEP

Bentley—<http://www.bentley.com>

AECOSim Building Designer

Graphisoft —<http://www.graphisoft.com>

Archicad

Project Review Software

Autodesk—<http://www.autodesk.com>

NavisWorks Simulate

NavisWorks Manage

Bentley—<http://www.bentley.com>

Project Navigator (formally ProjectWise Navigator)

Solibri—<http://www.solibri.com>

Solibri Model Checker

Tekla—<http://www.tekla.com>

Tekla Structures

THE APPENDIXES

Domain-Specific Software

Autodesk—<http://www.autodesk.com/products/fabrication-products/overview>

Autodesk Fabrication CADmep

Autodesk Fabrication ESTmep

Autodesk Fabrication CAMduct

Trimble—<http://mep.trimble.com/products>

Trimble Pipe Designer 3D

Trimble Duct Designer 3D

Trimble Accubid Enterprise Estimating

Trimble AutoBid Mechanical

Trimble AutoBid Sheetmetal

Vulcan – Sheet Metal CAM cutting software

CADPipe (Published by Orange Technologies)—
<http://www.cadpipe.com/>

Gen2 Commercial Pipe

Gen2 HVAC

Gen2 Industrial Pipe

Gen2 ISO

Gen2 P&ID

Intergraph—<http://www.intergraph.com/>

Intergraph Process Piping, Power and Marine

MetaLab—<http://www.practicad.com/>

PractiCAM: a sheet metal manufacturing and estimating solution

PractiCAD: a design, drafting, and detailing tool for the HVAC and sheet metal industries. AutoCAD-driven

Drawtech—<http://drawtech.com/>

Drawtech 7

Drawtech CAM

THE APPENDIXES

EastCoast CAD/CAM—<http://www.eccadcam.com>

MEP Design to Fabrication

Fabrication for AutoCAD MEP, sheet metal, piping and plumbing

DuctMaker - Sheet Metal CAM cutting software

Shopdata—<http://www.shopdata.com/>

Quickduct CAD

Quickduct CAM

Intellicad—<http://www.intellicad.org/>

IntelliCAD 7

SYSque—<http://sysque.net/>

Pipe and Duct design and fabrication inside Revit MEP

Fire protection

Fireacad—<http://www.fireacad.com/index.htm>

HydraCAD—<http://www.hydratecinc.com/>

AutoSprink—<http://www.autosprink.com/>

Sprinkcad—<https://www.sprinkcad.com/>

Industry Resources

Trade Associations

MCAA—<http://www.mcaa.org>

SMACNA—<http://www.smacna.org>

NECA—<http://www.necanet.org>

National Institute of Building Sciences

National Institute of Building Sciences—<http://www.nibs.org/>

National BIM Standard – United States V2—

<http://www.nationalbimstandard.org/>

JBIM - Journal of Building Information Modeling—

<http://www.wbdg.org/references/jbim.php>

THE APPENDIXES

Building Smart Alliance—<http://www.nibs.org/?page=bsa>

JBIM - Journal of Building Information Modeling—
<http://www.wbdg.org/references/jbim.php>

BIM Forum

AGC BIM Resources—
<http://bimforum.org/resources/agc-bim-resources/> JBIM - Journal of

BIM Tools Matrix—http://bimforum.org/wp-content/uploads/2011/02/BIM_Tools_Matrix.pdf

Building Information Modeling—
<http://www.wbdg.org/references/jbim.php>

Contract language

ConsensusDocs—<https://www.consensusdocs.org/>

Other resources

AIA Document E202 – BIM Level of Development
<http://www.aia.org/contractdocs/training/bim/aia078742>

McGraw Hill SmartMarket
<https://analyticsstore.construction.com/index.php/market-trends/smartmarket-reports.html>

Penn State BIM Execution Planning —<http://www.bim.psu.edu>
This information is available for free.

Glossary

2D	Two dimensional (X, Y plane). Drawings on paper that present buildings in a variety of views showing height and width, height and depth, or width and depth such as floor plans, elevations, sections, ceilings and detail drawings.
3D	Three dimensional (X, Y, Z plane): Drawings that present buildings in a variety of views showing height, width, and depth.
AOR	Architect of Record. The architect or architecture firm whose name appears on a building permit issued for a specific project on which that architect or firm has or is performing its services
BIM	Building Information Modeling. A process involving the generation and management of digital representations of physical and functional characteristics of a structure. The resulting building information models become shared resources that can support decision-making about a facility from earliest conceptual stages to eventual demolition.
BIM Execution Plan	A document created by the Design Team and construction team that defines the size, complexity, and schedule of a construction project and the contractual responsibilities, and deliverables of the participating individuals and firms.
BIM Implementation Plan	A business strategy document that outlines the resources a company needs to buy and to hire and identifies the changes to current internal processes that are required to fully support BIM projects.
CAD Authoring Software	A computer application used to depict the physical appearance and properties of objects included in a building or building system. Also known as detailing software.

GLOSSARY

Communications**Protocols**

A particular way of storing and organizing data in a computer and in software applications so that people and other applications can be easily access and share the data.

CNC**machining**

A process used in manufacturing sheet metal or pipe in which computers are used to control machine tools. CNC stands for Computer Numerical Control. Under CNC Machining, shop and fabrication machine tools function through numerical control.

Domain-specific CAD authoring tools contain a library of virtual objects. Every object maintains its unique geometry and attributes, which represent how it is to be manufactured, using an industry standard information exchange called G-Code. G-Code controls exact positioning and velocity of the tool.

Data structure

A particular way of storing and organizing data in a computer or software application so that it can be used efficiently by people and by software applications.

Design-Bid-**Build**

A method of project delivery in which the Owner procures a design and bid package from a designer and solicits independent bids for the construction of the building.

