SmartMarket Report

DODGE DATA & ANALYTICS

The Business Value of BIM for Mechanical and HVAC Construction

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SmartMarket Report

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The Business Value of BIM for Mechanical and HVAC Construction SmartMarket Report

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DODGE DATA & ANALYTICS

About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of analytics and software-based workflow integration solutions for the construction industry. Building product manufacturers, architects, engineers, contractors, and service providers leverage Dodge to identify and pursue unseen growth opportunities and execute on those opportunities for enhanced business performance. Whether it's on a local, regional or national level, Dodge makes the hidden obvious, empowering its clients to better understand their markets, uncover key relationships, size growth opportunities, and pursue those opportunities with success. The company's construction project information is the most comprehensive and verified in the industry. Dodge is leveraging its 100-year-old legacy of continuous innovation to help the industry meet the building challenges of the future.

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Introduction

Mechanical and HVAC contractors are responsible for critically important aspects of increasingly complex projects, while dealing with cost and schedule pressures, workforce issues and safety concerns. Over recent years many of these companies have found that BIM technologies provide enormous benefits in these areas, and they are actively seeking to expand their use of BIM as well as encouraging greater engagement with it and the collaborative, model-related processes that amplify its impact throughout their project teams and supply chains.

The *Business Value of BIM for Mechanical and HVAC Construction SmartMarket Report* from Dodge Data & Analytics is the result of a comprehensive research study conducted among mechanical and HVAC contractors in the US that are working with BIM to determine:

- **Their level of engagement with modeling the mechanical work they will install.**
- **How they are using data from mechanical models for coordination, quantity take-offs, constructability evaluation, sequencing, shop drawings and other related workflows.**
- **Their use of BIM for prefabrication and modularization.**
- **The ways they are deploying BIM in the field.**
- **How BIM is impacting key metrics of their project performance.**
- **The benefits these companies are receiving from their use of BIM.**
- **What challenges they face in expanding their use of BIM.**

The findings of the research set forth in this SmartMarket Report clearly demonstrate that the use of BIM and related technologies and processes that leverage data from models is delivering meaningful impact to mechanical and HVAC contractors on a wide variety of measures:

- **Improved cost and schedule performance**
- **Reduced material waste**
- **Greater speed and accuracy in field layout**
- **Lower labor costs and greater productivity**
- **Better worker safety**
- **Fewer errors**
- **Better collaboration between stakeholders**
- **Lower site logistics costs**
- **Improved quality of installed work**
- **Increased profitability**
- **Winning new work and maintaining repeat business**

For analysis by trade, the report highlights differences between four types of mechanical and HVAC contractors:

- **Sheet metal/ducting**
- **Mechanical piping**
- **Plumbing**
- **Multi-trade (where no single trade represents the majority of revenue)**

Where relevant, the report also describes differences between contractors of different sizes and in different regions of the US.

We thank the Mechanical Contractors Association of America, Pinnacle Infotech, Autodesk, the Air Conditioning & Mechanical Contractors' Association (Australia) and Innovative Construction Technology for their financial support of this project. In addition we thank the Sheet Metal and Air Conditioning Contractors' National Association for their assistance in obtaining completed surveys. And an additional thanks to the Air Conditioning & Mechanical Contractors' Association (Australia) for help in assembling an advisory group of mechanical construction executives to guide this project.

Stephen A. Jones
Senior Director
Industry Insights Research
Dodge Data & Analytics

Stephen A. Jones leads DD&A's Industry Insights Research division. He is active in numerous industry organizations and frequently speaks at industry events around the world. Before DD&A, Jones was vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he was principal and a Board of Directors member with Burt Hill, a major A/E firm (now merged with Stantec).

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Donna Laquidara-Carr currently provides editorial direction, analysis and content to DD&A's *SmartMarket Reports*. Prior to this position, she worked for nearly 20 years with DD&A's Dodge division, where she gained detailed insight into the construction industry.

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Cover Image Courtesy of Pinnacle Infotech. Image at right courtesy of BNIM.

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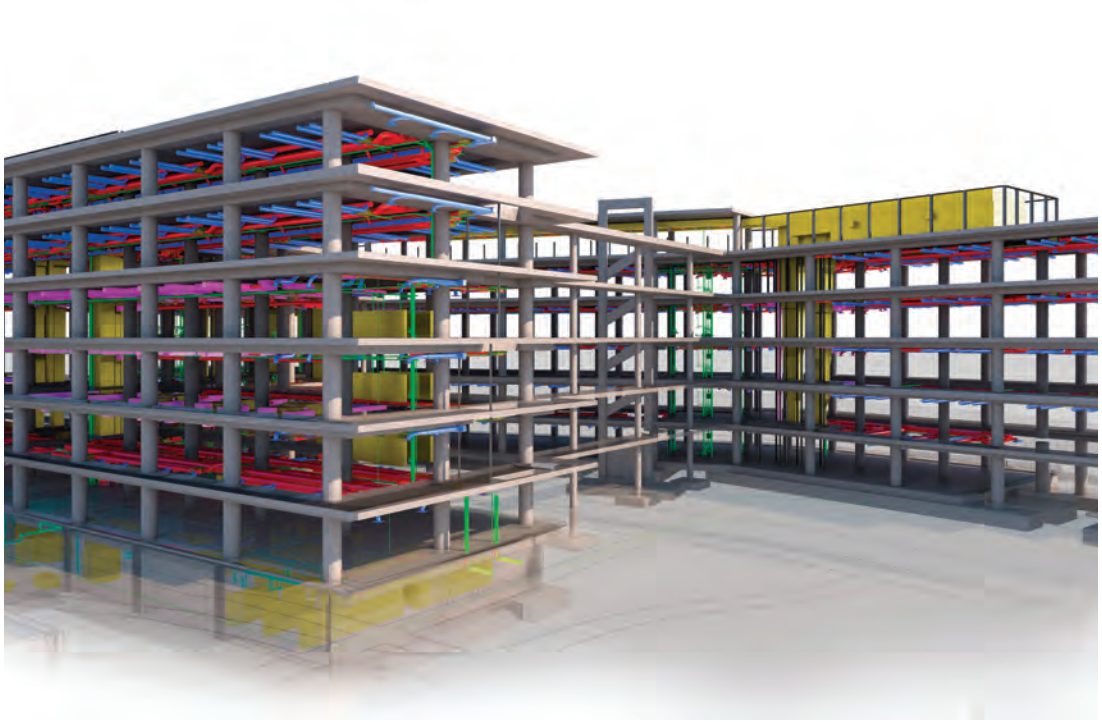


Front Cover:
A BIM-enabled mechanical room installation allows for zero conflicts and is essential for coordinated mechanical services.

This page:
MEP services modeled in BIM for the Pacific Center Campus project led by BNIM.

Executive Summary

Mechanical and HVAC Contractors Are Highly Engaged With BIM and Enjoying Multiple Benefits

The results of this latest research by Dodge Data & Analytics indicates that the use of BIM by mechanical and HVAC contractors is widespread and is encouraging growth in related activities such as prefabrication and modular. And the benefits they are receiving are compelling.

How Frequently Mechanical Contractors Are Responsible for Providing a Mechanical Model on Their BIM Projects

On their projects that involve BIM, mechanical and HVAC contractors are frequently responsible for providing a model of the work they will install. Findings shown in the matrix below indicate that almost two thirds (65%) are responsible on half or more of their projects, and only 5% are never responsible.

Frequency of Modeling by Mechanical Contractors Who Use BIM (Percentage of Projects on Which Mechanical Contractors Who Use BIM Are Responsible for Producing a Model of the Work They Will Be Installing)

Percentage of Projects	None/Not Sure	1% to 49%	50% or More
Percentage of Contractors	5%	30%	65%

How Frequently Mechanical Contractors' Internal Resources Are the Primary Authors of Their Mechanical Models

As the matrix below shows, almost all (90%) mechanical contractors produce their models with internal resources at least some of the time, and over two thirds (67%) do so half or more of the time.

Frequency of Using Internal Resources to Produce Mechanical Model (Percentage of Projects on Which Mechanical Contractors Use Internal Resources to Produce Their Mechanical Model)

Percentage of Projects	None/Not Sure	1% to 49%	50% or More
Use of Internal Resources	10%	23%	67%

How Frequently External Sources Are the Primary Author of the Mechanical Model When Mechanical Contractors Do Not Use Internal Resources

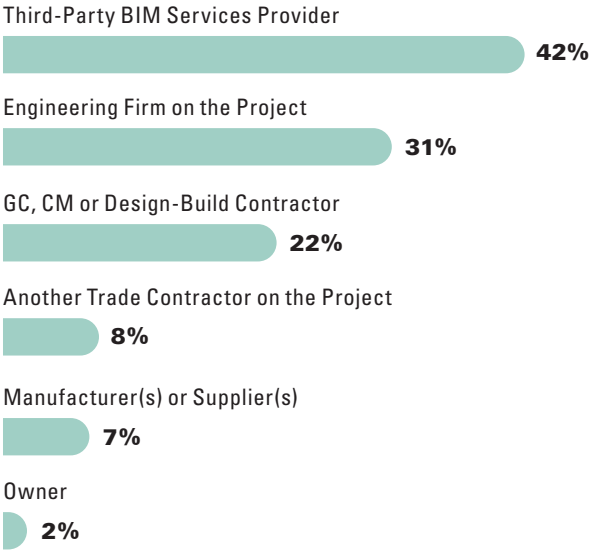
In the cases where mechanical and HVAC contractors do not use their internal resources to produce a mechanical model that they are responsible for providing, they were asked to identify as many as three from a list of external resources that produce models for them.

The chart below shows very strong results for third-party BIM service providers (42%), underscoring the fast growth of that market.

- **An above-average number of mechanical piping contractors (52%) take advantage of these services.**
- **Contractors in the Midwest (49%) are the most frequent users.**

Frequency of External Resources Producing Mechanical Models (Percentage of Projects on Which External Resources Produce the Mechanical Model When Mechanical Contractors Do Not Use Internal Resources to Produce It)

Dodge Data & Analytics, 2020

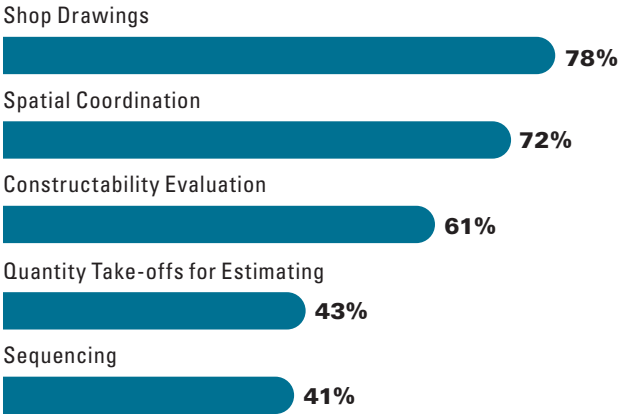


Using BIM for Analysis

As the chart below shows, mechanical and HVAC contractors are taking advantage of many of the powerful analytical capabilities of BIM on a majority of their projects.

Frequency of Use of BIM for Analysis by Mechanical Contractors (Percentage of Mechanical Contractors Who Use BIM to Conduct Analysis on 50% or More of Their BIM Projects)

Dodge Data & Analytics, 2020

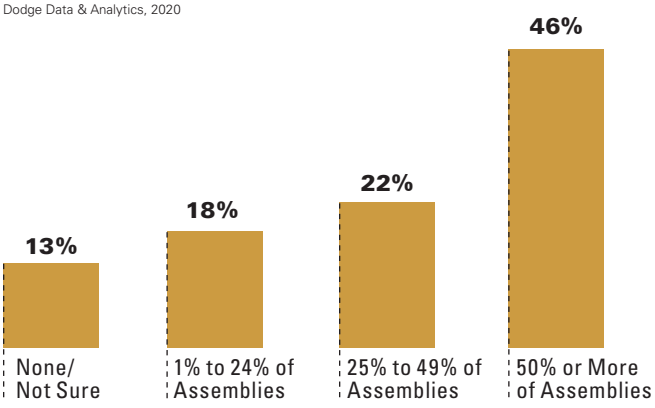


Using BIM for Prefabrication

As shown below, among mechanical and HVAC contractors who use BIM, almost all (87%) are applying it to prefabrication.

Frequency of Use of BIM for Prefabrication of Mechanical Assemblies (Percentage of Mechanical Assemblies Where BIM Is Used for Prefabrication)

Dodge Data & Analytics, 2020

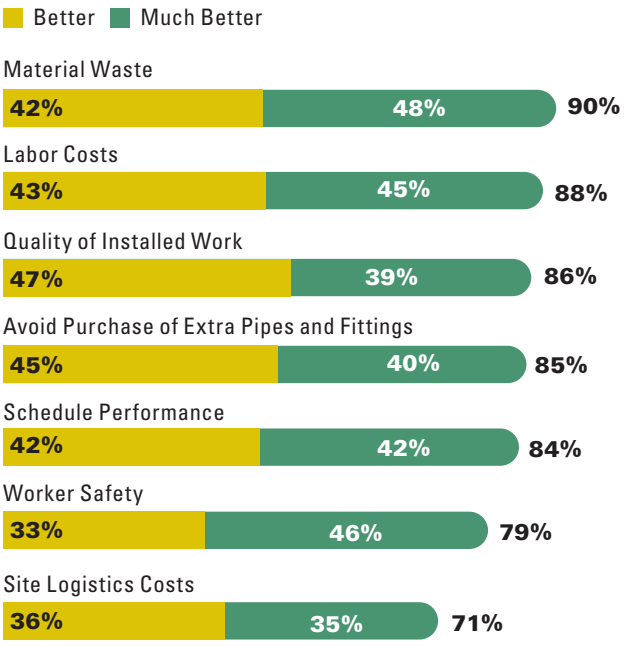


Benefits of Using BIM for Prefabrication Compared With Site Construction

Mechanical and HVAC contractors are enjoying numerous benefits from the use of model-driven prefabrication. As shown in the chart below, high percentages of them cite improvements to these seven key metrics when they compare working with BIM to the traditional methods of site-based construction.

Positive Impact From Using BIM to Prefabricate Versus Site Construction (Percentage of BIM Users Reporting Improvement Compared With Site Construction)

Dodge Data & Analytics, 2020



Overall Benefits to Mechanical and HVAC Contractors From Using BIM

The survey asked mechanical and HVAC contractors about the benefits they receive from their use of BIM. Below is an index ranking (on a 1–10 scale) of the top nine responses, conveying a powerful message about the positive impact of BIM.

Company-type variances among the top five benefits include:

- **Multi-trade contractors most frequently report increased productivity, improved fabrication and better utilization of resources.**
- **Mechanical piping contractors are most likely to report increased profitability and improved cost performance.**

Challenges for Mechanical and HVAC Contractors in Expanding Their Use of BIM

In order to better understand the changes needed for growth, the survey also explored the challenges these companies face in expanding their level of BIM engagement. Below is an index ranking (using the same 1–10 scale as Benefits) of the top nine responses.

Company-type variances among the top five challenges include:

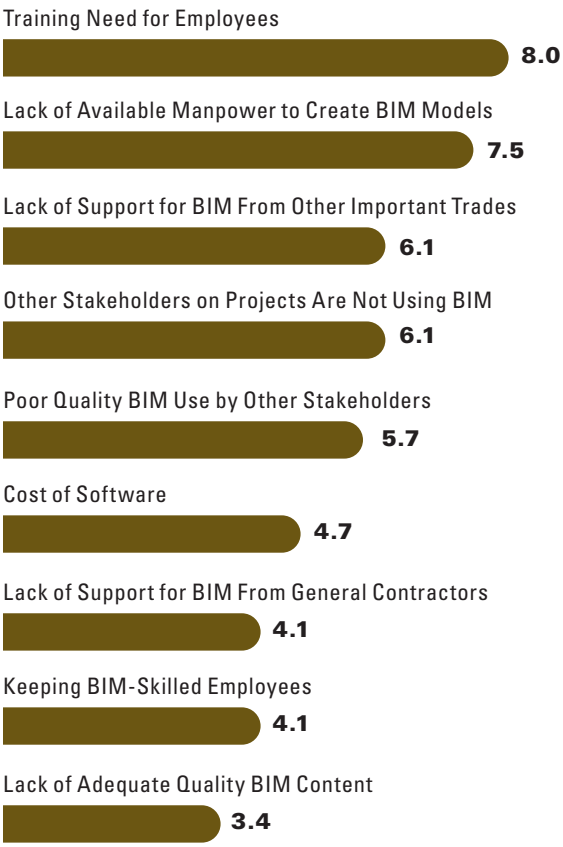
- **Plumbing contractors most frequently cite need for training, lack of support from other trades, other stakeholders not using BIM and poor-quality BIM use by others.**
- **More multi-trade contractors identify lack of manpower than the single-trade companies.**

Top Benefits of BIM for Mechanical Contractors (Relative Index Rating [1–10 scale] of Most Important Benefits Cited by Mechanical Contractors)

Dodge Data & Analytics, 2020

Top Challenges for Mechanical Contractors in Expanding Use of BIM (Relative Index Rating [1–10 scale] of Most Important Challenges Cited by Mechanical Contractors)

Dodge Data & Analytics, 2020



Data: Introduction

Dodge Data & Analytics has been studying the adoption and implementation of BIM in the design and construction industry since 2007, and has published nearly 20 reports in the *SmartMarket Report* series focusing on specific aspects on BIM, including:

- **Regions of the world** (e.g., US, Europe, China, Korea, Australia, the Middle East)
- **Project types** (e.g., Green Buildings, Infrastructure, Water & Waste Water)
- **Aspects of the model-based digital workflow** (e.g., Generative and Computational Design, Integrated Design and Fabrication, Cloud-Based Collaboration)
- **User types** (e.g., Owners, Contractors)

This new report, *The Business Value of BIM for Mechanical and HVAC Construction,* focuses on how these types of trade contractors are engaging with BIM, how model data is impacting their workflows and processes, what benefits BIM is generating and the challenges they face in expanding its use on their projects.

The survey for this research was developed with the help of an Advisory Group of senior executives from leading mechanical and HVAC contractors, assembled with the help of the Air Conditioning and Mechanical Contractors Association, which we thank for their contribution. Relevant insights from selected members of the Advisory Group are also referenced in a special article on page 54.

For this survey, "BIM" is intentionally defined broadly as **"the use of 3D modeling technologies to create and use information-rich digital models and the related simulation, analysis, calculation and visualization capabilities and collaborative processes to leverage the value of the models, also sometimes referred to as VDC (virtual design and construction) or model-based design and construction."** Respondents are considered "BIM users" if they author models, or if they rely on or directly use data derived from models that are authored by others (e.g., for spatial coordination, quantity take-offs, constructability evaluation, sequencing, fabrication, etc.).

The findings demonstrate that mechanical and HVAC contractors are receiving a wide variety of important benefits from BIM and their innovative use of BIM and its related processes can be expected to show significant growth in coming years.

About the Data

The data and analysis in this report are based on the responses to an online survey conducted in November and December 2019 of 122 contractors who report using BIM for mechanical construction.

Three analytical variables are used in the report. The first is the type of mechanical construction most frequently done by the companies that report using BIM. The breakdown among those respondents is:

- **Sheet Metal/Ducting*: 12%**
- **Mechanical Piping*: 39%**
- **Plumbing*: 19%**
- **Multi-Trade**: 30%**

* That trade represents at least half of their work.
** No single trade makes up more than 50% of their total work.

The second analytical variable is the size of the companies that report using BIM.

- **Revenue of under $10 million: 11%**
- **Revenue of $10 million to under $50 million: 28%**
- **Revenue of $50 million to under $100 million: 31%**
- **Revenue of $100 million and over: 30%**

The third analytical variable is the region in which the companies that report using BIM do most of their work.

- **Northeast: 19%**
- **South: 12%**
- **Midwest: 30%**
- **West: 17%**
- **Multiregional: 21%**

Regional percentages total 99% due to rounding.

More information about the survey is available in the Methodology section of this report, on page 60.

Data: Use of Mechanical Models

Sourcing and Authoring Models for
Mechanical and HVAC Construction

Mechanical and HVAC contractors who want to use BIM on a project need a model of the architecture and systems design to start their work with. The survey asked respondents to identify how often they receive this kind of a base model from each of the three potential sources shown in the chart at right.

The design team is the most frequent source.

- **One third of mechanical and HVAC contractors report they get a base model from the architect and/or the engineer at least 75% of the time.**
- **This high frequency varies by size of contractor, though, with 39% of the larger ones (over $50M annual revenue) reporting it compared with just 24% of the others. This may reflect their working with larger design firms who generally have more BIM capability and experience.**

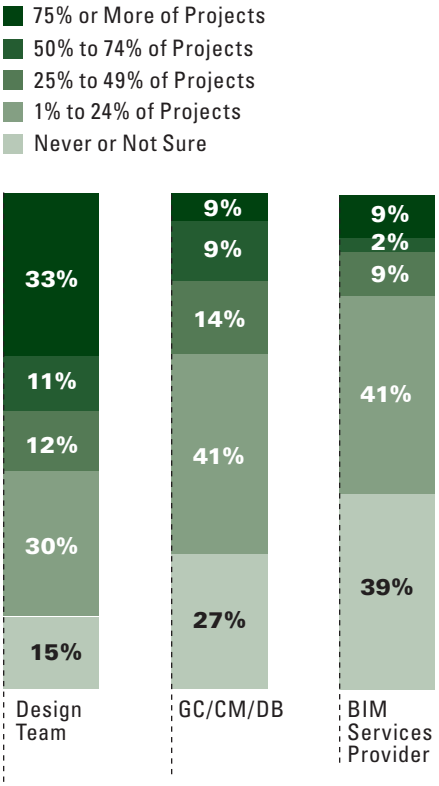
The general contractor, construction manager or design-build contractor is less frequently cited with only 18% of respondents saying they receive a base model from that source on half or more of their projects.

