

# Current BIM Practices Amongst MEP Contractors and Suggestions for Improvement

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The mechanical, electrical and plumbing (MEP) systems are three of the most important systems within a building. These systems alone can account for 40-60% of the total construction costs for commercial building projects (Second, Hanna, 2010). It is crucial that these systems function adequately. With the technological advances within the construction industry, the push for advanced technologies such as Building Information Modeling (BIM) has significantly increased. This research provides a detailed literature review examining how BIM is now used in the industry. BIM, a three-dimensional tool used to model a building and its components, is commonly used during the planning, design, construction and operation phases of a project. A literature search suggests that specialty trades use BIM to increase collaboration between stakeholders. Current literature suggests that according to the Best Value Approach (BVA), upfront collaboration between clients and vendors lead to inefficiencies. BVA decreases collaboration by creating a system in which clients can better utilize the expertise of high-performance vendors, without enforcing project requirements and control measures. The authors suggest that BIM usage may be more effective if paired with BVA; doing so will simplify communication from MEP experts and minimize risk caused by collaboration.

**Keywords:** Delivery of services, Best Value Approach, BIM.

## Introduction

The construction industry is experiencing issues of low-performance. There have been various potential solutions which shown signs of success. Information Technology (IT) has significantly affected the construction industry in recent years. Modern tools, such as Building Information Modeling (BIM), are becoming the new standard within the industry, and will more than likely replace 2D design development. Specialty contractors have steadily adopted BIM software hoping to increase efficiency. As of 2009, over 50% of architects, engineers and contractors were using BIM technologies (McGraw Hill, 2013), a 250% increase in a two-year span. Defining BIM, poses its own set of challenges. Logan, Jackson and Hainsworth (2014) define BIM as “the creation of cross-disciplinary, coordinated 3D models, incorporating 3D objects that can be presented across synchronized 2D drawings”. According to the team, the key to BIM’s success lies within the user’s ability to understand and connect information. Given that BIM is a specialized technology and relatively new, it is common for companies to hire BIM specialists to model the building and its components digitally (NBS, 2016). These are often recent graduates with advanced technological skills, but little to no real-world problem-solving skills. This typically results in building design and constructability flaws. BIM expertise is directly linked to experience. It is essential for BIM modelers to have prior industry experience.

Most research on BIM focuses on general contractors opposed to the specialty trades (mechanical, electrical, plumbing [MEP]). This creates a disconnect between the two and leaves a level of uncertainty how BIM is being used. Given the fickle nature of the construction industry, defining BIM and how it is being used within the industry is still unclear.

### *Best Value Approach*

The “Best Value Approach” (BVA) is a supply chain management model licensed by Arizona State University’s (ASU) licensing arm Skysong Technologies. The BVA is the most licensed intellectual property (60 licenses over 20 years) developed at ASU (identified as the most innovative university for the past four years by the U.S. News and World Report. Arizona State University, 2018; U.S. News, 2018). This research has been tested over 2,000 times delivering over \$6.6B of services in ten different countries (Kashiwagi, 2017; Rivera, 2017; PBSRG, 2018).

The BVA is not a process-centered solution but requires a change in paradigm. The primary function of BVA is the utilization the expertise. This goal has three major components:

1. Identifying experts through a competitive process using performance metrics.
2. Allowing expert vendors to define the scope of work, create the risk mitigation plan, and plan the project from beginning to the end.
3. Create transparency by using a simplified milestone schedule to track project time and cost deviations known as the Weekly Risk Report (WRR) and Director’s Report (DR).

The entire process minimizes the professionals’ thinking and decision making in the entire supply chain, allowing the expert vendors to minimize cost by 5–30%, and minimize their caused time and cost deviations to under 1% (Kashiwagi, 2018a).

This process is contrary to the price-based approach that clients have used for decades to deliver professional services. The Industry Structure (Figure 1) highlights the identification and utilization of expertise (Quadrant II) as the most efficient and effective approach (lower cost and higher quality and value) (Rivera, 2017; PBSRG, 2018, Kashiwagi, 2018). Since the BVA is not a process-centered solution, it is compatible with other construction processes and techniques such as Indefinite Delivery/Indefinite Quantity (IDIQ), Design-Bid-Build (DBB), Design-Build (DB), and Job Order Contracting (JOC) (Kashiwagi, 2016).