Design-Build

A method of project delivery in which one firm assumes responsibility for the design and construction of the project.

Design**consultant**

An engineer on a construction project who is responsible for performing and overseeing the design of structural, mechanical, electrical, HVAC, and fire protection systems.

GLOSSARY

Digital data	Any form of information, communications, drawings, model elements, or assemblies contained and managed with a virtual model or software application.
Digital sign-off	A mathematical key in a document file that, when selected by an authorized individual, constitutes a legally binding signature of an individual or company.
Disruptive innovation	A product or service that creates a new market and value chain, eventually displacing an earlier technology and the processes that depended on or supported it. The term is used to describe changes to a product or service in ways that the market does not expect.
Federated Model	The Design-Intent Model that is extended by aggregating multiple models. Each model represents the work of different domains and the Coordination Team. A Federated Model is typically aggregated and viewed with project review software.
Federated Construction-Only Model	A variant of the Federated Model that stops at construction LOD 400 when there is no contractual obligation to supply any further deliverables to the Owner.
File-naming conventions	A set of rules for constructing unique and descriptive names for digital files. The rules specify the order and the length of words, phrases, or abbreviations used in the name.
HVAC	Heating, Ventilation, and Air Conditioning

GLOSSARY

Information exchange	Digital data that is passed from one party to another in the BIM process. The parties involved have agreed upon and understand what information will be exchanged.
Integrated Model	The Design-Intent Model that is extended by all Project Participants, who are using the same software platform to design and detail it in all phases of the project lifecycle.
Inter-Operability	The exchange of information between software applications, between people, and between people and a software application by direct communication without interference.
LOD	Level of Development. A specification of the completeness of a Design-Intent Model. The LOD specification enables practitioners in the construction Industry to describe with a high level of clarity the content and reliability of Building Information Models at various stages in the design and construction process.
MEP	Mechanical, Electrical, Plumbing, and Fire Protection
model	A 3D representation of a building project or any part of a project in digital form.
the Model	The digital representation of a building as designed, with all its details and systems. This representation is created by the Design Team and extended with the contributions of contractors on the project. In the various stages of its development, the Model is called the coordinated model, the construction model, and the as-built model.

GLOSSARY

Modified Federated Model	A variant of the Federated Model in which the models of building systems produced by MEP contractors are integrated into the Design-Intent Model by the Design Team.
MTO	Material take-off. A list of the materials required to build a designed and domain specific system, assembly, or item. This list includes the quantities and types of these materials and is generated by analysis of a LOD 400 Model or other design document. Also known as BOM (Bill of Materials).
Object	A digital representation in a model of a physical component that is manufactured or purchased to be installed in a domain-specific system in a building. Objects that contain properties and attributes that further define the physical object they represent are called “intelligent objects.”
Open Standards	Non-proprietary protocols and data structures that support the exchange of digital data and information across domains, people, and software applications.
Outsourcing	The process of obtaining resources or skills that are not available within a company. These skills and resources can be obtained on a part-time, per project, or other limited basis.
Participants	The individuals who represent companies and perform roles on a Coordination Team for a construction project.
Phase	A period of time or activity that represents a unique phase of the building lifecycle.

GLOSSARY

Pre-design	The additional phase of work required of some MEP contractors to develop the design and information to achieve an LOD-300-compliant model. The information that some trades traditionally receive in the Design-Intent Model is at LOD 200, 100, or even 0. Yet these contractors are required to submit compliant LOD 350 and LOD 400 drawings. This situation is most common to electrical contractors.
Project review software	A software application platform that provides the tools that Coordination Teams use to coordinate their system designs, resolve conflicts between domains, and plan projects prior to construction or renovation.
Quantity take-off	To count, measure, and extract any or all of the identified elements contained in a 3D model.
Render	To create from digital data an image of a design or a model with accurate material texture, lighting, reflectivity, and shadows.
RFI	Request for Information.
Schedule	A sequence of activities that are based on a construction plan and represent decisions by the Construction Manager, General Contractor, or Coordination Team.
Virtual design	A realistic representation of physical objects, elements, assemblies, and integrated multi-domain computer models of a building in a computer software application.

"BIM is a business process leveraging our investment in design software and capabilities to enhance the overall project execution. If you're new to the process or a seasoned user, this guide provides valuable information to establish a common understanding among all the stakeholders."

—Tony Ahern

Executive Vice President Pipe Fabrication and Operations J.F. Ahern Co.

"Regardless of your role on a given project, this complete BIM guide has everything you and your company will need to walk you through the process. Whether you are a detailer, in business development, or the president of the company, there are several best practices that will help you be more efficient as a contributing member of the construction team."

—Ken Collins

Executive Vice President Fire Protection J.F. Ahern Co.

"Well-run BIM projects eliminate waste and reward the many skills required to plan and perform the work. This definitive guide fills a gap in the HVAC and MEP industry by discussing the management, personnel, and technical issues encountered in the BIM process."

Whether you're about to launch or have already set sail on the BIM journey you won't want to miss the experienced advice contained in this guide."

—Stacy Zerr, P.E.

Director of Operations Technology, The Waldinger Corporation

I found this book accurate, informative and corroborative in many areas with Rosendin Electric's current policies, procedures and best practices. This guideline is insightful and reflective towards the industry's current demands, challenges and subsequent evolution that are faced by today's MEP specialty contractors. Rosendin Electric has spent significant resources over the last five years broadening the development of its BIM initiatives, policies and procedures so we have depth of experience we speak from. This guideline is truly reflective of many of those "life lessons" we have encountered and ways to mitigate if best practices are followed!

—Fred Meeske, EET

Corporate Director Building Informations Systems, Rosendin Electric, Inc

Feedback and comments are welcome

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