Third-Party BIM Services Providers

Third-party BIM services providers are a relatively new but fast-growing source of models for projects, supplementing both design teams and contractors with specialized modeling services. As a sign of the wide use of this capability in the US market, **61% of mechanical contractors report having received a model from a BIM services provider.**

As the use of BIM continues to expand and the demand for comprehensive technical models increases, it is reasonable to expect significant growth for these types of outsourced services.

Source of Models to Mechanical Contractors
(Percentage of Projects Where Mechanical Contractors Receive Models From Each Source)
Dodge Data & Analytics, 2020



Responsibility for Providing a Mechanical Model

Mechanical and HVAC contractors who are currently working with BIM were asked how frequently their company is responsible for providing a mechanical model, i.e., a model for the mechanical work that their company will be installing on a project. The chart at right shows the frequency for each of four types of companies surveyed.

A high proportion of all the companies surveyed report at least some projects where they have been responsible for providing a model of their work, and most are doing so on half or more of their BIM projects.

- **Sheet metal/ducting contractors are most frequently responsible for modeling with half (50%) saying it is the case on almost all (75% or more) of their projects.**
- **Multi-trade contractors are nearly as frequently responsible, at 46% in the high frequency category. (Multi-trade firms report that they work with multiple types of mechanical systems, and no one system represents the majority of their project work.)**
- **Plumbing contractors, though slightly less often responsible, still show 30% reporting high frequency.**

COMPANY SIZE IMPACT

Only a quarter (23%) of the smallest companies surveyed (under $10M) report providing models on over three quarters of their BIM projects, compared with nearly half (47%) of the largest ones (over $100M). The average for the others ($10M to $100M) is 39%.

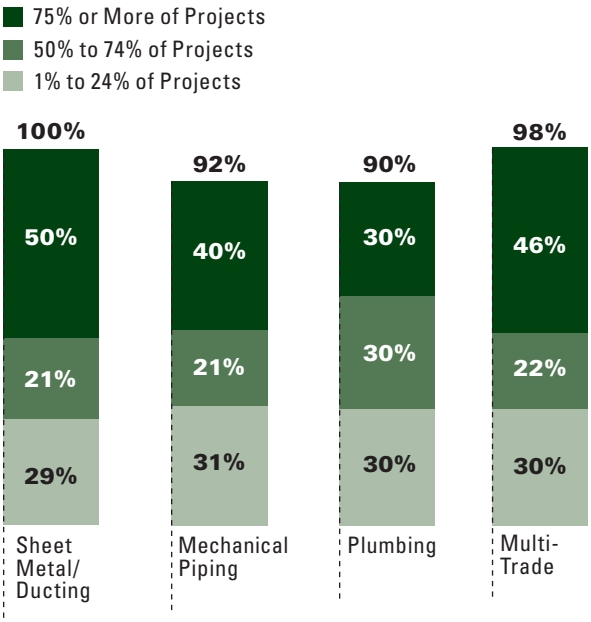
REGIONAL IMPACT

Almost two thirds (60%) of the contractors in the South report this high frequency, as well as over half (54%) of the multiregional firms. Yet just over a quarter (27%) of companies in the Midwest and just over one third (37%) of Northeastern companies cite it. The West shows 43%.

Frequency of Mechanical Model Production by Trades

(Percentage of Projects on Which Model Is Produced by Each Trade)

Dodge Data & Analytics, 2020



Formal Contract Requirement to Provide Mechanical Model

The mechanical and HVAC contractors who report being responsible for providing a mechanical model on at least some percentage of their BIM projects were asked how frequently that responsibility is a formal contract requirement. The chart at upper right shows the frequency for each of the four company-types surveyed.

Half or more of both sheet metal/ducting and multi-trade contractors report having a formal modeling requirement in 75% or more of their contracts on BIM projects.

COMPANY SIZE IMPACT

As the matrix below demonstrates, the frequency of a formal contract requirement for modeling varies directly with company size.

Percentage of Contractors Reporting a Modeling Requirement on 75% or More of Their Contracts on BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**27%**	**34%**	**40%**	**55%**

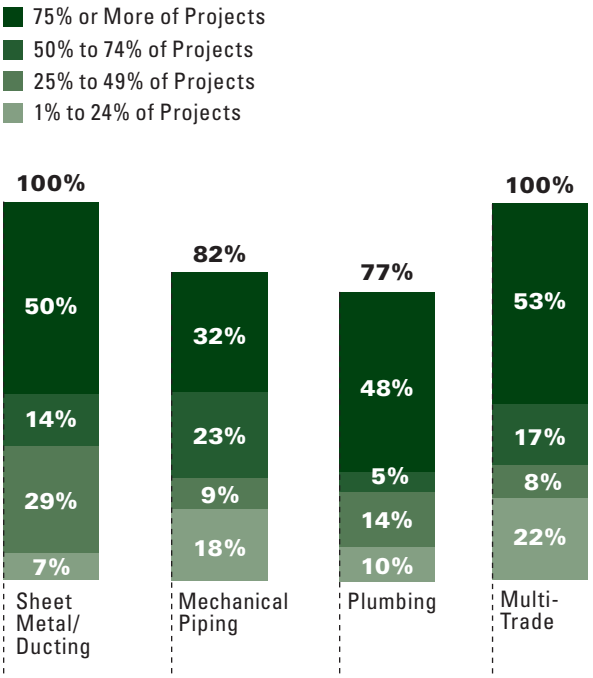
Going Beyond What Is Contractually Required

The companies were also asked, in the instances where they are contracted to provide a model, how frequently do they exceed the contractual requirements. As the chart at lower right clearly indicates, over 70% report doing so, especially the multi-trade companies (89%).

Frequency of Formal Contract Requirement for Mechanical Model Production by Trades

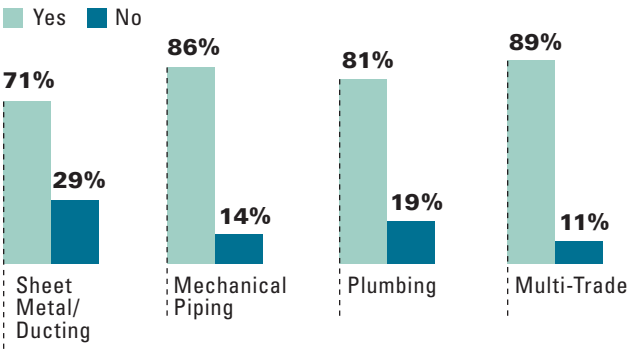
(Percentage of Projects on Which Model Is Required by Contract to Be Produced by Each Trade)

Dodge Data & Analytics, 2020



Trades That Do More Than What Is Contractually Required (Percentage of Trades That Report Doing More Than What Is Specifically Called for in Contract)

Dodge Data & Analytics, 2020



Use of Internal Resources to Author the Mechanical Model

The contractors who are responsible for providing a mechanical model on their BIM projects were asked how often their internal resources are the primary author of it. The chart at right shows the frequency breakdown.

Half (50%) or more of each of the four types of contractors surveyed reports utilizing internal resources to produce their models on three quarters or more of their projects, led by sheet metal/ducting companies (64%).

Not surprisingly this high frequency of internal resource deployment varies by level of BIM implementation, with almost two thirds (62%) of companies that use BIM on at least half their projects reporting it, compared with just 36% of the lesser-engaged companies. This likely reflects a growing investment in BIM staff as modeling activity increases.

COMPANY SIZE IMPACT

As the matrix below shows, high frequency usage of internal resources (over 75% of projects) varies significantly by company size.

Percentage of Contractors Reporting Use of Internal Resources for Modeling on 75% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**23%**	**44%**	**60%**	**68%**

REGIONAL VARIANCES

As the matrix below shows, more multiregion firms report this very high use of internal resources.

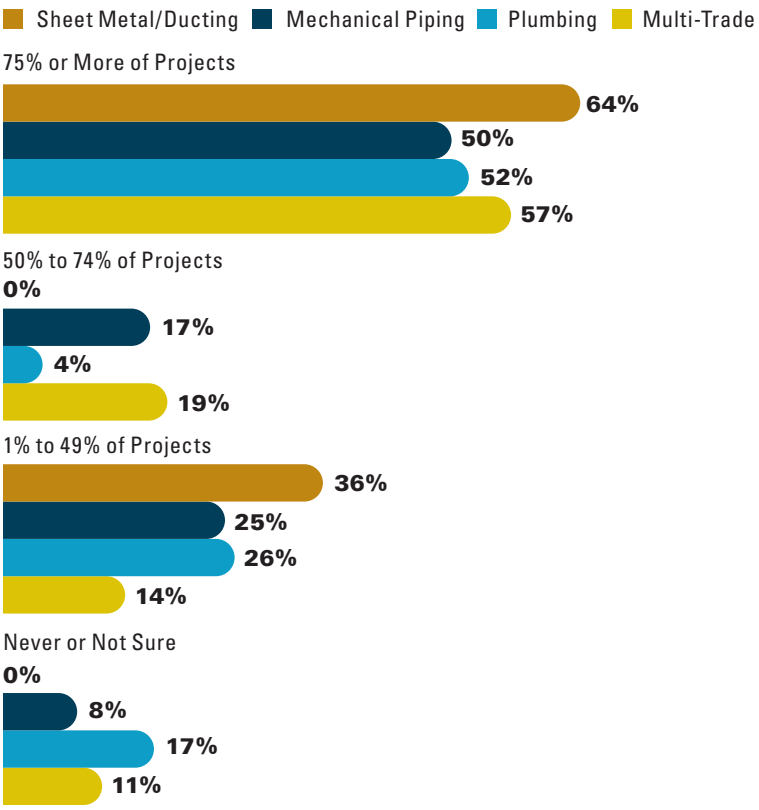
Percentage of Contractors Reporting Use of Internal Resources for Modeling on 75% or More of Their BIM Projects, by Region

Location	Northeast	South	Midwest	West	Multi-region
Frequency	**61%**	**47%**	**41%**	**52%**	**73%**

Frequency of Using In-House Resources for Mechanical Model Production by Trades

(Percentage of Projects on Which Mechanical Model Is Primarily Authored by Internal Resources)

Dodge Data & Analytics, 2020



Use of External Resources for Mechanical Model Production

For any instance where they did not use internal resources to produce models, companies were asked to identify the frequency of several other sources as the primary author of the model, shown in the chart at right.

- **BIM services providers are the most frequent source overall** and especially popular with mechanical piping contractors (52%). Also, half of all the companies with low BIM implementation (use BIM on less than half of their projects) report having models made by BIM services companies, far more than any other source.
- **Engineering firms are also a relatively frequent source,** although much more so for sheet metal/ducting (43%) than the other specialties (average 29%).

COMPANY SIZE IMPACT

As the matrix below shows, more of the larger mechanical contractors are using engineering firms for modeling than their smaller counterparts, whereas use of BIM services companies is relatively consistent across three of the four tiers of company sizes.

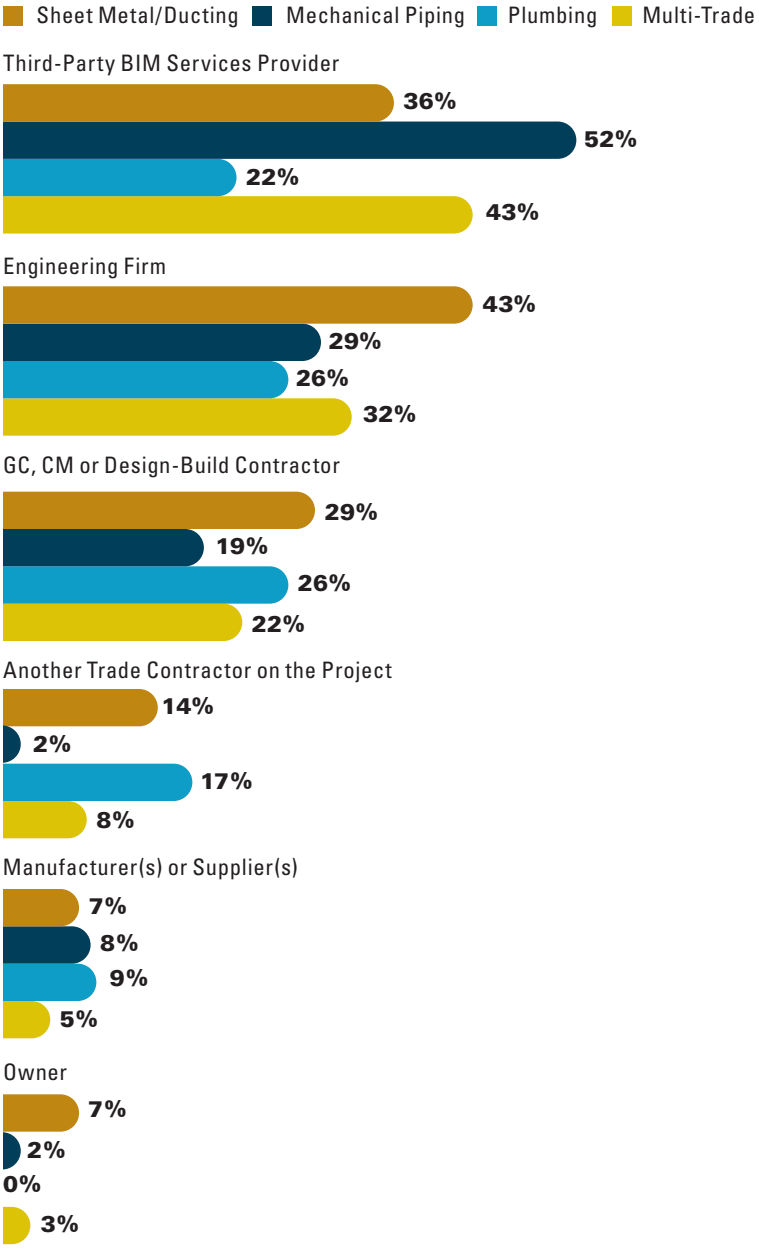
Percentage of Contractors Sourcing Modeling From BIM Services Companies and From Engineering Firms, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
BIM Services Provider	46%	47%	29%	41%
Engineering Firms	23%	28%	29%	38%

Frequency of Using External Resources for Mechanical Model Production When Not Using Internal Resources

(Percentage of Projects Modeled by Various External Resources When Not Modeled In-House)

Dodge Data & Analytics, 2020



Using Mechanical Models for Spatial Coordination

Mechanical and HVAC contractors are using models for a variety of valuable purposes. This section and the next four sections of the report examine five of the most important:

- Spatial Coordination
- Quantity take-offs for estimating
- Constructability evaluation
- Sequencing
- Shop drawings

Spatial Coordination

As shown in the chart at upper right, most contractors who are producing their own models are also leveraging them for spatial coordination.

IMPACT OF COMPANY SIZE

As shown in the matrix below, the size of a company has a dramatic impact on its use of BIM for spatial coordination.

Percentage of Contractors Using BIM for Spatial Coordination on 50% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**38%**	**69%**	**77%**	**82%**

REGIONAL VARIANCES

Most companies in the South (80%) and West (81%) report the use of BIM for spatial coordination on at least half their projects, yet only 62% of the Midwest companies report that frequency.

Use of a BIM Services Provider for Spatial Coordination

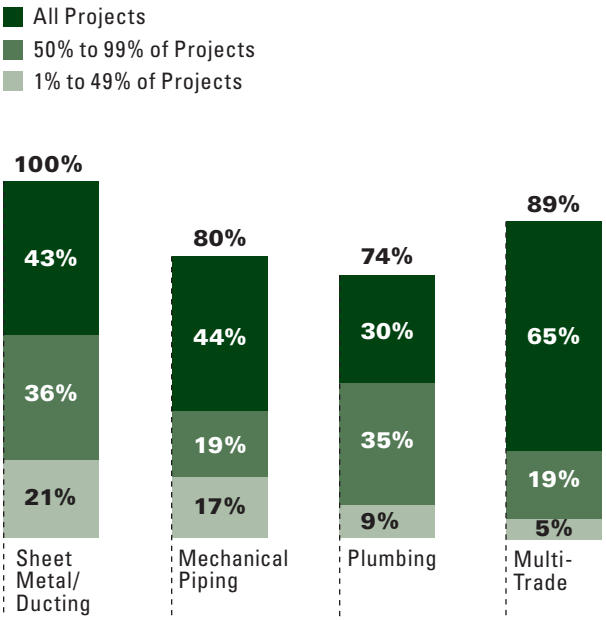
Many BIM services providers can conduct various analyses of models as well as author them. The chart at lower right shows the percentage of each of the company-types surveyed that reports using BIM services providers to conduct spatial coordination on some proportion of their projects.

This practice is particularly popular in the South, where 27% of mechanical contractors report doing it on at least half of their projects.

Frequency of Using Mechanical Models for Spatial Coordination

(Percentage of Projects Where Spatial Coordination Is Performed When Modeled In-House)

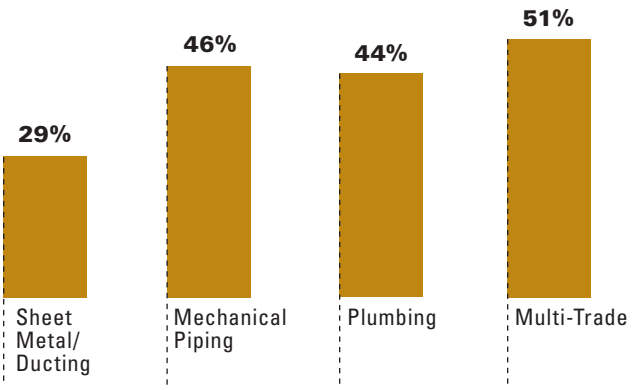
Dodge Data & Analytics, 2020



Frequency of Using Third-Party BIM Services Provider For Spatial Coordination

(Percentage of Projects Where a Third-Party BIM Services Provider Is Used for Spatial Coordination)

Dodge Data & Analytics, 2020



Using Mechanical Models for Quantity Take-offs

For Estimating

Compared with the high frequency of using BIM for spatial coordination, notably fewer contractors are leveraging it to do quantity take-offs for estimating, as demonstrated in the findings shown at upper right.

IMPACT OF COMPANY SIZE

Interestingly, in this case the smallest firms (46%) are almost as active as the large (51%) and very large (50%) ones, and it is the midsize companies (22%) who seem most reluctant to use BIM for quantity take-offs for estimating.

Percentage of Contractors Using BIM for Quantity Take-offs for Estimating on 50% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**46%**	**22%**	**51%**	**50%**

REGIONAL VARIANCES

More companies in the South (60%), Midwest (54%) and the multiregional companies (54%) report the use of BIM for quantity take-offs on at least half their projects than the Midwestern (38%) or Northeastern (22%) ones.

Use of a BIM Services Provider for Quantity Take-Offs for Estimating

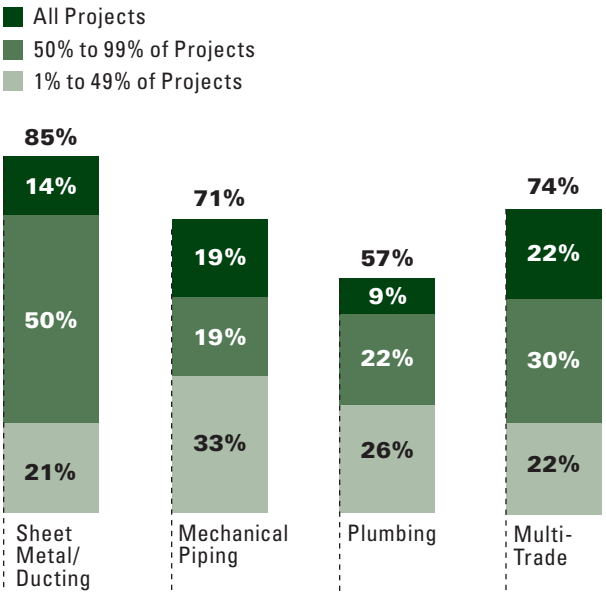
The chart at lower right shows the percentage of each of the company-types surveyed that reports using BIM services providers to conduct quantity take-offs for estimating.