<b>Performance</b>	<b>High</b>	<b>III. Negotiated-Bid</b> Minimized competition Long term Relationship based Vendor selected based on performance	<b>II. Best Value Approach</b> Identify and utilize expertise Transparency Language of metrics Value of expertise increases Lower cost and high quality  <b>Utilize Expertise (No Thinking)</b>
	<b>Low</b>	<b>IV. Unstable Market</b>	<b>I. Price Based</b> Buyer directs vendors All vendors are the same Lowest price wins Minimum standards No accountability Low performance is acceptable <b>Manage, Direct and Control (Influence)</b>
		<b>Low</b>	<b>High</b>

Figure 1: Industry Structure.

Kashiwagi (2018) proposes that a price-based environment leads clients to manage, direct, and control (MDC) expert vendors. When MDC is present, the vendors' expertise is minimized, and instead, they are required to meet the demands of the client. Kashiwagi proposes that client demands arise from minimum requirements, contract enforcement, litigation, increased communication, and collaboration.

### Research Objective and Methodology

BIM is a relatively new software widely used in the construction industry. This research aims to understand how companies use the technology and how it can integrate with other solutions such as the Best Value Approach. This paper focuses on current BIM practices used by commercial MEP contractors and how the BVA can complement BIM.

To meet the research objective, a literature review has been performed to identify, understand and analyze BIM and the BVA. The methodology consists of the following:

1. Identify the existing practices and potential issues of BIM.
2. Investigate the feasibility of using the BVA to address common BIM issues.
3. Investigate the compatibility of BIM and BVA through previous documented cases.

### Literature Review

#### *BIM Utilization Amongst Trades*

The MEP sector of the construction industry is essential to a project's overall success. BIM was introduced as a tool to assist in providing more efficiency within a project. MEP contractors are some of the highest adopters of BIM (Young, Jones & Bernstein, 2008). The Engineering News Record reported that 41% of trade contractors used BIM on 50% or more of their projects (2016). A study by Hanna, Boodai & Asmar (2013) found that 60% of MEP contractors were using BIM, 70% of electrical contractors in the U.S. were using BIM, and 51% of mechanical contractors were using BIM on projects. The study also revealed varying degrees of BIM

implementation, which could create inconsistencies between trades. BIM use was higher in larger companies as compared to smaller ones. The team also measured the level of expertise of BIM users and found that 59% considered themselves to be experts in BIM, while 41% considered themselves as beginners. Figure 1 illustrates the relationship between BIM experts compared to those considered as novice-users.

MEP systems coordination involves establishing critical locations for components of systems in overfilled spaces not only to avoid obstructions but also to meet the necessary design, construction, and operations criteria. The process of MEP systems coordination provides opportunities to improve on project performance by an integrated approach (Tatum & Korman, 1999). There are, however, some areas of improvement in current practice that still exists today. In Tatum and Korman’s study, the team sought to shorten and reduce the cost during design and coordination phases. They also sought to develop and implement a tool which would assist in the coordination of design input between MEP trades on complex projects.

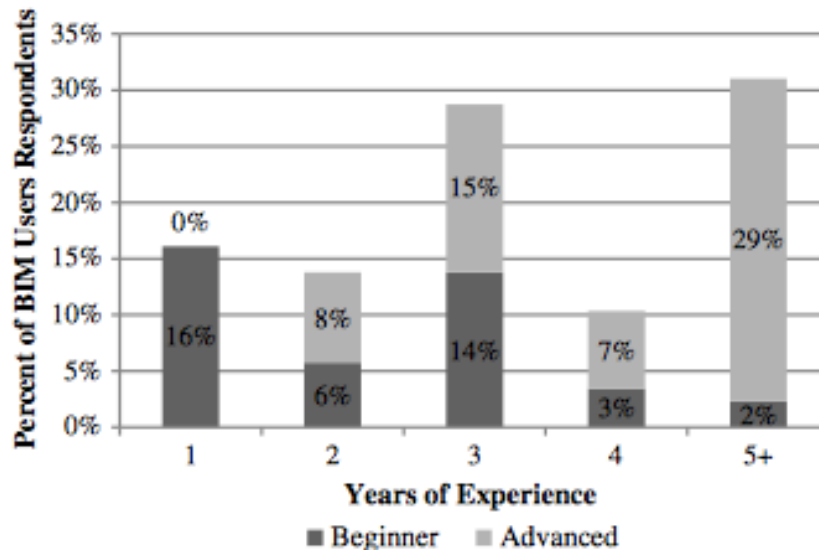


Figure 1: A Comparison of BIM Levels of Expertise (Hanna, Boodai & Asmar, 2013).