- **This usage tends to be more frequent with smaller firms than with larger ones, which makes sense because of the greater likelihood of having internal resources on staff at the bigger companies.**
- **It also varies by region where a quarter of the mechanical contractors in the South report doing this on half or more of their projects.**

Frequency of Using Mechanical Models for Quantity Take-offs for Estimating

(Percentage of Projects Where Quantity Take-offs for Estimating Are Performed When Modeled In-House)

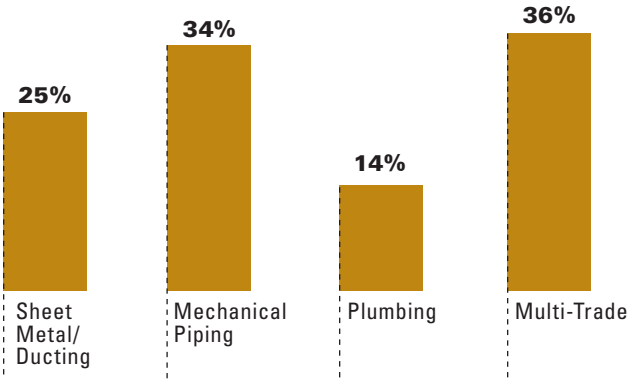
Dodge Data & Analytics, 2020



Frequency of Using Third-Party BIM Services Provider for Quantity Take-offs for Estimating

(Percentage of Projects Where a Third-Party BIM Services Provider Is Used for Quantity Take-offs for Estimating)

Dodge Data & Analytics, 2020



Using Mechanical Models for Constructability Evaluation

While the overall use of BIM for constructability evaluation is relatively high, there is a notable difference between the company-types. As the chart at upper right shows, all or nearly all sheet metal/ductwork and multi-trade contractors are users, compared with only about two thirds of mechanical piping and plumbing contractors. This may reflect a relatively lower need for such work by these trades, especially plumbing where only 17% report using BIM for constructability evaluation on every project compared with the same intensity reported by 43% of sheet metal/ducting and 49% of multi-trade contractors.

IMPACT OF COMPANY SIZE

While the smallest firms (54%) are not as active as the large (71%) and very large (76%) ones, they once again outpace the midsize companies (41%).

Percentage of Contractors Using BIM for Constructability Evaluation on 50% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
	54%	41%	71%	76%

REGIONAL VARIANCES

More Western (76%) and multiregional companies (69%) are using BIM for constructability evaluation on over half their projects than those in the Northeast (57%), South (53%) or Midwest (54%) regions.

Use of a BIM Services Provider for Constructability Evaluation

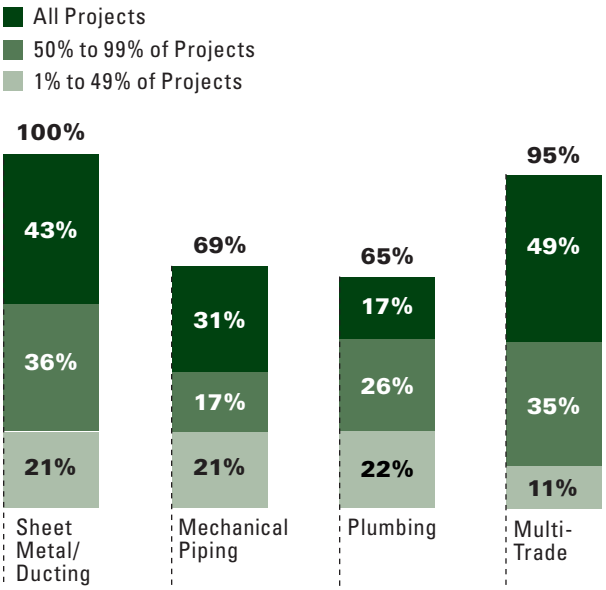
The chart at lower right shows the percentage of each of the company-types surveyed that reports using BIM services providers to conduct constructability evaluations for them.

Over one third (36%) of mechanical contractors in the South report doing this on at least half of their projects, versus 15% of the multiregional outfits.

Frequency of Using Mechanical Models for Constructability Evaluation

(Percentage of Projects Where Constructability Evaluation Is Performed When Modeled In-House)

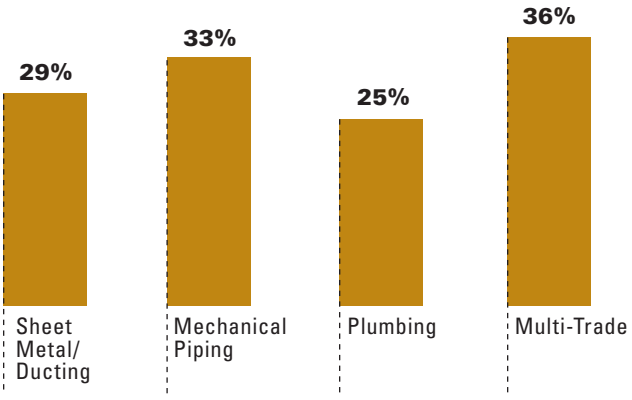
Dodge Data & Analytics, 2020



Frequency of Using Third-Party BIM Services Provider for Constructability Evaluation

(Percentage of Projects Where a Third-Party BIM Services Provider Is Used for Constructability Evaluation)

Dodge Data & Analytics, 2020



Using Mechanical Models for Construction Sequencing

Well over half of mechanical contractors report using BIM for construction sequencing on at least some portion of their BIM projects.

- **As with other BIM uses studied, the sheet metal/ ducting and multi-trade contractors lead in overall usage.**
- **In this case, mechanical piping contractors are also very active, with 42% doing it on at least half of their projects.**

IMPACT OF COMPANY SIZE

As the matrix below indicates, while well established at midsize and larger organizations, this practice is far less common among small companies, perhaps because their projects may be less complex, therefore not requiring sophisticated digital sequencing. But it is clearly a capability that will be necessary to grow.

Percentage of Contractors Using BIM for Construction Sequencing on 50% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	%50M to Less Than $100M	$100M or More
Frequency	**15%**	**38%**	**40%**	**50%**

REGIONAL VARIANCES

More Western (52%), Southern (47%) and multiregional companies (46%) are using BIM for construction sequencing on over half their projects than those in the Northeast (30%) or Midwest (35%) regions.

Use of a BIM Services Provider for Construction Sequencing

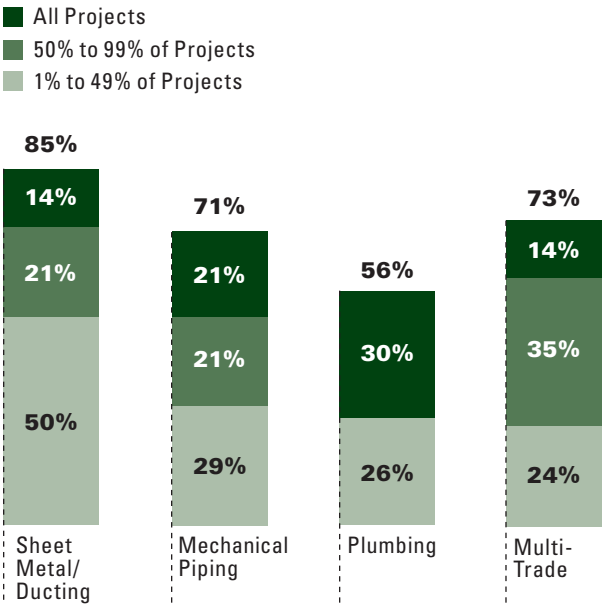
The chart at lower right shows the percentage of each of the company-types surveyed that reports using BIM services providers to conduct construction sequencing for them.

Mechanical contractors in the South are the most active users of BIM services providers for construction sequencing, with one third (33%) saying they do it on at least half of their projects.

Frequency of Using Mechanical Models for Sequencing

(Percentage of Projects Where Sequencing Is Performed When Modeled In-House)

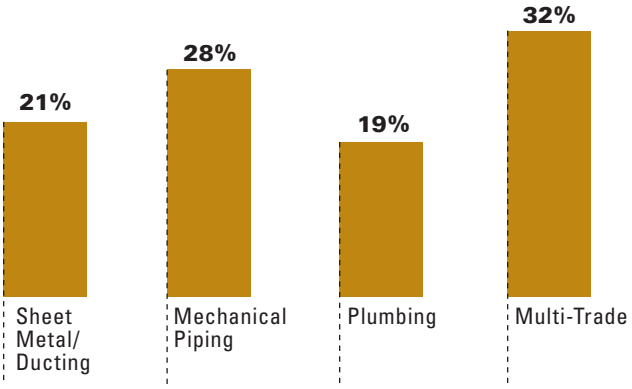
Dodge Data & Analytics, 2020



Frequency of Using Third-Party BIM Services Provider For Sequencing

(Percentage of Projects Where a Third-Party BIM Services Provider Is Used for Sequencing)

Dodge Data & Analytics, 2020



Using Mechanical Models for Shop Drawings

Similar to the frequent use of BIM for spatial coordination, large numbers of mechanical contractors report leveraging models for shop drawings.

- **Well over half of sheet metal/ducting (64%), mechanical piping (56%) and multi-trade contractors (59%) use this on all their projects.**
- **Even though plumbing contractors show the least overall engagement (74%), almost two thirds (65%) are doing it on at least half of their projects.**

IMPACT OF COMPANY SIZE

As shown below, although over half (54%) of small organizations are using BIM for shop drawings on at least 50% of their projects, this still significantly lags the usage rate among the larger companies.

Percentage of Contractors Using BIM for Shop Drawings on 50% or More of Their BIM Projects, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**54%**	**78%**	**83%**	**82%**

REGIONAL VARIANCES

Usage of BIM for shop drawings on the majority of projects is more regionally consistent than other analyses studied in this section of the report, with the South (87%) and West (86%) only slightly outperforming multi-regional (77%), Northeastern (74%) or Midwestern (73%) companies.

Use of a BIM Services Provider for Shop Drawings

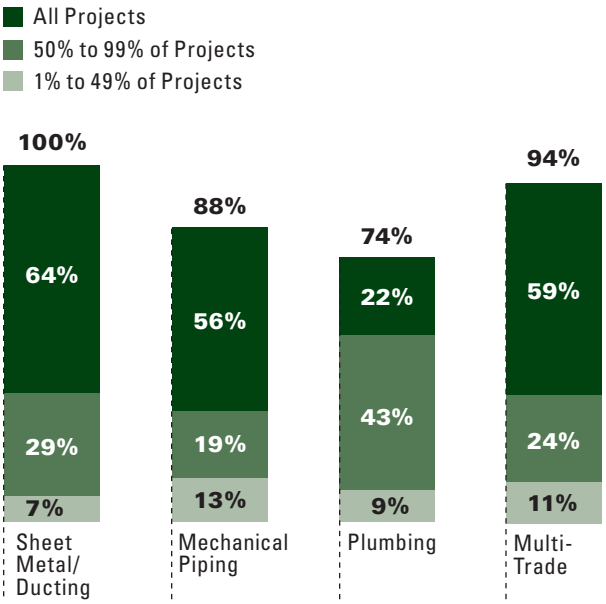
The chart at lower right shows the percentage of each of the company-types surveyed that reports using BIM services providers for shop drawings.

Over one third (36%) of mechanical contractors in the South and nearly one quarter of them (24%) in the West report using BIM services providers for shop drawings on at least half of their projects.

Frequency of Using Mechanical Models for Shop Drawings

(Percentage of Projects Where Model Is Used for Shop Drawings When Modeled In-House)

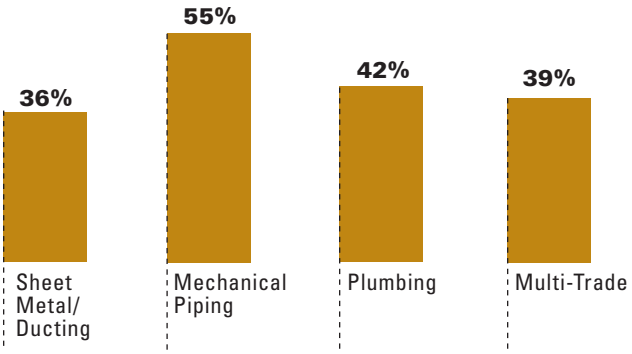
Dodge Data & Analytics, 2020



Frequency of Using Third-Party BIM Service Provider for Shop Drawings

(Percentage of Projects Where a Third-Party BIM Services Provider Is Used for Shop Drawings)

Dodge Data & Analytics, 2020



Impact of BIM on Workflows

BIM is impacting a number of important workflows for mechanical and HVAC contractors. This section of the report examines:

- The speed of creating shop drawings
- Extracting material quantities from BIM
- Using BIM for estimating

Speed of Developing Shop Drawings

As shown in the chart at upper right, most contractors believe BIM is making the development of shop drawings faster compared with their previous methods. Interestingly, sheet metal/ducting contractors boast both the highest percentage who believe it speeds the process up (62%) and the most that say it slows them down (31%).

IMPACT OF COMPANY SIZE

More small companies (64%) believe BIM speeds shop drawing development than larger ones do (average 50%). This may be a useful benefit to attract more small contractors to BIM.

REGIONAL VARIANCES

Companies in the Midwest (60%) and West (55%) as well as the multiregional companies (56%) outnumber firms from the Northeast and the South (both 38%) that find that BIM speeds the development of shop drawings.

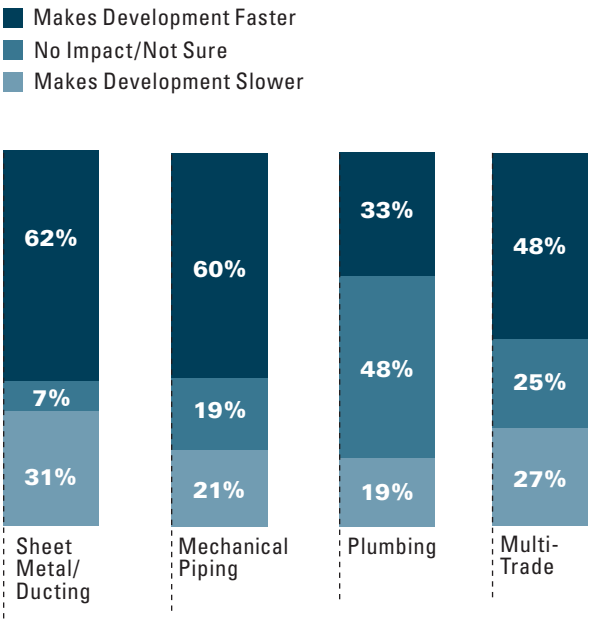
Degree of Improvement in Speed of Shop Drawing Development

Those who expressed the belief that BIM speeds shop drawings were asked to identify a percentage of improvement as shown in the chart at lower right.

Interestingly, although fewer plumbing contractors (33%) stated this belief, almost three quarters of them (72%) say it generates at least a 10% improvement.

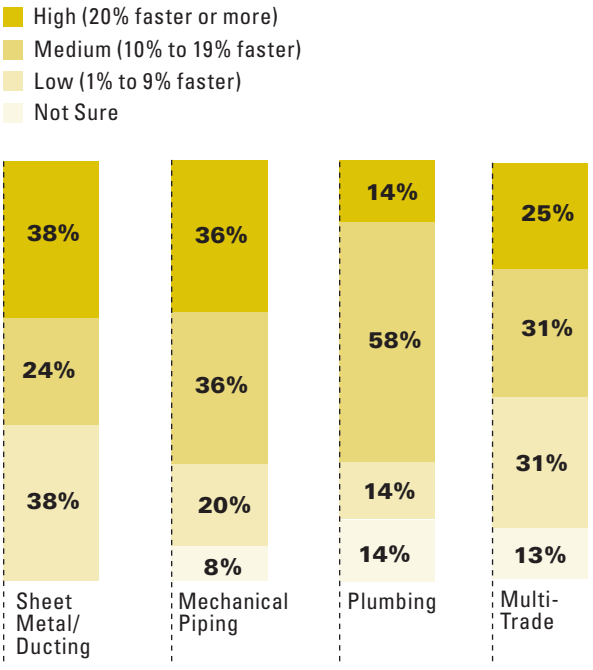
Impact of BIM on Speed of Developing Shop Drawings (Percentage Who Report Each Level of Impact)

Dodge Data & Analytics, 2020



Degree of Positive Impact of BIM on Speed of Developing Shop Drawings
(Percentage Who Report Each Level of Positive Impact)

Dodge Data & Analytics, 2020



Use of Mechanical Models

Impact of BIM on Workflows CONTINUED

Extracting Material Quantities From BIM

The chart at upper right shows that the majority of the mechanical contractors who are using BIM are also extracting material quantities from it.

To evaluate the accuracy of extracted material quantities, users were asked to compare BIM-provided quantity figures with the actual quantity of material needed (excluding scrap material). The table below reveals that, although almost half are satisfied, the findings on variances show more under than over.

Comparison	Percentage
Over 10% Higher Than Actual Need	3%
2%–10% Higher Than Actual Need	19%
Within 2% of Actual Need	47%
2%–10% Lower Than Actual Need	25%
Over 10% Lower Than Actual Need	6%

Using BIM for Estimating

The natural BIM evolution beyond extracting material quantities from a model is to import the model directly into estimating software. As shown in the chart at lower right, this is still an emerging practice:

- **Only a few companies are doing it on half or more of their projects.**
- **A greater number (29% on average) say they are doing it on less than half of their projects, and encouragingly this jumps to 46% among very large companies (over $100M).**
- **58% respond that they are not currently engaged with this practice at all.**

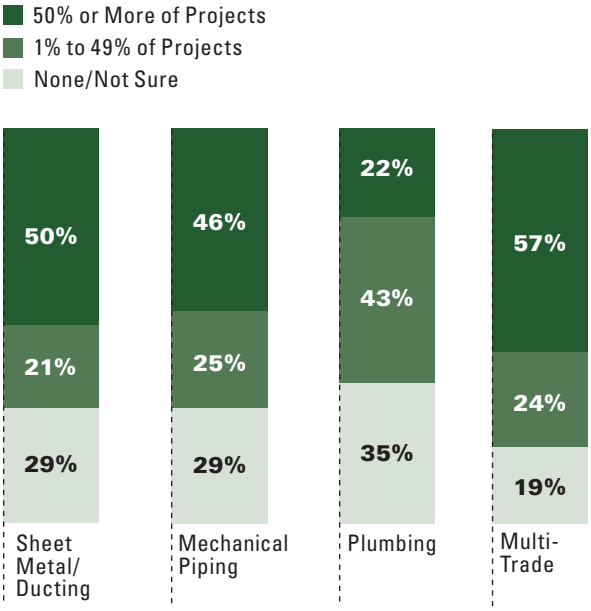
REGIONAL VARIANCES

Only 35% of the multiregional companies cite no usage of BIM for estimating compared with 87% in the Northeast. The multiregionals also lead in the percentage using it on half or more of their projects (23%) followed by companies in the West (10%).

Extracting Material Quantities From BIM

(Percentage of Projects)

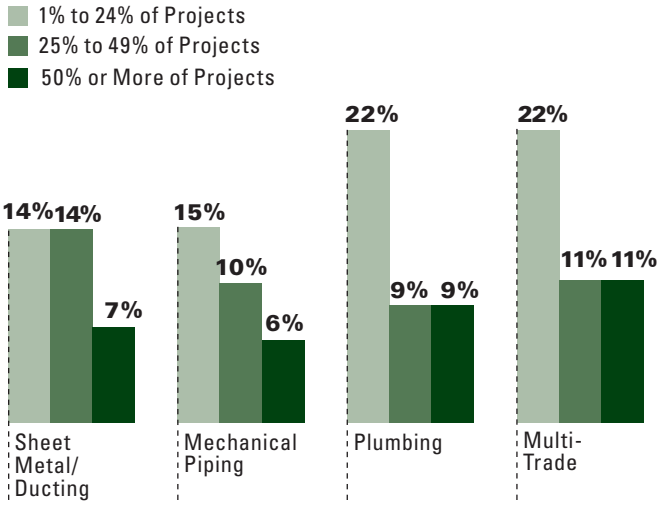
Dodge Data & Analytics, 2020



Frequency of Using BIM for Estimating

(Percentage of Projects Where BIM Is Used for Estimating)

Dodge Data & Analytics, 2020



Sourcing BIM Content

Where Mechanical Contractors Are Getting BIM Content

Mechanical and HVAC contractors who use BIM were asked to identify all the sources they utilize to get content for modeling. The chart at right shows those findings.

Most report that they are developing their own BIM content, especially sheet metal/ducting (71%) and multi-trade contractors (65%).

- **This practice is particularly popular in the West (76%) and among multiregional contractors (62%), especially when compared with Southern contractors (40%).**
- **Interestingly, many more small (62%) and very large (71%) companies practice this than do midsize (38%) ones.**

A sizable number of contractors, with the notable exception of sheet metal/ducting (21%), are also subscribing to content services, although small firms (8%) do this far less than do large (49%) and very large (53%) ones. It is also a far more common practice in the Northeast (57%) than the West (19%).

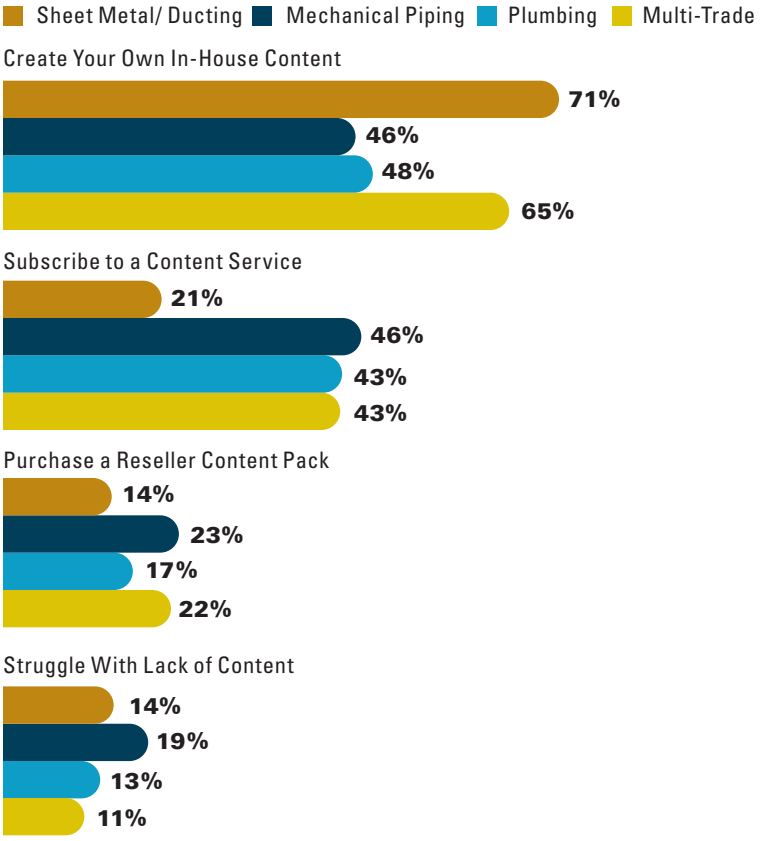
A number of resellers offer content packs but those are not cited by more than one quarter of any company-type studied.

Fortunately, only a small number of mechanical contractors (average of 15%) say they struggle with a lack of content. Not surprisingly, small companies (31%) show twice that average whereas only 6% of the very large organizations cite the same challenge.

Frequency of Sourcing BIM Content

(Percentage of Mechanical Contractors Obtaining BIM Content From Each Source)

Dodge Data & Analytics, 2020



Adoption of BIM Across the Supply Chain

While a wide spectrum of engineers and contractors are reaping the benefits of BIM in the mechanical, electrical and plumbing trades, users see significant gaps in adoption that limit its effectiveness throughout the process and the supply chain.

Most companies report that to take full advantage of BIM, all contractors should share a common data environment. However, different levels of BIM adoption and data quality issues hamper companies' ability to achieve that common data environment.

Doug Smith, director of technology at Dynamic Systems, Inc., says that between trade contractors who haven't adopted BIM and the wide mix of capabilities of those who have, DSI strives to take the lead on trade coordination whenever possible, so that it knows its standards are being met.

"In the past we've even drawn the fire protection for a general contractor—because they didn't have the capability at the time to do it—just so we didn't have any problems later," he says. "We didn't charge them for it, we just didn't want the changes later. It was out of necessity that we did it. ... That's the importance of BIM. If we can fix it on the computer before we go build it, it's well worth it."

Stacy Zerr, director of preconstruction services at The Waldinger Corporation, says she sees skepticism about the value of BIM among electrical contractors impacting their interest in adoption. "As an industry, they've been slower to adopt," she says. "And I understand [their skepticism]. As an organization, we struggle to quantify [the value of BIM], but we believe it's there." Zerr says that she believes that the best way to drive improved adoption is by owners mandating it. "It will take more owner requirements, where, to be able to bid, you have to be able to [use BIM]," she says.

Data Quality Challenges

Todd Young, vice president in the commercial business group of distributor Ferguson, says two of the main issues he sees on the path to broader BIM adoption are inconsistency of data and limited cross-trade utilization of BIM on projects. Both issues, he says, discount the value of BIM and hinder the motivation for adoption.

"A project that uses BIM may not truly be a shared environment," he says. "The contractor uses it to their own benefit, but because the owner isn't mandating constant updates or use from all trades, it discounts the effectiveness of the BIM model. A contractor uses it to detail their own work, but not to really drive cross-trade coordination."

Inconsistent data can exacerbate the problem. "Every contractor that is using BIM and creating their own dataset is limiting its effectiveness," he says. "Contractors add their own secret sauce to content files and that's a stumbling block [for cross-trade coordination]."

Young says, while many manufacturers will provide data to users for BIM content creation, that data can also be inconsistent. "It's difficult to get that consistent one data point [from manufacturers]," he says. "There has to be one data point that is shared across everyone's shared product file so you get a seamless experience."

DSI's Doug Smith says that while many of its partners have adopted BIM, he sees a lack of "quality information"—from designers through to manufacturers. DSI, which uses BIM on nearly all of its projects, has its own fabrication facility for modular and pre-assembled building elements. Many of its machines are able to fabricate from digital files, and Smith says the company is aiming to have all of its machines read digital files in the future. However, quality of data can limit its effectiveness.

"Consistency of material data is a big issue," he says. "We need to know which parts we will build from, how to build them, how much they weigh and how big they are. To do that, we have to have accurate data from the manufacturers. We find ourselves having to create accurate data from every single vendor we work with."

In fact, Smith says that DSI now considers the consistency and quality of a vendor's data when pricing a project. "If the difference between two vendors is small, we're going to pick the one we know gives us good data and stay with it," he says. "It's easier for us in the long run, if we get the same data every time. It's a huge effort to go back and change things after the fact." ■

How Mechanical Contractors Are Using BIM in the Field

Using BIM for Layout

As the chart at upper right clearly demonstrates, almost all mechanical contractors are exporting data from models to be used for layout in the field.

- **Over half of the sheet metal/ducting (64%) and multi-trade contractors (70%) are doing it on three quarters or more of their projects.**
- **Less than a quarter are merely occasional users (less than half of their projects), which further reinforces the extent of implementation.**

IMPACT OF COMPANY SIZE

Size is a factor, in that 85% of very large contractors (over $100M) engage in this on over half their projects compared with only 46% of small organizations (under $10M).

REGIONAL VARIANCES

Region has an impact as well. 87% of Southern companies do it on the majority of their projects versus only 61% of Northeastern ones.

Using BIM Robotic Total Stations for Layout in the Field

Respondents were asked about their frequency of using robotic total stations for layout in the field. The findings align with those above but show slightly lower rates of implementation.

IMPACT OF COMPANY SIZE

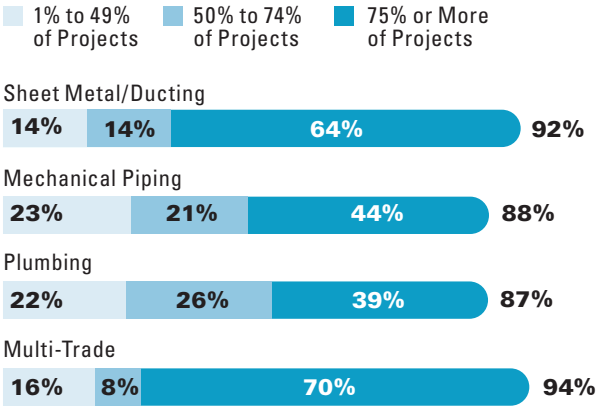
Size is a factor here also, with 70% of large and very large contractors using this approach on half or more of their projects compared with 45% of midsize companies and just 30% of small ones.

REGIONAL VARIANCES

Regionally, the Midwest shows the lowest implementation with 48% of contractors citing use on half or more of their projects, while 87% of Southern companies report that activity level.

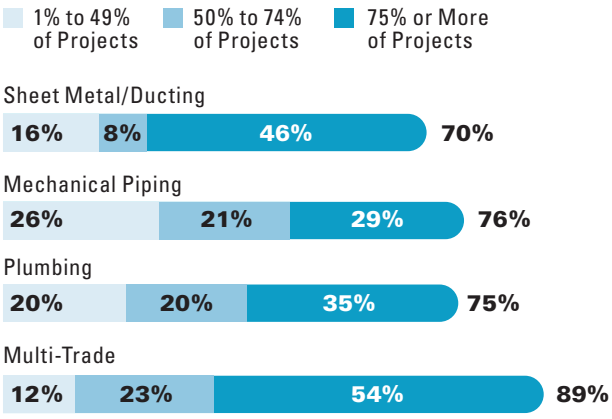
Exporting Data From Models for Layout in the Field (Percentage of Projects Where Model Data Is Exported for Layout)

Dodge Data & Analytics, 2020



Use of Robotic Total Stations for Layout in the Field (Percentage of Projects Where Robotic Total Stations Are Used for Layout)

Dodge Data & Analytics, 2020



Impact of Using BIM on RFIs

Reducing RFIs is a positive benefit for everyone on a project team. The respondents were asked to rate the positive impact of BIM on four aspects related to RFIs. The chart at right shows the percentage of each type of company surveyed who rated the positive impact to be high or very high (compared with none, low or moderate).

In general, between one quarter and half of contractors rate the positive impact of BIM to be high or very high, with the notable exception of plumbing contractors (average 6%) and to a lesser degree sheet metal/ducting companies (average 28%). The most benefits appear to accrue to mechanical piping (average 36%) and multi-trade companies (average 38%).

IMPACT OF COMPANY SIZE

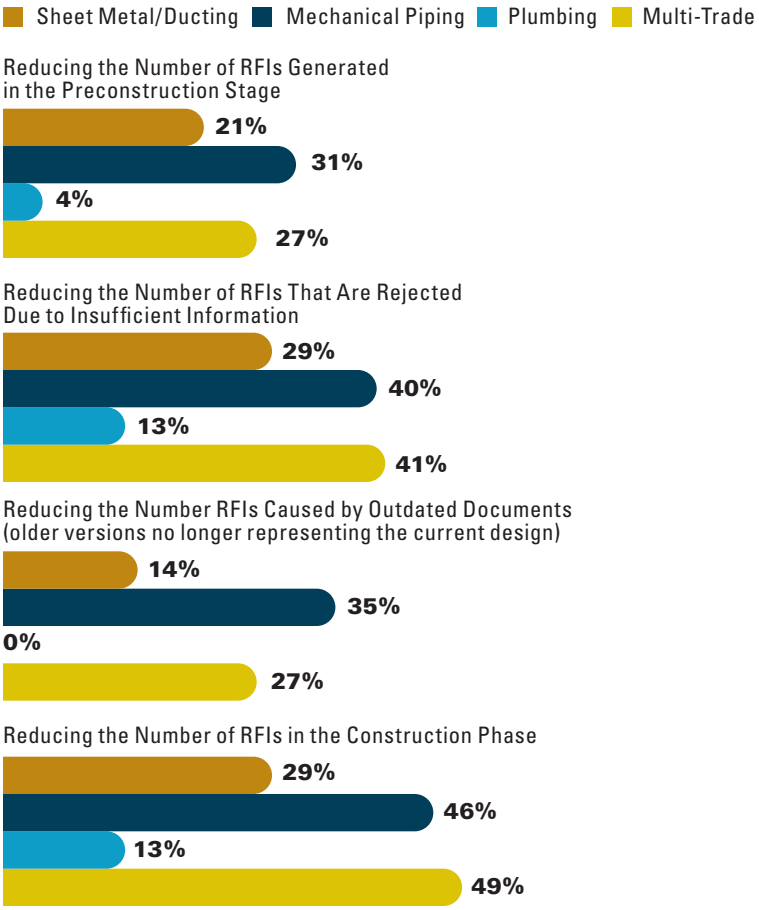
Across the four benefits in the chart, 35% of large and 46% very large companies report high or very high positive impact from BIM, while just 14% of medium and 13% of small companies agree.

REGIONAL VARIANCES

The benefits of BIM related to RFIs shows less variation between regions than many of the other aspects of BIM included in this study do, hopefully indicating a consistent pattern of achievable improvements.

Impact of BIM on RFIs
(Percentages Reporting High or Very High Positive Impact From BIM)

Dodge Data & Analytics, 2020



Impact of BIM on Key Metrics of Project Performance

Respondents were asked to rate the positive impact of BIM on the three metrics shown in the chart at right. The percentages represent how many of each company-type gave high or very high ratings.

Mechanical piping and multi-trade contractors are the most positive and are very closely aligned in their responses, with about half weighing in for the cost and synchronization benefits. Schedule improvement appears more difficult to achieve.

IMPACT OF COMPANY SIZE

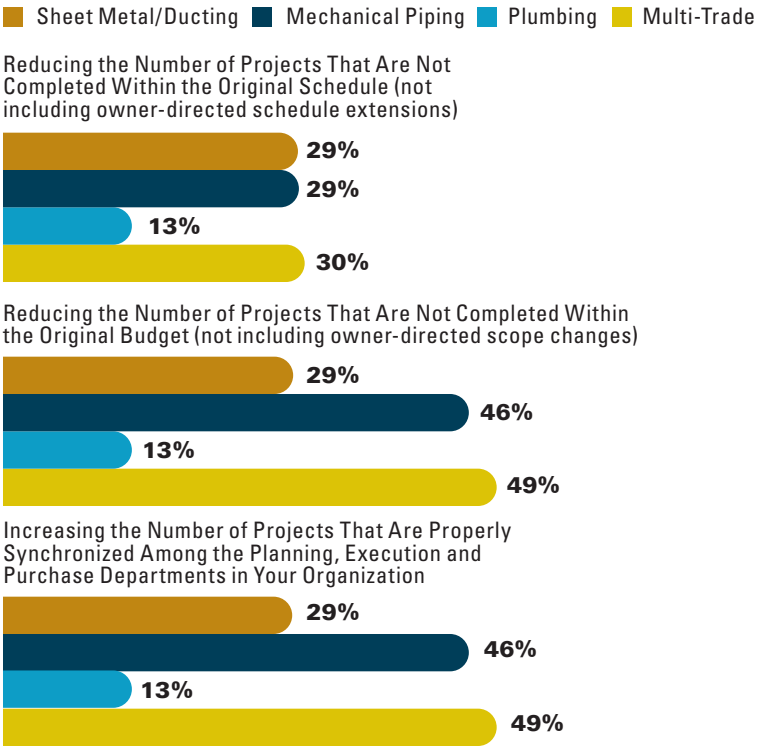
Where on average 39% of large and very large companies cite high or very high positive impact of BIM across all three of these metrics, none (0%) of the small contractors and only 11% of the midsize ones give similar ratings. This imbalance is most extreme with the benefit of proper internal synchronization between planning, execution and purchasing, where half (50%) of very large (over $100M) and over one third (37%) of large ($50M to $100M) companies cite high or very high impact from BIM, versus none (0%) of the small companies (under $10M).

REGIONAL VARIANCES

The Northeast and Midwestern regions average 20% across the three metrics compared with 35% in the South and among multiregional contractors.

Impact of BIM on Project Performance
(Percentages Reporting High or Very High Positive Impact From BIM)

Dodge Data & Analytics, 2020



Impact of Using BIM for Layout

The respondents who use BIM for layout were asked to rate the positive impact of BIM on that process compared with their previous methods. The chart at right shows the percentage of each type of company surveyed who rated the positive impact to be high or very high (compared with none, low or moderate).

IMPACT OF COMPANY SIZE

As with many of the benefits of BIM studied in this report, larger companies generally report higher occurrence levels.

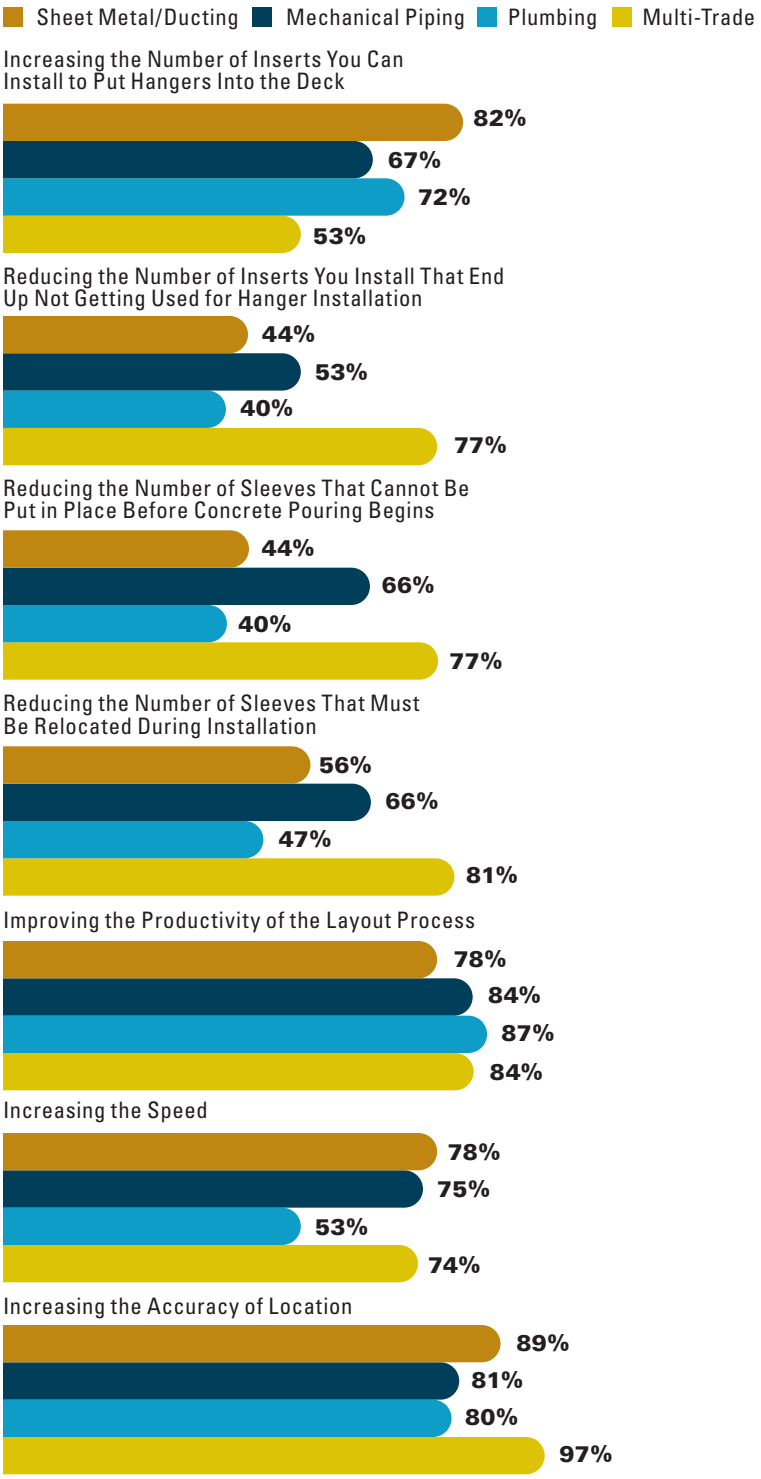
- **Averaging across the first four benefits in the chart related to inserts and sleeves, 76% of large and very large companies cite a high or very high beneficial impact of BIM compared with just 36% of the small companies surveyed.**
- **Almost all (96%) very large contractors cite high or very high positive impact on productivity versus only 57% of small ones.**
- **Improved accuracy from using BIM is more universally enjoyed, with 86% of small contractors and 93% of the very large ones reporting high or very high positive impact.**

REGIONAL VARIANCES

A high or very high productivity gain is identified by 95% of Midwestern contractors, versus only 76% among Northeastern ones. Similar variances between these two regions are found with increased speed (77% versus 59%) and increased accuracy (91% versus 76%).

Impact of BIM on Layout Activities (Percentages Reporting High or Very High Positive Impact From BIM)

Dodge Data & Analytics, 2020



The Drive for BIM Standards

Years of a dearth of content have forced contractors to create custom libraries for their models, but this has led to content that is challenging to use in a shared environment. Association groups are leading efforts to tackle this challenge by establishing standards for mechanical BIM content.

MCAA

This year, the Mechanical Contractors Association of America. is rolling out a new standard that aims to define the roles of US contractors and manufacturers within the BIM platform. Tim Moormeier, president of U.S. Engineering and co-chair of the MCAA committee that established the standard, says the initiative was a natural outgrowth of the association's web-based *Labor Estimating Manual*. The existing WebLEM offered a database of manufacturers' products with labor units for each piece. Leveraging the existing database, MCAA aims to also provide content for each listing in both ITM and RFA formats, without allowing a broad mix of custom content on the site, so it saw an opportunity to create a standard for content that it aims to become an industry-wide standard in the US.

Moormeier notes that use of detailed BIM content for fabrication is a major driver for new standards, as companies are increasingly dependent on reliable content for use in fabrication. "At the majority of mechanical shops, contractors are modeling with content that is not dimensionally accurate. They get to the shop and then literally the shop foreman pulls a pencil out and marks the dimensions of the actual valves they bought."

Additionally, a lack of consistent naming conventions has been a significant hurdle."For [objects] to connect together," he says, "they have to have certain naming conventions, and a configuration that allows this collection of parts to fit together the way they [should]."

Under the standard, MCAA states that manufacturers are responsible for: dimensional accuracy for spooling and prefabrication; software joining methodology; and reporting data for material procurement. Contractors are responsible for: specifics with each contractor's technology environment; labor values; and material pricing values.

Moormeier says he expects manufacturers to embrace the new standards. "Manufacturers have been asked for years to provide content at contractor and engineer requests," he says. "But they might create content for one company, and then another wants it in a different format… We are giving manufacturers some confidence that if they offer content one way, they will be done with it."

AMCA

In Australia, the Air Conditioning & Mechanical Contractors' Association has been working on standards for more than a decade. As BIM adoption was still in its early stages, Sumit Oberoi, executive director of the AMCA, says the association started its efforts by standardizing basic content. "We started the initiative because there wasn't standardization around what generic content would look like," he says. "If the consulting engineers use their own libraries and the mechanical guys have something else, it makes it really complicated."

The goal, he says, was to get the government and clients to require specification of its BIM MEP standard and what deliverables would look like for anything related to building services. With advancements in use of building data for operations, Oberoi says AMCA now sees greater demand for standards. "Clients are requesting more data now, and they want it structured," he says.