Multiple software tools exist today, which are used in combination with BIM during both preconstruction and construction phases (Kensek, 2014). Typical modeling software includes Revit, AutoCAD and Autosprink VR, illustrated in Figure 2 below. BIM is typically depicted as the solution to team collaboration and coordination within the industry. However, according to Dossick and Neff (2010), this is not enough in creating project collaboration as MEP detailers were not only uncertain about the digital information they received, but they also felt the need to rely upon formal means of communication, separating them from those who contained the necessary information. Additionally, the general contractor typically takes the lead on MEP project collaboration and coordination; however, most MEP contractors believe their specialty trades should take the lead during the modeling coordination process. According to Khanzode (2008), for BIM technologies to reach its full potential, an integrated approach is required. It is a vital element because it promotes collaboration between owner, architect, engineer, and key trades. This is not possible with the traditional Design-Bid-Build delivery method given key personnel cannot partake in the process early on given the contractual constraints.

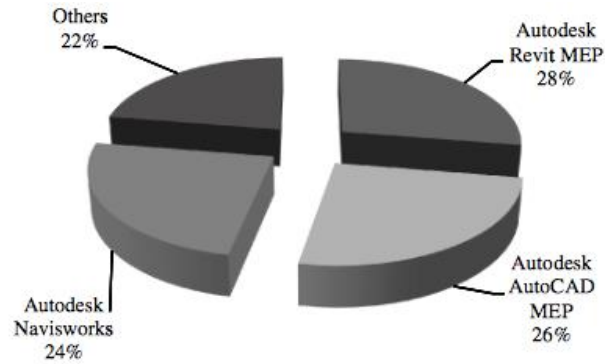


Figure 2: BIM Software Utilized by MEP Contractors (2013).

According to Kensek (2014), some common uses of BIM include, but not limited to:

- Project scheduling
- Construction sequencing
- Constructability analysis
- Quantity take-off
- Estimating and cost planning
- Visual presentations
- Clash detection

Clash detection is a method of identifying and inspecting interference in a three-dimensional project model. It is perhaps one of the most mentioned uses of BIM within MEP contracting. While clash detection was shown to produce the most value amongst MEP trades (Hanna, Boodai, Asmar, 2013), it can also create multiple issues. When a large number of clashes are detected, it is more challenging to decipher results; this makes it harder to find high-risk clashes (Kensek, 2014). Prior to BIM technologies, clash detections transpired on the construction job site. It also involved overlapping two-dimensional drawings to examine clashes. This method was deemed ineffective and costly (ACD, 2012).

#### *Collaboration and Project Performance*

According to the BVA, performance increases when management, direction, and control (MDC) is minimized. Kashiwagi (2018) asserts that collaboration leads to MDC. When parties collaborate, the primary goal is knowledge transfer. If parties disagree, the only option is management and enforcement. Other researchers support this idea, proposing that collaboration increases the complexity of projects (Norton Rose Fulbright, 2017).

BVA minimizes collaboration and MDC by encourage expert vendor participation in project pre-planning stages. Before a project begins, the vendor will define the scope of work, create a risk mitigation plan, and create a detailed milestone schedule. Next, the client can clarify the vendor's plan by asking questions. This permits the vendor to plan the project without being controlled by the vendor.

Through the duration of the project, BVA requires vendors to maintain a Weekly Risk Report (WRR) and a Director's Report (DR). These documents provide high-level, non-technical performance metrics regarding risks, schedule, and cost deviation. The WRR summarizes performance of individual projects while the DR compiles information from multiple WRRs from different contractors and projects. Clients and other stakeholders can view these documents to gain a clear understanding of the current conditions of the project.

Kashiwagi (2018), proposes that WRR/DR increase performance and cost savings because it reduces time and resources spent on administration and communication. On the other hand, any efforts that increase collaboration require more people, communication, clarification, and administration.

### **Integrating BIM and the Best Value Approach**

The critical function of BVA is to ensure that clients utilize vendor expertise throughout the duration of the project (procurement and delivery). BVA minimizes the need for collaboration because it increases transparency along the supply chain. This allows non-expert clients to understand the performance and end deliverables of complex projects.

MEP trades depend on BIM because it is a simple modeling tool that allows non-experts to see the deliverables of MEP projects and estimate how they might impact other components of construction. As technology progresses, BIM (and other similar software) will become more advanced and ubiquitous in the MEP industry (NBS, 2016). This technology can improve the efficiency of expert vendors and reduce communication among stakeholders. Risk may occur when non-expert clients use this technology to manage, direct, and control expert vendors.