As with MCAA, Oberoi says AMCA is increasingly focused on bringing more manufacturers into its discussions about content standards. It is also working on building an industry library with manufacturer content available for download that its members can use.

Oberoi notes that the Australian marketplace has been uniquely successful in establishing standards due to a high level of collaboration between engineers and contractors. Contractors also see standards as a benefit, not as something that could eliminate the competitive advantage of a custom solution. "The mentality here has always been to compete on innovation and business practices," he says. "But we don't compete on standards because we want some clarity. Everything from naming conventions all the way through. Why would we compete on those sorts of things? There's no intellectual property involved." ■

Digital Twins

Digital twins are seen in the building and infrastructure markets as an opportunity for communication, coordination and analytics, including the performance of building systems.

In the evolution of design, construction and operational building data, the concept of a digital twin for the built environment is gaining traction. At its basic level, a digital twin is defined as a digital representation of a physical asset, typically connected to sensors placed at key locations throughout the actual asset that transmit functional and operational data to the digital twin for analysis, often in real time.

Early Engagement by Owners

David Fink, digital manager at Henning Larsen Architects, says the role of building owners and operators is critical when creating a digital twin. "You have to get the people running the building involved from the start. They know what type of data they want out of this and what sensors they need to get that data. If you wait and build a system without getting them involved, you risk creating something useless."

Fink maintains that the information needed to design a building and its systems "flows in reverse," starting with the vision for an operational building. "Holistically, we need to start at the end to plan the beginning. We need to say, 'How will the operator use this data downstream?'" By establishing a detailed plan for a building's future operations, Fink says designers can make more informed decisions about what needs to be measured, the types and quantities of sensors needed, and where they should be placed.

The necessity to place sensors throughout a building could require an extra level of coordination with contractors to make sure the design is properly planned and executed. Fink notes that sensors can be placed in areas that are difficult to access and that power needs to be supplied to sensors. "It requires an extra level of planning for how you get data from the sensors back to the system and record and compile the data," he says. "It's not only the mechanical contractor involved, but also the electrical contractor."

Fink recently worked with Alejandro Mata, automation manager at Ramboll in Denmark, to test the creation of a digital twin in an existing building. The team navigated the challenges of working with an older building management system that couldn't create data as well as other systems where the building's "data was locked up." In the end, the team created a custom solution, including building its own open source sensors to gather shareable data.

While the project, described in more detail in the Autodesk University webinar "Digital Twin: Bringing MEP Models to Life," did successfully exchange data with the digital twin model, it also highlights the challenges of creating a digital twin within existing systems.

"The challenge is that normally design engineers do the conceptual phase, and they create the normal MEP system they are used to, then the constructor makes all of the sensors, then at the end they try to match together all of the sensors with the old model," Mata says. "We wanted to show [in the webinar] that it is very important to start thinking about the digital twin at the beginning."

Single View of Truth Over Time

For a digital twin to be effective, the data needs to be continuously updated through the sensors that connect to the digital twin, says Adam Klatzkin, vice president of iTwin services at Bentley Systems.

He says the primary building blocks for a digital twin are components, context and chronology—allowing for in-depth analysis based on performance over time. Klatzkin notes that although a digital twin is a singular concept, it leverages data federated from a multitude of sources. As such, he notes that any platform for a digital twin needs to be built on a foundation of openness.

"A digital twin needs to take into account all information—regardless of where it's coming from—that is relevant to the asset and is connected with visualization and analytics," Klatzkin says. "It's not a single source of truth, it's a single view of truth." ■

Data: Mechanical Fabrication

Model-Driven Fabrication for
Mechanical and HVAC Construction

Frequency of BIM for Prefabrication

Mechanical and HVAC contractors were asked to identify the percentage of mechanical assemblies for which they use BIM data to prefabricate. The chart at upper right shows the findings by each of the company-types surveyed.

Over three quarters of all the contractors report prefabricating some percentage of their mechanical assemblies.

- **Multi-trade contractors show the highest overall participation (91%).**
- **Sheet metal/ducting contractors have the highest number (36%) that prefabricate assemblies on 75% or more of their projects.**

REGIONAL VARIANCES

Prefabrication of half or more of a company's assemblies is reported more frequently in the West (70%) and South (57%) than the Northeast (36%) or Midwest (28%).

Type of Assemblies That Are Being Prefabricated

Respondents were asked about the percentage of their projects on which they prefabricate ductwork assemblies and/or plumbing/piping assemblies. The chart at lower right shows the findings.

The high percentages doing this on half or more of their projects suggest that the prefabrication of these assemblies is well on its way to becoming standard practice in the industry.

IMPACT OF COMPANY SIZE

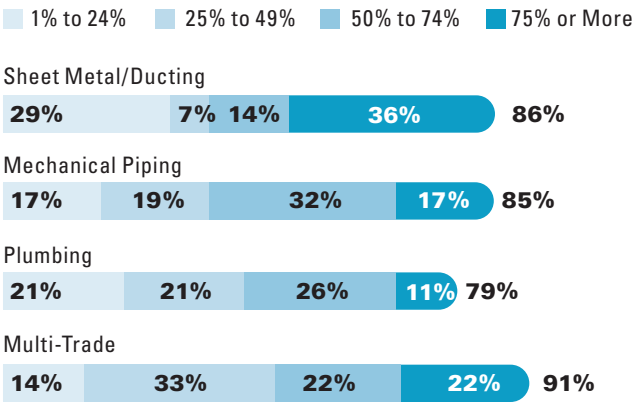
An average of 63% of the very large companies (over $100M) report prefabricating these assemblies on over half of their projects versus only 26% of small and midsize companies (less than $50M).

REGIONAL VARIANCES

On average, 61% of Western and 54% of Southern and multiregional contractors report this high level of activity, compared with just 34% in the Midwest and 26% in the Northeast.

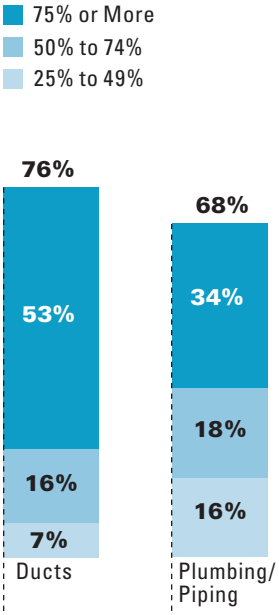
Frequency of Using BIM to Prefabricate Mechanical Assemblies (Percentage of Mechanical Assemblies Where Model Data Is Used for Prefabrication)

Dodge Data & Analytics, 2020



Frequency of Using BIM to Prefabricate Duct and Plumbing/Piping (Percentage of Projects Where Model Data Is Used for Prefabrication)

Dodge Data & Analytics, 2020



Overview of Impact of BIM on Key Metrics

Impact of Model-Based Prefabrication on Mechanical Construction Performance

Mechanical and HVAC contractors who are using BIM to prefabricate were asked about its positive impact on seven key project performance metrics compared with site construction:

- Worker Safety
- Material Waste
- Labor Costs
- Site Logistics Costs
- Schedule Performance
- Purchase of Extra Pipes and Fittings
- Quality of Installed Work

The matrix at right shows a color-coded summary of the percentages of respondents who say they experience an improvement because of their use of BIM for prefabrication. The following pages provide detail on each metric.

IMPACT OF COMPANY SIZE

While the overall responses shown in the findings at right are very supportive for the value of BIM-based prefabrication, responses vary significantly by company size as shown in the matrix below.

Average Percentage of Contractors Reporting an Improvement on All Seven Metrics From Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	59%	78%	84%	92%

REGIONAL VARIANCES

More encouragingly, there is relatively little regional variation.

Positive Impact on Key Performance Metrics From Using BIM for Prefabrication Compared With Site Construction

(Percentages of Each Type of Contractor Citing Improvement)

	Sheet Metal/ Ducting	Mechanical Piping	Plumbing	Multi-Trade
Worker Safety	67%	83%	73%	82%
Material Waste	92%	90%	80%	94%
Labor Costs	83%	88%	80%	94%
Site Logistics Costs	75%	70%	73%	70%
Schedule Performance	83%	85%	80%	85%
Purchase of Extra Pipes and Fittings	83%	85%	80%	88%
Quality of Installed Work	83%	78%	93%	94%

Impact of BIM on Worker Safety

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication either makes worker safety better or much better.

IMPACT OF COMPANY SIZE

Size is a meaningful differentiator for improved safety performance.

Percentage of Contractors Reporting an Improvement in Worker Safety Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**63%**	**79%**	**77%**	**84%**

REGIONAL VARIANCES

Only 67% of companies in the South see safety improvement, while 89% of those in the West do.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

Unlike many of the other findings in this study, plumbing contractors are extremely positive about the impact on safety.

IMPACT OF COMPANY SIZE

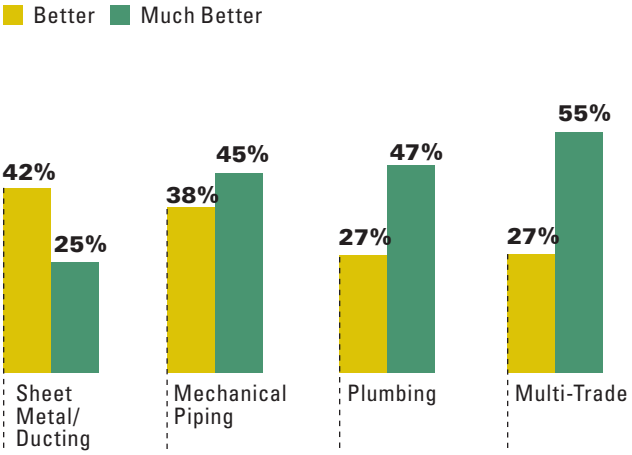
While somewhat fewer companies with less than $50M in revenue report 5% or greater improvement than larger ones, the industry is relatively consistent about this benefit across all sizes of companies.

REGIONAL VARIANCES

94% of Western and 92% of Northeastern companies report over 5% improvement, yet only 61% of multiregional contractors concur.

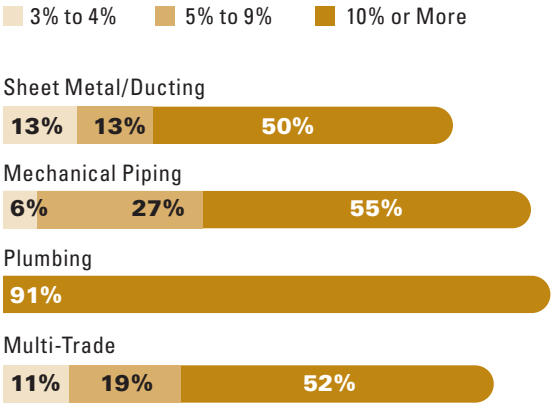
Worker Safety: Positive Impact From Using BIM to Prefabricate Versus Site Construction (Percentage of Users Reporting Improvement Compared With Site Construction)

Dodge Data & Analytics, 2020



Degree of Positive Impact on Worker Safety (Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Material Waste

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication reduces material waste.

IMPACT OF COMPANY SIZE

Size has a significant impact, in that all (100%) very large companies cite improved material waste versus just 63% of small ones.

Percentage of Contractors Reporting an Improvement in Material Waste Because of Using Model-Based Prefabrication

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	63%	83%	94%	100%

REGIONAL VARIANCES

92% or more of multiregional companies and those in the Midwest and South see improved material waste, yet just 78% of those in the Northeast do.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

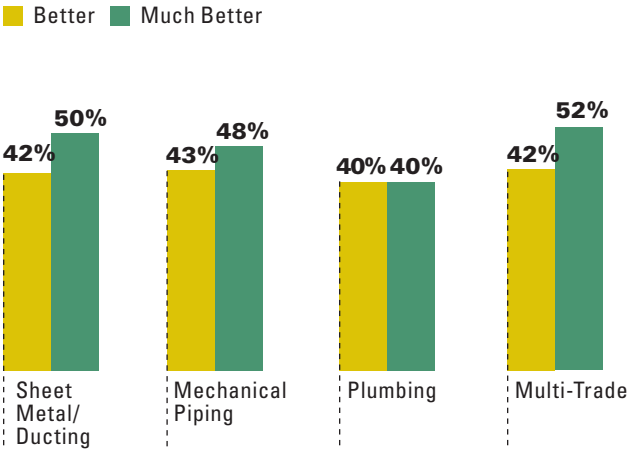
91% of very large companies report 5% or better improvement, compared with between 60% and 66% of all others.

REGIONAL VARIANCES

The Midwest is relatively low (68%), while more multiregional (82%) and Western (80%) contractors report 5% or better improved performance.

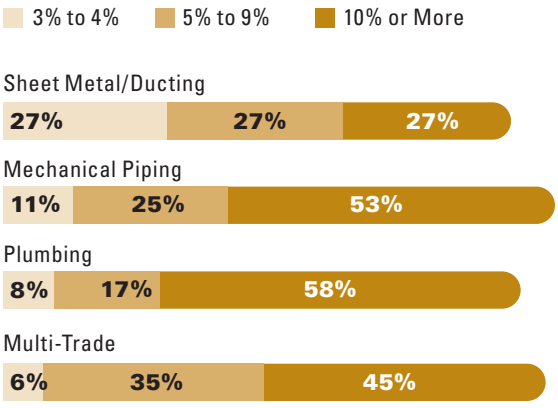
Material Waste: Positive Impact From Using BIM to Prefabricate Versus Site Construction (Percentage of Users Reporting Improvement Compared With Site Construction)

Dodge Data & Analytics, 2020



Degree of Positive Impact on Material Waste (Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Labor Cost

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication reduces labor cost.

IMPACT OF COMPANY SIZE

Size is once again an impactful factor in the benefit of reduced labor cost, with just 63% of the smallest companies surveyed citing an improvement versus 84% or more for all larger organizations.

Percentage of Contractors Reporting an Improvement in Labor Cost Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**63%**	**92%**	**84%**	**94%**

REGIONAL VARIANCES

Midwestern (97%), multiregional (96%) and Southern (92%) companies outweigh those in the Northeast (83%) and the West (78%).

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

Only 68% of midsize companies ($10–$50M) report 5% or better improvement in labor cost, compared with between 80% and 87% of all others.

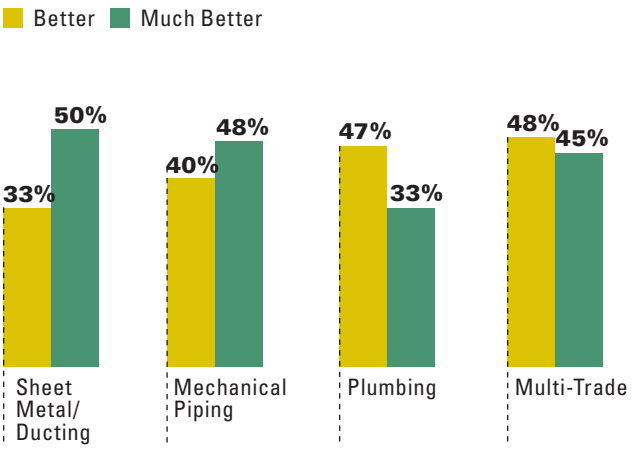
REGIONAL VARIANCES

93% of Western contractors cite 5% or better improvement, far outpacing the Midwest and South (73% each).

Labor Cost: Positive Impact From Using BIM to Prefabricate Versus Site Construction

(Percentage of Users Reporting Improvement Compared With Site Construction)

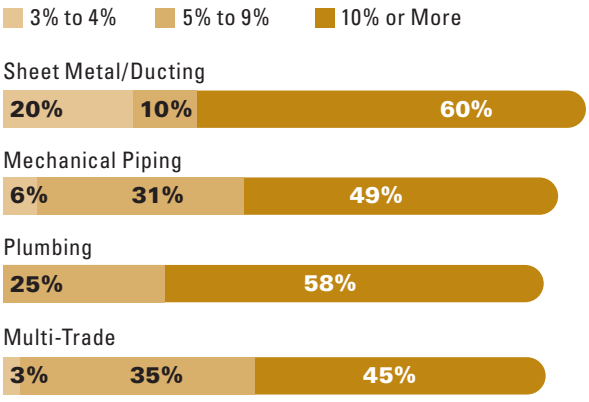
Dodge Data & Analytics, 2020



Degree of Positive Impact on Labor Costs

(Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Site Logistics Costs

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication reduces the costs related to site logistics.

IMPACT OF COMPANY SIZE

Only 63% of small and midsize companies report lower site logistics costs from their use of model-based prefabrication compared with over 70% of larger contractors.

Percentage of Contractors Reporting an Improvement in Site Logistics Cost Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**63%**	**63%**	**71%**	**81%**

REGIONAL VARIANCES

The Midwest and West (each 83%) greatly exceed the Northeast (50%) and the South (58%) in those who report a positive impact from BIM on site logistics cost.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

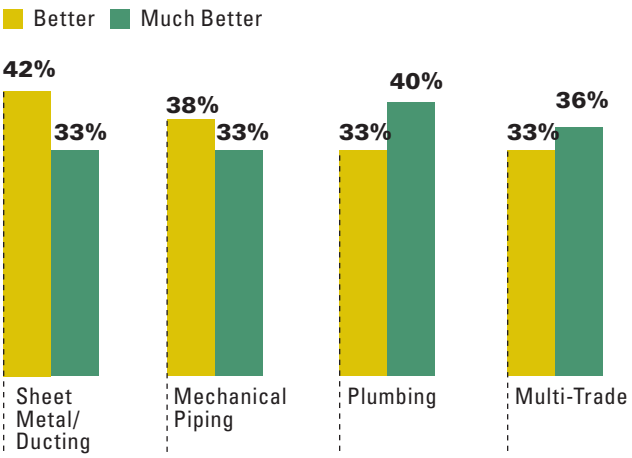
Only 58% of midsize companies ($10–$50M) report 5% or better improvement in site logistics costs, compared with 80% of small contractors and 89% of very large ones.

REGIONAL VARIANCES

94% of Western contractors and 92% in the Northeast cite 5% or better improvement, far outpacing the South (75%), Midwest (71%) and the multiregionals (61%).

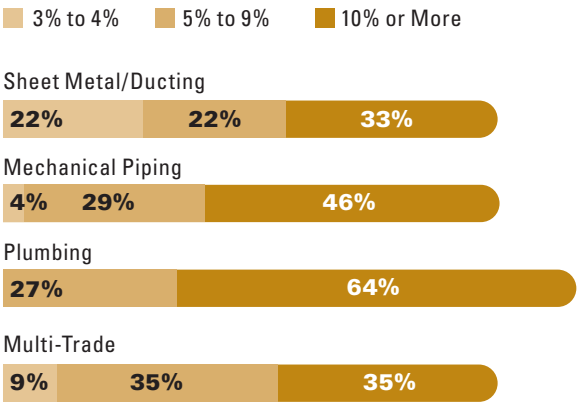
Site Logistics Costs: Positive Impact From Using BIM to Prefabricate Versus Site Construction (Percentage of Users Reporting Improvement Compared With Site Construction)

Dodge Data & Analytics, 2020



Degree of Positive Impact on Site Logistics Costs (Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Schedule Performance

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication improves schedule performance.

IMPACT OF COMPANY SIZE

The larger companies again dominate the group reporting this benefit.

Percentage of Contractors Reporting an Improvement in Schedule Performance Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	63%	71%	84%	100%

REGIONAL VARIANCES

The Northeast (78%) significantly lags the South (92%) with the other regions in a tight range of 83% to 87%.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

The percentage of small companies (80%) reporting at least a 5% schedule improvement is nearly equal to the share of very large ones (84%), suggesting that this benefit may be attractive to bring more small contractors to BIM and model-driven prefabrication.

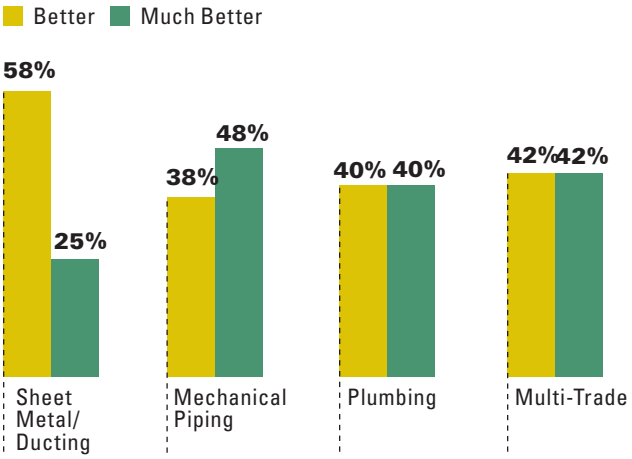
REGIONAL VARIANCES

The multiregionals (85%) and the West (80%) notably exceed the South (73%), Midwest (71%) and Northeast (64%) in the percentage that report at least a 5% schedule improvement.

Schedule Performance: Positive Impact From Using BIM to Prefabricate Versus Site Construction

(Percentage of Users Reporting Improvement Compared With Site Construction)

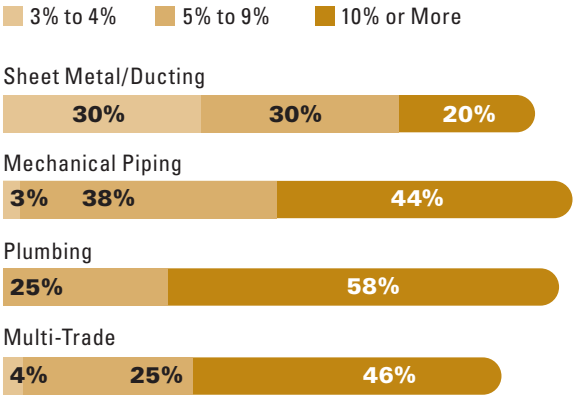
Dodge Data & Analytics, 2020



Degree of Positive Impact on Schedule Performance

(Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Reducing the Need to Purchase Extra

Pipes and Fittings

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication reduces the instance of purchasing extra pipes and fittings.

IMPACT OF COMPANY SIZE

This benefit shows the greatest difference between small companies and their larger peers.

Percentage of Contractors Reporting an Improvement in Purchase of Extra Pipes and Fittings Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**38%**	**79%**	**90%**	**94%**

REGIONAL VARIANCES

All respondents from the South (100%) report this benefit whereas only 72% from the West and 78% from the Northeast do the same.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

80% of the very large companies report at least a 5% improvement in the purchase of extra pipes and fittings, while the other size tiers range between 61% and 68%.

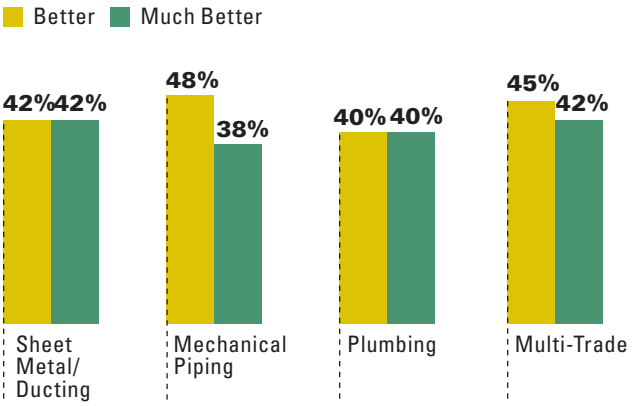
REGIONAL VARIANCES

The West (92%) leads in reporting at least a 5% improvement, while the Northeast (50%) significantly lags.

Purchase of Extra Pipes and Fittings: Positive Impact From Using BIM to Prefabricate Versus Site Construction

(Percentage of Users Reporting Improvement Compared With Site Construction)

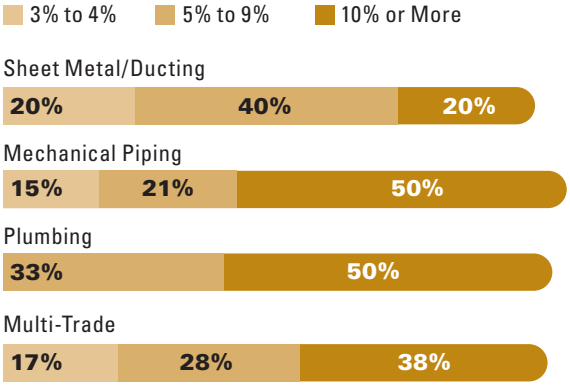
Dodge Data & Analytics, 2020



Degree of Positive Impact on Purchase of Extra Pipes and Fittings

(Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Quality of Installed Work

The chart at upper right shows the percentages of each company-type that believe BIM-based prefabrication improves the quality of installed work.

IMPACT OF COMPANY SIZE

This benefit shows more notable gaps between tiers of company sizes.

Percentage of Contractors Reporting an Improvement in the Quality of Installed Work Because of Using Model-Based Prefabrication, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**63%**	**79%**	**87%**	**94%**

REGIONAL VARIANCES

While slightly more of the multiregional contractors (91%) report improved quality of installed work because of model-based prefabrication, all other respondents fall within a tight range (83% to 86%) indicating a widespread enjoyment of this important benefit.

The Degree of Improvement

Respondents who say they see an improvement were asked to identify the percentage range that best represents the impact. The chart at lower right shows the findings.

IMPACT OF COMPANY SIZE

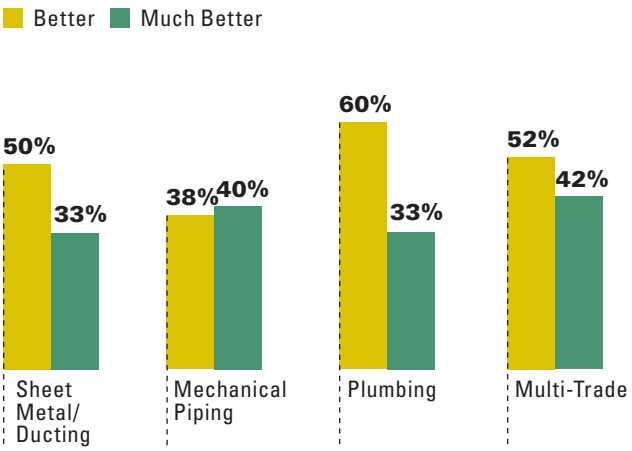
An average of 82% of the large and very large companies report at least a 5% improvement in the quality of installed work. Unfortunately, only an average of 62% of small and midsize contractors report similar strong results.

REGIONAL VARIANCES

The West (87%) leads in reporting at least a 5% quality improvement, while the South (70%), Northeast (73%) and Midwest (76%) are lower.

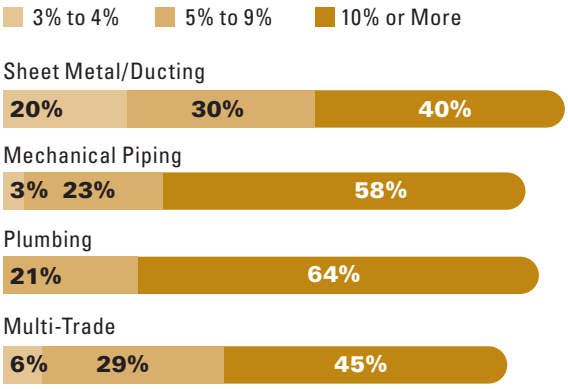
Quality of Installed Work: Positive Impact From Using BIM to Prefabricate Versus Site Construction (Percentage of Users Reporting Improvement Compared With Site Construction)

Dodge Data & Analytics, 2020



Degree of Positive Impact on Quality of Installed Work (Percentage Reporting Each Degree of Improvement)

Dodge Data & Analytics, 2020



Impact of BIM on Modularizing Multiple Services

Into Single Racks

The prefabrication of multidiscipline racks is providing significant benefits to the industry. The chart at upper right shows the percentage of respondents that are engaging in this practice on their projects.

IMPACT OF COMPANY SIZE

Significantly more of the larger companies are engaging in this activity.

Percentage of Contractors Modularizing Multiple Services Into Single Racks, by Size

Annual Revenue	Less Than $10M	$10M to Less Than $50M	$50M to Less Than $100M	$100M or More
Frequency	**23%**	**53%**	**71%**	**91%**

REGIONAL VARIANCES

More multiregional contractors (81%) report engaging in this activity, but the others fall within a range of 59% to 67%, so it is reasonably widespread.

Installation Time Savings From Prefabricating Multiservice Racks

Respondents who engage in this activity were asked about the degree to which it reduces installation time. The chart at lower right shows the results.

IMPACT OF COMPANY SIZE

About 40% of large and very large companies report more than a 10% installation time improvement, and 18% report more than a 20% time savings.

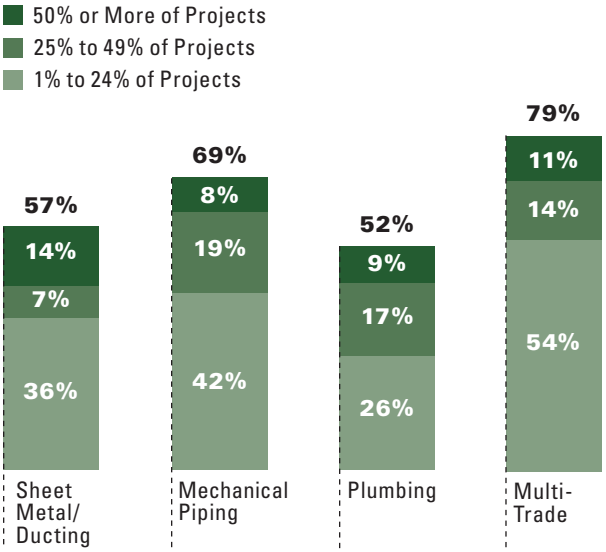
REGIONAL VARIANCES

The West (57%) leads in reporting over a 10% installation time improvement, while multiregionals (44%) the Northeast (40%), Midwest (32%) and South (30%) range somewhat lower.

Frequency of Using BIM to Modularize Multiple Services Into a Single Rack System

(Percentage Reporting Degree of Frequency)

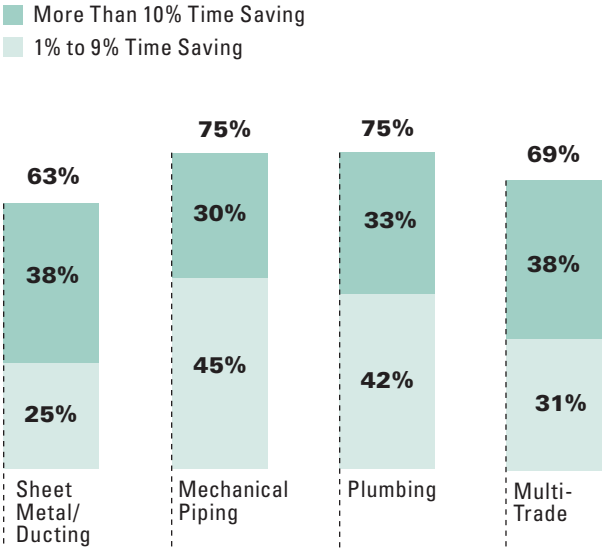
Dodge Data & Analytics, 2020



Time Savings From Using BIM to Modularize Multiple Services Into a Single Rack System

(Percentage Reporting Degree of Time Savings)

Dodge Data & Analytics, 2020



Artificial Intelligence, Machine Learning and BIM

Artificial intelligence and machine learning have the potential to help mechanical contractors get much more out of their use of mechanical models.

To understand the kinds of opportunities mechanical contractors can expect as artificial intelligence (AI) applications begin to boost the power of BIM, it's essential first to get a broad handle on what AI and machine learning (ML) are. AI is technology that enables a computer to take in information, interpret it and decide on a goal-oriented response. ML, a branch of AI, is an automated method of data analysis in which software's capability improves progressively in response to iterative exposure to data.

Like electricity, AI is a general purpose technology. It can be applied to almost any set of circumstances, and new applications will continue to develop over time. So, "if you're motivated to automate a problem, there is a way to do it," says Bruce Orr, chief data scientist at ProNovos Construction Analytics. "The question is whether it's economically viable."

Automations in the Pipe

An example of one of the most economically viable applications of ML—and a top pick among industry observers for the next major advance in BIM for the mechanical sector—is software that automates the task of expanding the digital data associated with "like" objects in a model. When an object is first placed in a project's BIM, the modeler applies basic data, such as system, location, name, type and class. As the model develops, increasingly detailed data is added to the object, and more and more "like" objects are replicated throughout. And while all 2-inch gate valves, say, will have certain data in common, they will also have data—such as pressure class, for example—that is unique to their location in the project. "Today much of this unique data is provided through manual editing by the professional responsible for that particular element or construction phase," says David Quigley, managing director of Emerson Research, a consultancy focused on MEP contractors and their technologies, "but it's a natural fit for AI."

Other examples of potential efficiencies from AI occur in the functionality gap between BIM and 2D drawings. For example, while BIM has long facilitated quantity take-offs, AI-enabled software can now generate them from a pdf. And software under development may soon be able to auto route MEP from a single-line diagram, generate a 3D model from that same diagram and even configure services automatically in a ceiling plenum in 3D—within an existing BIM model or from 2D drawings.

Sector-Wide Change

Efficiencies like these have the potential to take a load off mechanical contractors in their day-to-day operations. Beyond that, AI-based innovations capable of systematizing the expertise that a firm's BIM models embody may also have implications for the sector as a whole. Because human expertise is central to construction problem-solving, contractors are often limited to the region their experts can serve. However, "computers can capture knowledge and turn it into a tool," says Brett Young, co-founder of M2x.AI, a software company that applies ML and advanced computation to preconstruction 2D and 3D deliverables. "The ability to build custom tools that let you break out of your geography is going to be the prime benefit of AI for BIM in the MEP sector." He predicts that systematizing contractors' expertise will enable increasing specialization and market reach.

In the meantime, however, to take advantage of the efficiencies expected to emerge from applying AI to BIM, a majority of MEP contractors still have some ground to cover with BIM itself. "Throughout the history of BIM, successful implementation comes down to the expertise of individual AEC firms, and the degree to which their expertise is demonstrated in the quality of their models—and translated into results in their projects," says Quigley. "AI will certainly be a major part of the next frontier of BIM, but there remain a number of firms who will need to continue to focus on integrating BIM practices and methodologies, and building internal expertise." ■

Data: Benefits and Challenges of BIM

Key BIM Benefits and the Obstacles to Expanding Use of BIM

The following pages show the most important benefits that mechanical and HVAC contractors are receiving from their use of BIM, and the top obstacles they face as they try to expand their usage of it.

Benefits of BIM for Mechanical Construction

The survey explored two types of benefits: those that accrue to projects and those that more directly impact the BIM user's company. For each category, respondents were shown a list of eight benefits and although they may be enjoying all of them, they were asked to select just the three that are most important to either their projects or their company. The full lists are shown below (in alphabetical order).

PROJECT-RELATED BENEFITS

- Better collaboration between stakeholders
- Greater understanding of design intent
- Improved cost performance
- Improved fabrication process
- Improved quality of installed work
- Improved schedule performance
- Reduced errors
- Reduced waste

COMPANY-RELATED BENEFITS

- Attracting and retaining talent
- Better utilization of resources
- Enhanced industry reputation
- Improved safety performance
- Increased labor productivity
- Increased profitability
- Maintaining repeat business
- Winning new work

Obstacles for Mechanical and HVAC Contractors in Expanding Their Use of BIM

A similar approach was taken in the survey to determine the top obstacles that are facing mechanical and HVAC contractors as they seek to expand their engagement with BIM.

Two categories were established for the obstacles; 10 that are primarily people-related, and nine other, non-people-related challenges. Again, respondents were asked to select the three from each category that are generating the biggest challenges for them in expanding their company's use of BIM. The full lists are shown below (in alphabetical order).

PEOPLE-RELATED OBSTACLES

- Designers not sharing their BIM
- General contractors not sharing their BIM
- Issues related to using field personnel in the office
- Keeping BIM-skilled employees
- Lack of available manpower to create BIM models
- Lack of senior management buy-in to the value of BIM
- Motivating the staff to use more BIM
- Other stakeholders on my projects are not using BIM
- Other trades are not sharing their BIM
- Training needs for employees

OTHER (NON-PEOPLE-RELATED) OBSTACLES

- Cost of hardware
- Cost of software
- Lack of adequate quality BIM content
- Lack of BIM standards for my type of work
- Lack of fabrication level detail content
- Lack of support for BIM from general contractors
- Lack of support for BIM from other important trades
- Poor implementation of existing standards
- Poor quality BIM use by other stakeholders

Findings Organized By Company-Type

The following pages show these findings organized by the four types of mechanical and HVAC construction companies that participated in this research so that the unique perspectives of each can be understood and appreciated.

- Sheet Metal/Ducting
- Mechanical Piping
- Plumbing
- Multi-Trade (no single trade representing more than 50% of the work)

Key Benefits and Obstacles for

Sheet Metal/Ducting Contractors

Top Project-Related Benefits of BIM for Sheet Metal/Ducting Contractors

The chart at upper right shows the top five benefits of BIM identified by sheet metal/ductwork contractors.

Reduced waste garners top three designation from half of the sheet metal/ductwork companies. This is an important metric because sheet metal work done onsite traditionally generates large amounts of waste.

At 36% they lead the other company-types in greater understanding of design intent, whose average across all respondents is only 18% and whose low is 8% (from multiregional companies).

Among the project-related benefits that did not make it into the top five, improved schedule performance is notable because only 7% of sheet metal/ductwork contractors include it among their top three compared with the average of 31% across all respondents, and the very strong 49% shown by multi-trade contractors. This suggests that there can be specific work done to leverage BIM more effectively so that sheet metal/ductwork contractors can enjoy the schedule improvement benefits being reported by others.

Top Company-Related Benefits of BIM for Sheet Metal/Ducting Contractors

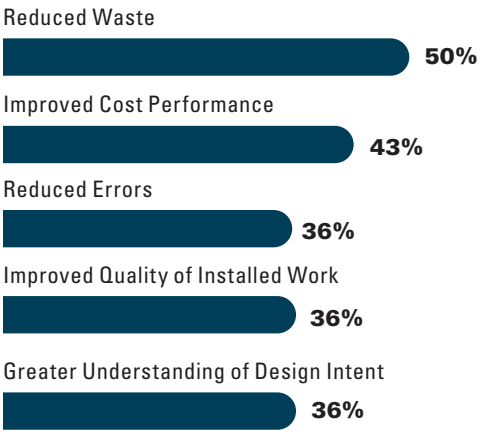
The chart at lower right shows the top company-related benefits.

Far more sheet metal/ductwork contractors (57%) cite winning new work as a top three benefit than the other types of contractors who average just 23%.

Conversely, even though increased labor productivity is their second-most popular benefit at 50%, that is notably lower than all other contractor-types, for whom the average is 67%.

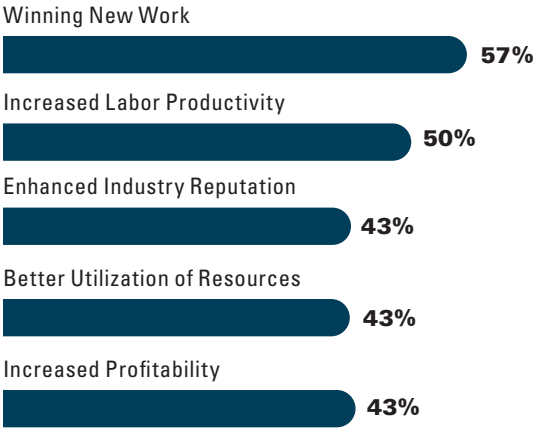
Sheet Metal/Ducting Contractors: Top Project Benefits of BIM
(Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Sheet Metal/Ducting Contractors: Top Company Benefits of BIM
(Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Sheet Metal/Ducting Contractors CONTINUED

Top People-Related Obstacles to Sheet Metal/Ducting Contractors Expanding Their Use of BIM

The chart at upper right shows the top five people-related obstacles.

Sheet metal/ducting contractors (50%) lead all the other company-types (average 38%) in their first-place challenge of other stakeholders not using BIM.

Only multi-trade contractors (54%) exceed sheet metal/ducting firms (50%) for their other first-place obstacle: lack of available manpower to create BIM models.

The biggest percentage difference between sheet metal/ducting companies and the others is with issues related to using field personnel in the office. At 43% this far outpaces the 10% from mechanical piping and just 4% from plumbing contractors. The multi-trade firms (22%) share their pain to some degree, but this appears to be another opportunity for close attention to a challenge unique to this trade.

Good news for sheet metal/ducting companies is that although training needs for employees ties for fourth place among their challenges at 36%, the other company-types average 56% and the worst is 65% (plumbing).

Other Obstacles to Sheet Metal/Ducting Contractors Expanding Their Use of BIM

The chart at lower right shows the top five most important among non-people-related obstacles.

As above, sheet metal/ducting contractors (50%) lead all the other company-types (average 34%, lowest 22%) in their first-place challenge of poor BIM use by other stakeholders. And that pattern holds for their other first-place obstacle, lack of support for BIM from other important trades, where their 50% outranks the average of 37% among the piping, plumbing and multi-trade contractors.

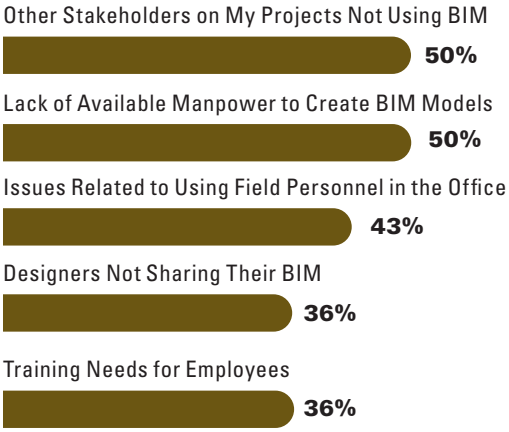
Continuing the theme, their 36% for lack of support for BIM from general contractors also leads the others, who average just 25%.

The findings clearly show that sheet metal/ducting contractors have a unique set of benefits and challenges.

Sheet Metal/Ducting Contractors: Top People-Related Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of 10)

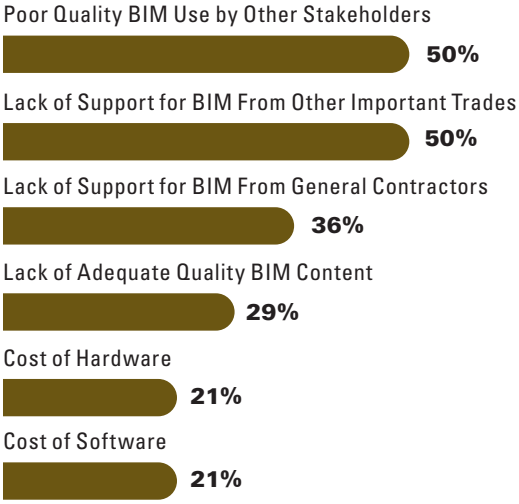
Dodge Data & Analytics, 2020



Sheet Metal/Ducting Contractors: Other Top Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of Nine)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for

Mechanical Piping Contractors

Top Project-Related Benefits of BIM for Mechanical Piping Contractors

The chart at upper right shows the top five benefits of BIM identified by mechanical piping contractors.