The BVA creates an environment that eliminates any MDC of expert vendors. By first implementing BVA, MEP vendors can use BIM more efficiently without incurring additional project risk. This will enable BIM to achieve the following:

- Create more transparency between clients and vendors.
- Allow MEP vendors to improve pre-planning and projections.
- Allow MEP to improve information management on project sites.
- Pave the way for system-automation and more advanced technology.

#### *BVA Case Studies*

The BVA has been tested through over 2,000 industry-based case studies. The authors have selected several case studies that showcase how BVA decreases collaboration but maintains high-performance.

##### *US Army Medical Command*

The United States Army Medical Command (MEDCOM) is a hospital construction organization that that struggled with poor project performance. MEDCOM manages the construction,

maintenance, and repair/renewal of over 26 medical facilities in the United States, servicing over 5 million soldiers (active, retired, and their relatives) and civilian employees (U.S. Army Medical Department 2008).

From 2005 to 2012, MEDCOM implemented the BVA on 600+ projects (Kashiwagi et al., 2009, Rivera, 2017). In that time, MEDCOM managed each project with an individual WRR, and compiled the data using a DR. In 2009, the MEDCOM group increased their performance: instead of 25% of projects delivered on time and 25% of projects deliver on budget, 40% were on time and 67% were on budget (Kashiwagi, et al., 2009)

### *Large Environmental State Agency*

The State Agency is one of the largest environmental regulators in the United States (over 400 employees) that manages various water, air and waste contaminants and pollutions in the State's environment. Over the last decade, the State Agency has had difficulty with performing their environmental professional services and has become increasingly dissatisfied. The major difficulties upper management identified was the following (Rivera, 2017):

1. Unable to identify performance and value of vendors (environmental experts).
2. Vendors were not meeting the quality expectations of the State Agency.
3. Management requirement of the vendors was too high.
4. Inability to spend all available resources.

The State Agency identified that the biggest impact was coming from its \$7 million department, Waste (WD). The WD was responsible for over 50 sites and 10 separate vendors on the indefinite delivery indefinite quantity contract.

From 2015 to 2017, the State Agency tested the BVA in the WD on 194 projects [\$21M budget], with 8 internal project managers. To minimize collaboration and confusion, upper management required each of their project managers to manage their projects using the WRR. Each week it was compiled into a DR and upper management would clear up any confusion in a weekly project management meeting. Overall, the results reported were:

- Cut the procurement cost by \$95K in the first year.
- Client could spend 100% of its budget (minimized risk of not receiving funding from governor's office).
- All projects were delivered on time and on budget.
- PMs received 36% more work from vendors.
- PMs work capacity increased by 71%.
- Minimized late invoices from 15 to 0, and reduced invoice discrepancies from 37% to 19%.
- Acceptance of the BVA by vendors increased on average by 23%.
- State Agency customer satisfaction increased by 28%.

### *Additional Case Studies*

Besides the case studies discussed above, the authors have identified additional studies that also suggest that BVA improves performance while minimizing collaboration (Rivera, 2017; PBSRG, 2018; Kashiwagi, 2018):

1. State of Minnesota testing on 400+ projects (2006-2010) show the vendor caused less than 1% of project cost and time deviation.
2. Dutch fast track projects (2009-2013) show that non-expert owner stakeholders caused over 90% of time and cost deviations.
3. State of Hawaii testing on 96+ projects (1998-2001) showed that vendors caused less than 1% of the risk on maintenance projects

### **Research Findings and Conclusion**

The most common usage of BIM among MEP projects is for project planning and estimation. However, these activities create more collaboration, such as clients using BIM as a method to communicate and manage vendors. The BVA reduces these issues by leveraging vendors' expertise. The authors have identified multiple longitudinal cases which validate the potential impact of the BVA to BIM.

While BIM may be a very effective analysis and pre-planning tool for MEP specialists, it cannot increase the expertise of non-experts. Collaboration creates an environment in which non-experts share their opinions and tell expert vendors what to do, thus devaluing expertise. The Best Value Approach (BVA), proposes that project performance increases when clients can utilize the expertise of vendors. This system minimizes collaboration, communication, and management of vendors. BVA can offer a simple solution that allows MEP specialties to use BIM without the need of collaboration. Under this system, BIM can create more transparency, improve pre-planning, improve information management, and allow for more technological advancements. The authors propose that when experts use BIM, it will improve project performance. When non-experts use BIM, it will increase risk. The authors recommend additional research to test the usage of BIM in a Best Value environment.



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