Mechanical piping companies lead all others in citing improved cost performance, which ties for first place (46%), compared with an average among other company-types of 38%.

At 10%, improved quality of installed work is their least selected benefit, significantly below the average of 35% among the other three company-types, and the highest of 43% (plumbing). This may reveal an opportunity to examine how BIM can help mechanical piping contractors enjoy the quality improvement being experienced by the other trades.

Top Company-Related Benefits of BIM for Mechanical Piping Contractors

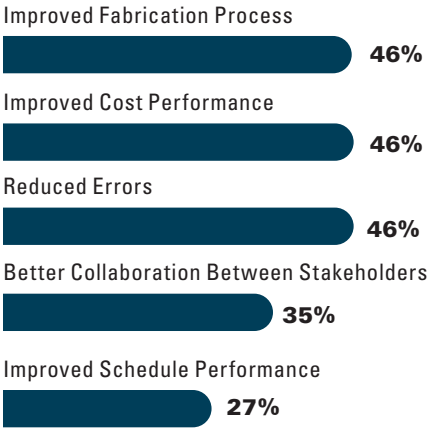
The chart at lower right shows the top company-related benefits.

The best finding for mechanical piping contractors is that at 65%, their top company-related benefit of increased profitability leads others who just average 43%.

Mechanical Piping Contractors: Top Project Benefits of BIM

(Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

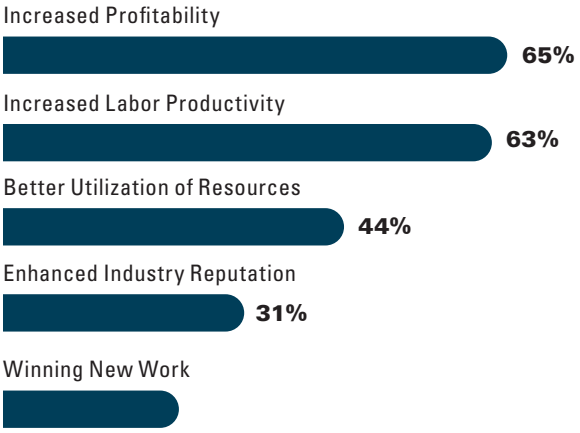
Dodge Data & Analytics, 2020



Mechanical Piping Contractors: Top Company Benefits of BIM

Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Mechanical Piping Contractors CONTINUED

Top People-Related Obstacles to Mechanical Piping Contractors Expanding Their Use of BIM

The chart at upper right shows the top five people-related obstacles.

For the most part, the percentages of mechanical piping contractors associated with each of the people-related obstacles shown in the chart are in line with the average across all companies. Variations include:

- **Lack of senior management buy-in to the value of BIM is cited by a quarter of mechanical piping contractors, yet only an average of 8% by all others. This may point to a need for engagement and education at senior executive levels at these organizations.**
- **On a positive note, mechanical piping and plumbing contractors tie for the lowest rating (35%) for the challenge of stakeholders on my projects not using BIM. The highest rating for that comes from sheet metal/ducting companies (50%).**

Other Obstacles to Mechanical Piping Contractors Expanding Their Use of BIM

The chart at lower right shows the top five most important among non-people-related obstacles.

Mechanical piping contractors lead the other trades in three of the six obstacles appearing in the chart.

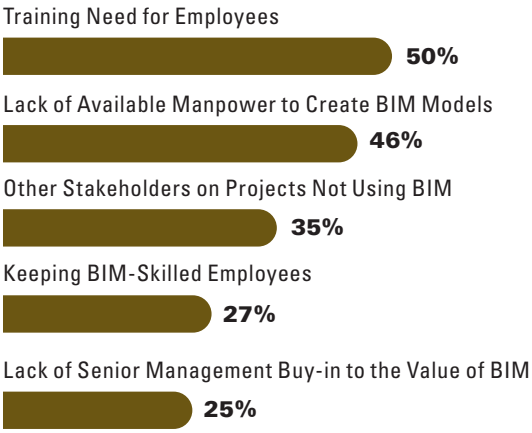
- **Lack of adequate quality BIM content (31%), where the average of all the others is 17%.**
- **Cost of software (31%), where the average of all the others is 19%.**
- **Poor implementation of existing standards (25%), where the average of all the others is 15%.**

These all point to issues more uniquely experienced by mechanical piping contractors than their peers in other trades, and worthy of specific attention.

Mechanical Piping Contractors: Top People-Related Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of 10)

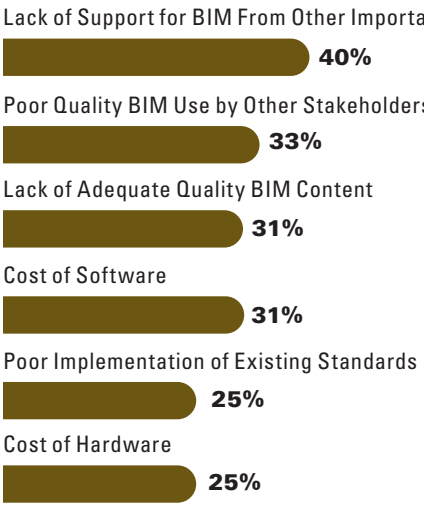
Dodge Data & Analytics, 2020



Mechanical Piping Contractors: Other Top Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of Nine)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Plumbing Contractors

Top Project-Related Benefits of BIM for Plumbing Contractors

The chart at upper right shows the top five benefits of BIM identified by plumbing contractors.

Plumbing contractors lead all other company-types in their top two most selected people-related benefits:

- **Better collaboration between stakeholders (48%), where all others average 33%.**
- **Improved quality of installed work (43%), where all others average 25%.**

On the converse, at 26% they are lowest for improved fabrication process, for which the average of the other company-types is 47% and the high is 68% (multi-trade). This suggests there is improvement to be made in this area that would benefit plumbing contractors.

Top Company-Related Benefits of BIM for Plumbing Contractors

The chart at lower right shows the top company-related benefits.

Plumbing contractors lead (or tie) the others on two of their top benefits

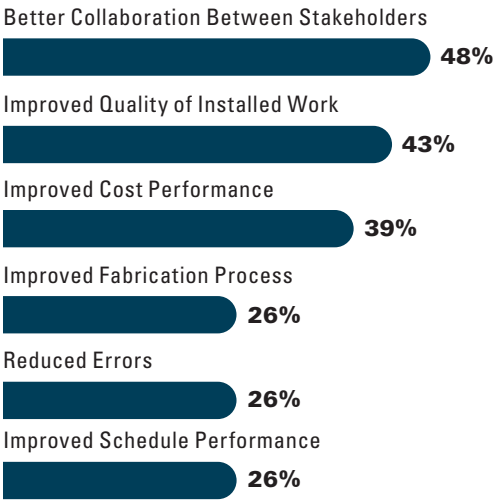
- **Enhanced industry reputation (43%), where all others average 33%.**
- **Maintaining repeat business (30%), where all others average 22%.**

Unfortunately, at 39%, plumbing contractors are lowest for increased profitability, which averages 52% across the others and shows a high of 65% (mechanical piping).

Plumbing Contractors: Top Project Benefits of BIM

(Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

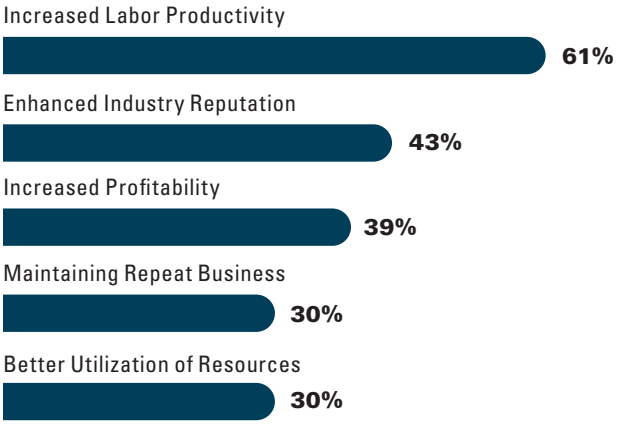
Dodge Data & Analytics, 2020



Plumbing Contractors: Top Company Benefits of BIM

(Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Plumbing Contractors CONTINUED

Top People-Related Obstacles to Plumbing Contractors Expanding Their Use of BIM

The chart at upper right shows the top five people-related obstacles.

As a positive perspective on their obstacles, plumbing contractors are among the lowest for two of their top five people-related challenges.

- **Lack of available manpower to create BIM models (43%), where all others average 50% and the highest is 54% (multi-trade).**
- **Other stakeholders on my projects are not using BIM (35%), where all others average 43% and the highest is 50% (sheet metal/ducting).**

On the negative side, plumbing contractors register the highest number (65%) who identify training need for employees as a top challenge. Others average 44% with a low of 36% (sheet metal/ducting). This represents an opportunity to develop resources that will address this problem effectively and bring their level of need in line with the others.

Other Obstacles to Plumbing Contractors Expanding Their Use of BIM

The chart at lower right shows the top five most important among non-people-related obstacles.

Plumbing contractors are again among the lowest for two of their top five other challenges.

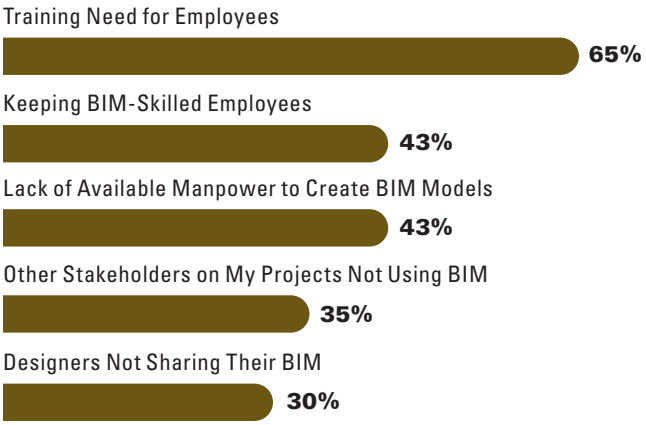
- **Lack of support for BIM from other important trades (30%), where all others average 44% and the highest is 50% (sheet metal/ducting).**
- **Poor quality BIM use by other stakeholders (22%), where all others average 45% and the highest is 50% (sheet metal/ducting).**

But they are the highest for their top challenge of software cost (48%) where others average just 25%, as well as for lack of BIM standards for my type of work (22%) where others average only 10%.

Plumbing Contractors: Top People-Related Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of 10)

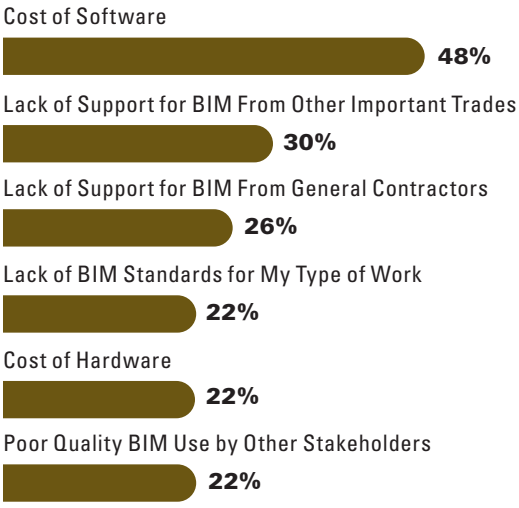
Dodge Data & Analytics, 2020



Plumbing Contractors: Other Top Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of Nine)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Multi-Trade Contractors

Top Project-Related Benefits of BIM for Multi-Trade Contractors

The chart at upper right shows the top five benefits of BIM identified by sheet metal/ductwork contractors.

Multi-trade contractors lead all others by a significant margin in their top two most frequently selected people-related benefits.

- **Improved fabrication process (68%), where all others average 33% and the low is 26% (plumbing).**
- **Improved schedule performance (49%), where all others average 21% and the low is 7% (sheet metal/ducting).**

However, at 32% they lag the field in improved cost performance, where the average of the others is 43% and the highest is 46% (mechanical piping).

Top Company-Related Benefits of BIM for Multi-Trade Contractors

The chart at lower right shows the top company-related benefits.

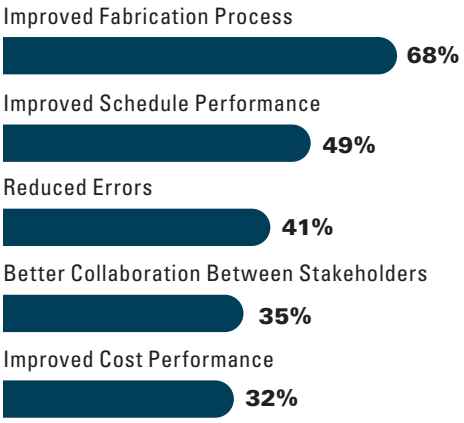
Multi-trade companies best the others again in two of their top benefits from this category.

- **Increased labor productivity (76%), where all others average 57% and the low is 50% (sheet metal/ducting).**
- **Better utilization of resources (51%), where all others average 39% and the low is 30% (plumbing).**

Slightly on the downside, their fifth-place benefit of enhanced industry reputation (27%) somewhat lags the others who average 39%, with two leaders at 43% (plumbing and sheet metal/ducting). They also trail the field in improved safety performance (27%) and maintaining repeat business (19%).

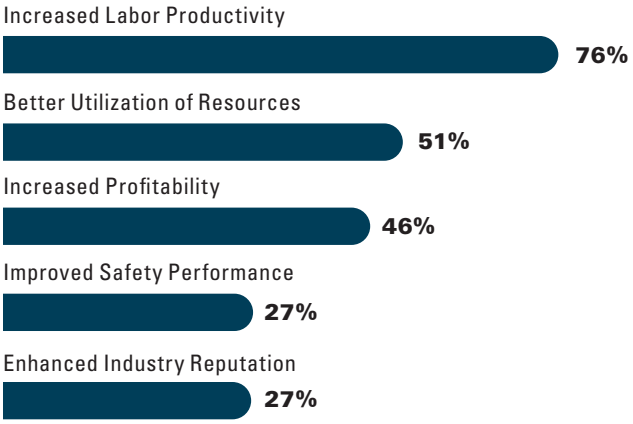
Multi-Trade Contractors: Top Project Benefits of BIM (Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Multi-Trade Contractors: Top Company Benefits of BIM (Percentage Selecting Each to Be Among Their Top Three Benefits From a List of Eight)

Dodge Data & Analytics, 2020



Key Benefits and Obstacles for Multi-Trade Contractors CONTINUED

Top People-Related Obstacles to Multi-Trade Contractors Expanding Their Use of BIM

The chart at upper right shows the top five people-related obstacles.

At 54%, multi-trade contractors lead in their need for manpower to create BIM models, where others average 46% and the lowest is 43% (plumbing).

On a positive note, they are the lowest (11%) for the issue of designers not sharing their BIM, where others average 28% with the highest rating of 36% (sheet metal/ducting).

Other Obstacles to Multi-Trade Contractors Expanding Their Use of BIM

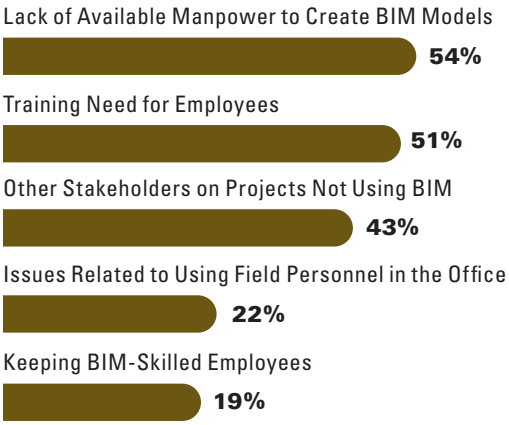
The chart at lower right shows the top five most important among non-people-related obstacles.

Multi-trade contractors are generally in line with the average percentages across all companies surveyed in their selections of the top non-people-related challenges.

Multi-Trade Contractors: Top People-Related Obstacles to Expanding Use of BIM

(Percentage Selecting Each to Be Among Their Top Three Obstacles From a List of 10)

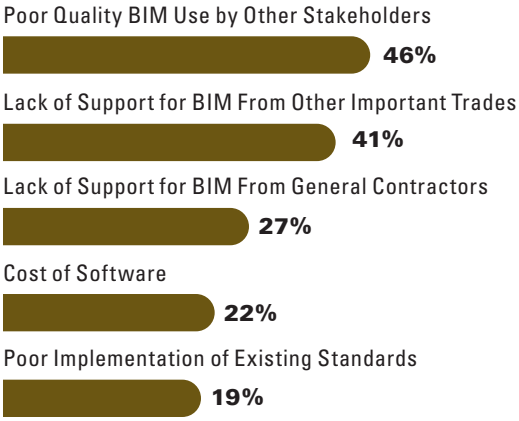
Dodge Data & Analytics, 2020



Multi-Trade Contractors: Other Top Obstacles to Expanding Use of BIM

(Percentage Selecting Each to be Among Their Top Three Obstacles From a List of Nine)

Dodge Data & Analytics, 2020



BIM Onsite: Extending the Value of the Model

Mechanical and HVAC contractors report two major ways in which they are currently getting value from BIM onsite: better visualization and improved data gathering onsite for real-time information.

Specialty contractors often have more skin in the game than anyone else on the team. On some project types—a hospital, for example—the mechanical and electrical trades alone may carry more than half the project value. So, in looking for ways to help mitigate that risk, leading firms are extending the useful life of their BIM model, and continuing to leverage its value onsite.

Among the most significant impacts of BIM onsite—perhaps ironically—is the technology's potential for diverting scope offsite: fewer welders, sheet metal workers, sprinkler fitters and associated materials congesting the building site make for a safer and more productive workplace.

For work that does take place onsite, mechanical contractors are extending the value of BIM in two key ways. The first and most direct way replaces 2D design documentation with enhanced visualization in the field. The second and longer-lasting way makes use of site-generated data to improve project management.

Enhanced Visualization

With cell phones, tablets and laptops, as well as augmented and virtual reality technologies, site personnel now have direct access to documentation of existing and proposed conditions in 3D. They can stand in a space and see what the finished job will look like. "In the past we would create a lot of 2D views to communicate what were basically installation instructions—isometrics, elevations and additional details," says Kiley Johnson, detailing department manager at Western Allied Mechanical. Now the firm's BIM team selects model views floor by floor, isolating ductwork or pipework as appropriate, and exports them to a cloud-based platform where installation teams can access them from the jobsite. "With site crews having access to the 3D model, whether it be through a 3D pdf or other format," says Johnson, "we've gotten rid of most of those drawings."

Beyond providing a more vivid set of instructions, onsite access to BIM facilitates coordination with other trades. Myriad building components jostling to fit into tighter and tighter spaces on increasingly complex projects means that contractors need to understand not only their own scope, but that of others as well. Being able to pull out a tablet and refer to the model on the spot allows workers to resolve clashes then and there, and being able to communicate with a design engineer at his or her workstation in real time—instead of through an RFI process or at weekly meetings—speeds the work. "BIM improves communication with the team onsite and helps them get ahead of potential change orders," says Josh Bone, a construction technologist with a focus on the MEP sector, who is now director of industry innovation with the National Electrical Contractors Association. "We're hearing, on average, three times faster in the coordination process with BIM."

There's a growing recognition, however, that the quality of the models coming from design teams often falls short of what's needed onsite. As owners compress schedules, and architects and engineers scramble to meet deadlines, coordination during the design process is slipping. Ceilings may be modeled at the wrong thickness, or even the wrong height, creating a world of trouble down the line. "Construction documents continue to get worse," says Bone, "and that's impacting mechanical contractors greatly." He suggests one solution is to involve trade partners earlier in the design process, when their site-based expertise can inform the design, enrich the BIM model with more fully resolved systems and help mitigate not only their own risk, but the rest of the project team's too.

Use of Site-Generated Data to Improve Project Management

In the second major method of deriving value from BIM onsite, contractors are supplementing their models with data and analytics to track workflows, improve decision-making and estimate with greater accuracy. At Western Allied, for example, each item in a model is independently tracked in the field,

and its status in the model changed to indicate when it has been installed. Status information can then be exported to a spreadsheet that generates a percentage of ductwork weight or piping footage hung in hours worked.

Similarly at U.S. Engineering, a work breakdown structure that is consistent from job to job subdivides projects into work packages, and, for each package, the company extracts data from the model to structure costing, scheduling and field payroll. At a finer grain, U.S. Engineering also leverages the data associated with each item in the model to monitor earned value, progress and production.

"For the first time in my career I've actually seen the collection and utilization of this data simplified," says Tim Moormeier, president of U.S. Engineering Company Holdings. This new window into onsite production rates in real time and at a work-package level offers quantifiable insights into the causes and impacts of workflow volatility. It also facilitates mid-course corrections as eventualities arise, and provides hard evidence of what those eventualities cost. "All of a sudden owners are very interested in what the data from similar jobs can tell you about manpower, production rate and schedule if they execute a job a certain way," Moormeier says.

Another technology used by sheet metal company Worcester Air Conditioning uses the BIM model to allow workers onsite to track their progress using an app on an iPad and provide real-time accurate data on what is being installed on the project. They first started using this technology on a large, complex high school project in Somerville, Mass. Bob Mahoney, outside superintendent at Worcester Air Conditioning, explains that they chose this project to implement the program because they had to do monthly submittals for billing on this project.

One advantage of using this software as opposed to just doing mockups from images drawn from BIM is that it can capture the elements of work being done in 3D. Mahoney explains, "It's capturing layers. If we have duct under duct, before [using 2D mock-ups], they would highlight the top duct and you would think both of them were in because you couldn't see the bottom duct. [The new software] captures exactly what's installed." For weekly and monthly meetings, he reports, they are able to see exactly how the job is going and which areas may be slipping off schedule, instead of discovering it much later in the process.

While they have not precisely documented the savings they have seen yet, Mahoney is certain that the system is saving them time and money. The report it creates in five minutes previously took eight hours, he estimates, and he would create that report once a month on over a dozen jobs. He also believes the real time field data monitoring will be a big cost saver over time.

So far, however, the use of BIM and its associated technologies among mechanical contractors onsite is "a lot lower than people want to think," says David Francis, chief technical officer at ICT Tracker, an augmented reality-based construction productivity software company. Francis also serves as national chairman of the Associated General Contractors of America BIM Forum MEP Group and as the MEP group lead on the AGC's Level of Development Specification Committee. In large part, he says, the widespread underutilization of BIM beyond prefabrication results from the fact that "with so many options and solutions out there, a lot of companies—especially small and midsize ones where money may be tight—are afraid to make a move."

Companies that are successful in generating additional value from BIM onsite are able to dedicate staff to understanding and vetting technologies, implementing them and then continuing to champion, maintain and run them. "You have to dedicate resources to helping you figure out how to improve your business," says Dave Pikey, vice president of corporate technology at The Hill Group, where a dedicated tech team has long been part of the firm's approach to improvement. Reluctant though companies may be to invest in overhead tech personnel, he says, "it's tough to create value from nothing." Ideally, software companies will alleviate this burden soon with increasingly relevant and integrated solutions.

Meanwhile, however, the industry has a long way to go, both in terms of the percentage of trade contractors that are bringing fully developed models to their projects, and the widespread availability of integrated software products for leveraging additional value from those models. "But it's going to get there," says Moormeier. "There's tremendous value in it." ■

Data: Mechanical Benchmarks

Baseline Metrics for Specific Challenges

The survey asked mechanical and HVAC contractors to identify their experience with 12 specific occurrences and project factors that cause inefficiencies or problems on their BIM projects. The key objectives of this part of the study are to:

- **Identify how frequently these occur so that companies can benchmark their own experiences against their peers.**
- **Understand which are most worthy of time and resources to address.**
- **Establish a baseline so that future research can track progress against them.**

Occurrences and Factors Studied

The first six topics studied are specific to mechanical construction:

- **The percentage of sleeves that cannot be put in place before concrete pouring begins.**
- **The percentage of sleeves that get relocated during installation.**
- **The percentage of inserts that are typically put into the deck but not used during hanger installation.**
- **The percentage of modularized racks that are not aligned with the adjacent rack onsite.**
- **The percentage of BIM-based prefabricated spool assemblies that are inaccurate and have to be:**
  - Reworked onsite
  - Brought back to the fab shop to be fixed

The other six are factors that can affect everyone on a project team (in alphabetical order):

- **Conflicting information**
- **Incorrect material onsite**
- **Late arrival of spool assemblies onsite**
- **Late information**
- **Unavailable information**
- **Waiting because of delays by other trades**

Sleeves

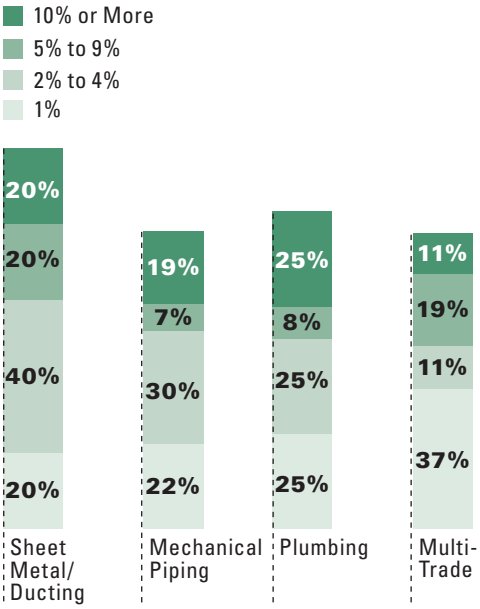
The charts at right show the findings for the two questions related to sleeves.

Contractors in the West and Midwest report high frequency of these sleeve-related challenges far more than other regions.

These challenges are consistently experienced across all company sizes.

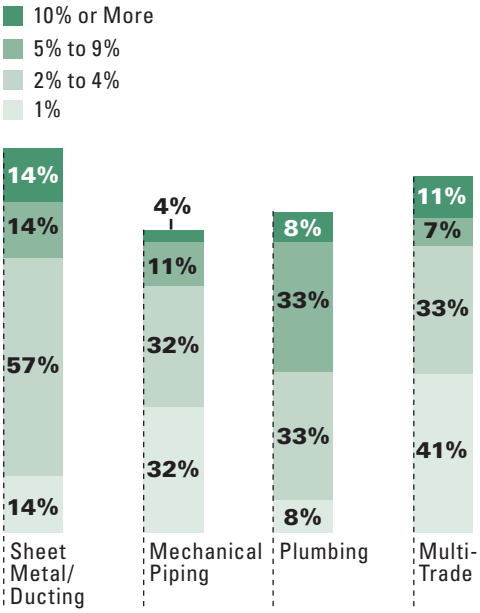
Percentage of All Sleeves That Cannot Be Put in Place Before Concrete Pouring Begins

Dodge Data & Analytics, 2020



Percentage of All Sleeves That Get Relocated During Installation

Dodge Data & Analytics, 2020



Unused Inserts

The chart at upper right shows the percentages of contractors by company-type who report not using hanger inserts that are put into the deck and the percentage of inserts that go unused when they do that.

Reporting of 5% or greater percentages of installed but unused inserts comes more often from contractors in the Northeast (64%) and Midwest (63%). Those in the West (38%) are notably lower.

BIM experience also lessens the frequency, as only 53% of contractors who do at least half their work in BIM report 5% or greater occurrence, compared with 69% of those who do less than half their projects with BIM.

Misaligned Modularized Racks

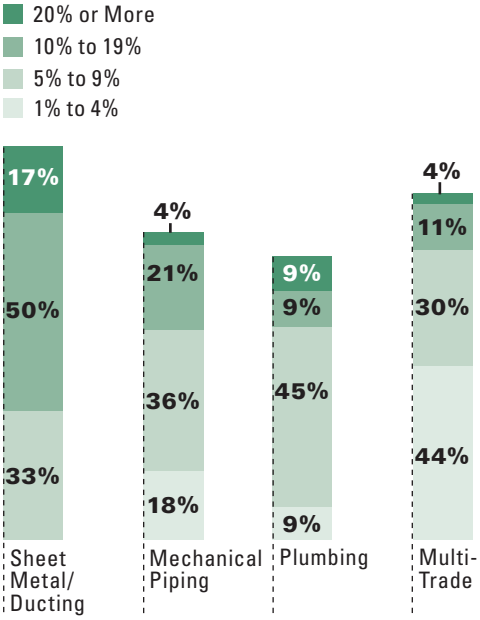
The chart at lower right shows the percentage of contractors by company-type who report alignment issues with modularized racks and the percentage of racks with which that problem occurs when they experience it.

Fortunately, the findings demonstrate that this is a relatively rare occurrence. There is some variation by region:

- **Multiregional firms have the highest overall incidence (46%).**
- **7% of contractors in the South report over a 5% incidence, compared with just 2% average across all the other regions.**

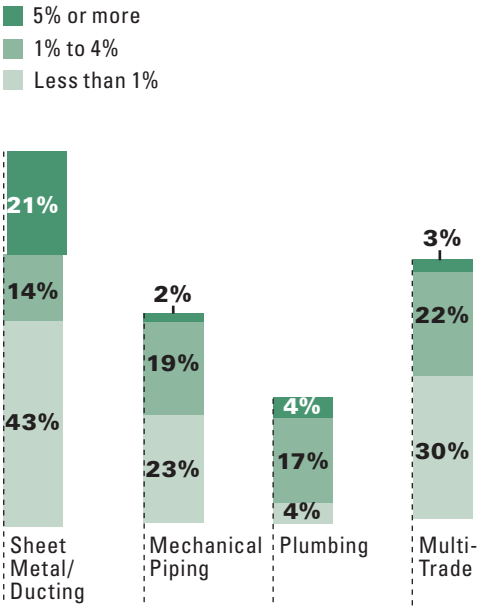
Percentage of All Inserts Put Into the Deck That Are Not Used During Hanger Installation

Dodge Data & Analytics, 2020



Percentage of All Modularized Racks That Are Not Aligned With the Adjacent Rack Onsite

Dodge Data & Analytics, 2020



Assemblies That Have to Be Reworked Onsite

The chart at upper right shows the percentages of contractors by company-type who report having to rework inaccurate prefabricated assemblies onsite and the percentage of those assemblies that this applies to.

The total incidence is lowest in the South (60%) and highest among the Northeastern (78%) and multiregional contractors (85%).

Almost a quarter (23%) of small companies (under $10M) report this happening on 5% or more of their assemblies, compared with just 6% of the very large (over $100M) ones.

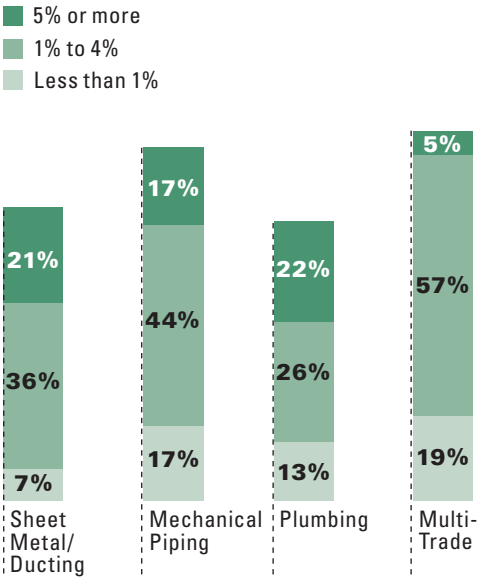
Assemblies That Have to Be Reworked at the Shop

The chart at lower right shows the percentages of contractors by company-type who report having to take inaccurate prefabricated assemblies back to the fab shop in order to rework them, and the percentage of those assemblies that this applies to.

The total incidence is again lowest in the South (47%) and highest in this case just among the multiregional contractors (81%). The Northeast, Midwest and West are closely grouped in a middle range of 61% to 68%.

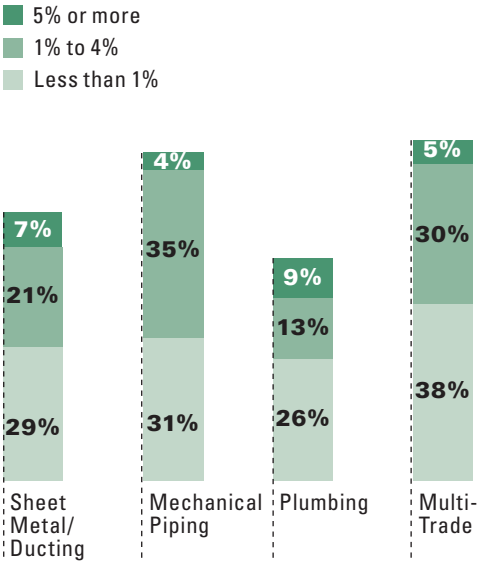
Percentage of BIM-Based Prefabricated Assemblies That Are Inaccurate and Have to Be Reworked Onsite

Dodge Data & Analytics, 2020



Percentage of BIM-Based Prefabricated Assemblies That Are Inaccurate and Have to Be Brought Back to the Fab Shop

Dodge Data & Analytics, 2020



Frequency and Impact of Six Key Factors on BIM Projects

Mechanical and HVAC contractors were first asked to cite how frequently each of these six disruptive factors occur on their BIM projects, and then separately asked to rate the relative degree of negative impact they have when they do occur.

These frequency and impact ratings are important measures that work together to help companies determine where to focus their energies when seeking to avoid or mitigate problems, because even if a factor has a highly negative impact, if it rarely occurs then it should have a lower priority when deciding on the most important issues to address. The chart at right shows both measures for the six factors studied.

Late Information and Waiting Because of Delays by Other Trades

- **These are good examples of frequent and disruptive factors, since almost half of respondents indicate they occur on more than 25% of their projects and well over half assign a high or very high negative impact to them.**
- **Late information is most frequently reported by multi-trade contractors (51%), whereas all others average only 40%.**
- **Waiting because of delays by other trades is reported as frequent by 71% of sheet metal/ducting contractors, far above the others, who average just 44%.**

Conflicting Information and Unavailable Information

- **These are equally disruptive, but less frequent.**
- **Plumbing contractors most frequently report both conflicting information (57%) and unavailable information (52%) compared with averages of just 32% and 38% respectively, among the other company-types.**

Late Arrival of Spool Assemblies Onsite and Incorrect Material Onsite

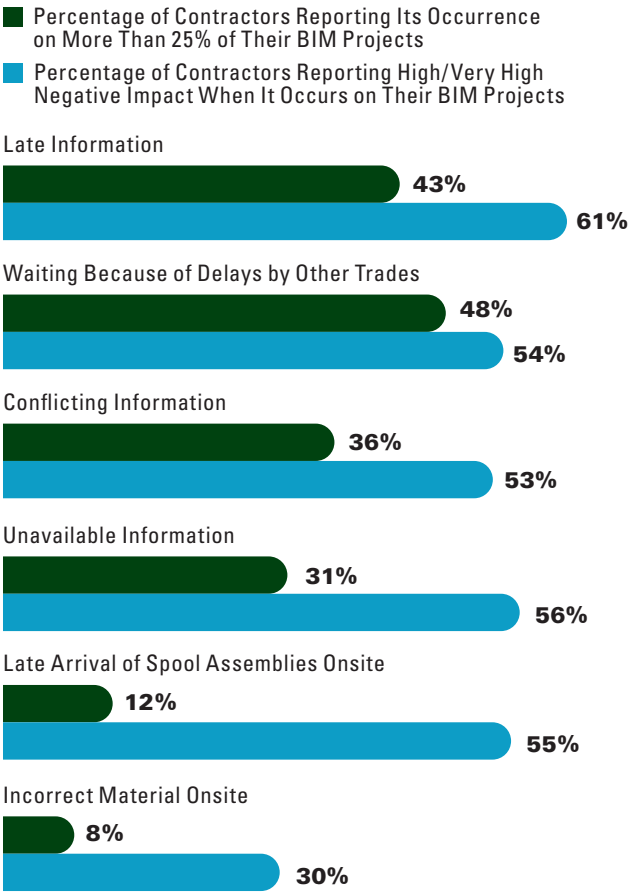
These are disruptive events that fortunately do not occur very frequently, so devoting resources to preventing or mitigating these can be a lower priority for management than the others shown above.

Applying Frequency/Impact Analysis to Other Workflows

This type of frequency/impact analysis can productively be applied by companies and teams for all types of processes, especially multiparty where many players participate in complex workflows over extended periods, and upstream events can cause significant downstream issues. It can also serve as a useful first step to identify issues for root cause analysis or process reengineering.

Relative Frequency and Negative Impact of Six Key Factors on BIM Projects (Percentage of Contractors Citing High Frequency and High or Very High Negative Impact for Each Factor)

Dodge Data & Analytics, 2020



The Current State and Future Potential of BIM for Mechanical Construction

Interviews with 14 industry experts reveal the top benefits experienced users derive from BIM, drivers and challenges for wider use of BIM for mechanical construction and their vision of what the future holds.

In addition to the quantitative online survey of contractors, the *Business Value of BIM for Mechanical and HVAC* research included a set of in-depth interviews of 14 industry experts on the use of BIM. These experts were identified by the Air Conditioning and Mechanical Contractors' Association (AMCA) and recruited by them to act as an advisory council on the project. (See the box on the opposite page for the list of participants.) Their insights reveal that while many practitioners have been using BIM for mechanical for years, there are still benefits and new uses to be gained in the future.

Top BIM Benefits

The participants brought up a wide range of benefits, from process improvements to better client relations to improved data analytics. Three benefits, though, were mentioned by several participants.

SUPPORT FABRICATION: All of the advisory council members who conduct prefabrication state that they have used BIM to support their prefabrication efforts for about a decade (in fact, many have done 3D modeling since the 1990s), and the most widely reported benefit they have experienced is the ability of BIM to support/improve the fabrication process. For example, Kyle Holmes from Brandt reports that the number one benefit he gains is that *"a proper BIM process generates an opportunity that can allow planned fabrication to reduce onsite risk."*

IMPROVED PRODUCTIVITY: Half of the respondents believe that BIM helps enhance productivity, at least in part through its ability to allow for better productivity tracking. Angie Simon from Western Allied finds that BIM provides a "full circle" approach to improving productivity: *"As we design something, we can take the data and track it easier, and figure out how long it's taking us. Bringing that information back into estimating and refining our process … is going to help us be lean and mean when the economy turns."* Productivity is also enhanced by the use of onsite tools that use the model, including robotic point set-out and 3D point cloud scans. Gavin Cheetham from AG Coombs finds that the latter both improves front-end planning and back-end validation of work on a project.

IMPROVE COORDINATION: The other major advantage noted by several participants was the improved coordination on projects. For most of the participants, this was a core functionality in BIM. Beyond coordination, though, BIM provides a major advantage as a collaboration tool. Joshua Getz from Southland states, *"To a certain extent, you don't really have a choice in adopting BIM if you really want to collaborate well with other team members. From a subcontractor perspective we work with the architects and structural and civil engineers, and the other subs, and most of the project teams are utilizing [BIM] for the most part. It enables collaboration in that space.*

Top Challenges

Participants were asked about their top challenges in two ways: internally at their own company and across project teams.

The most widely mentioned internal challenges are those around change management, training and keeping team members up to date on changes. Richard Drigo of Fredon Air finds that "*software moves at an almost exponential rate, and people's ability to adapt and change is almost a fraction of that time … I think we are 10, 15 years away from having proficiency in the industry to allow us to utilize BIM to its full degree.*"

The top team challenges are lack of proper design coordination around BIM or BIM project planning and the supply chain's lack of BIM experience and skills. Some also considered the models they receive from the design team as lacking in quality. However, others regard the fact that they commonly need to redo the model to have it include sufficient details for them to build as part of their work, and they do not expect designers to deliver a model at that level of detail.

Interestingly, though, one challenge mentioned several times throughout the interviews is that the people with BIM expertise frequently do not have construction expertise, and often the opposite is true as well. Richard Drigo was one of the people

who reported this challenge: *"We need to get those experienced with building to be able to use BIM. And the BIM guys, who are effectively software operators, need to learn how to build. If we get the two together, we've got a great thing."*

Encouraging Wider Use of BIM

While a couple of the participants believe BIM is already in very wide use in mechanical construction, most believe there are ways to see its use expand, including two key approaches mentioned by several respondents.

MORE COLLABORATIVE APPROACHES: Many participants regard the owner of the project as a key player to implement more collaborative approaches to projects. Richard Drigo explains that *"Often what happens is by the time we've come on board a project, the model's very progressed. And inevitably, the design needs to be almost reengineered, sometimes redesigned from scratch. So early involvement [will allow us] to take the most advantage of BIM."*

David Pikey of Hill Group agrees and believes the owner must be part of the solution: *"I don't think we're quite there yet in terms of building teams and sharing risks. I am not just talking about IPD or IFOA or something like that, but just having a more collaborative team approach to complicated, complex, modern construction and engineering challenges... When it comes to how we behave and how we treat each other as different stakeholders in the process, that's going to start with the owner."*

CREATION OF STANDARDS: Several participants think the lack of standards limits the use of BIM in the industry. For more information about how the creation of standards can encourage wider use of BIM, see pages 21 and 26.

The Future of BIM for Mechanical Construction

Participants were asked to address the question of the future in two ways: the top capabilities they expect from BIM in the future and the changes they expect to their industry by 2025.

Doug Moore from McKinstry sees BIM enabling visual project management to a greater degree as a critical benefit: *"You'll see colors of what's ordered and what's installed. The future of the model is that it will become the central piece of managing a project ... because all data will reside in the model."*

Tim Moormeier from US Engineering sees greater automation in the future: *"We believe that artificial intelligence will become a real consideration, where the first pass of coordination can be done by the machine instead of by an individual."* Steve Whitmer from ACCO agrees, and in particular sees automation enhancing fabrication. He describes a twofold approach, improving the software and detailing in BIM and in full automation in the shop.

Gavin Cheetham sees a streamlined data flow as the future of mechanical industry by 2025, from design through construction and facilities management. "*Centralized data, all the way through. At the moment, there's a lot of broken and dumbed down information . We want to see that streamlined significantly."* ■

Advisory Council Members

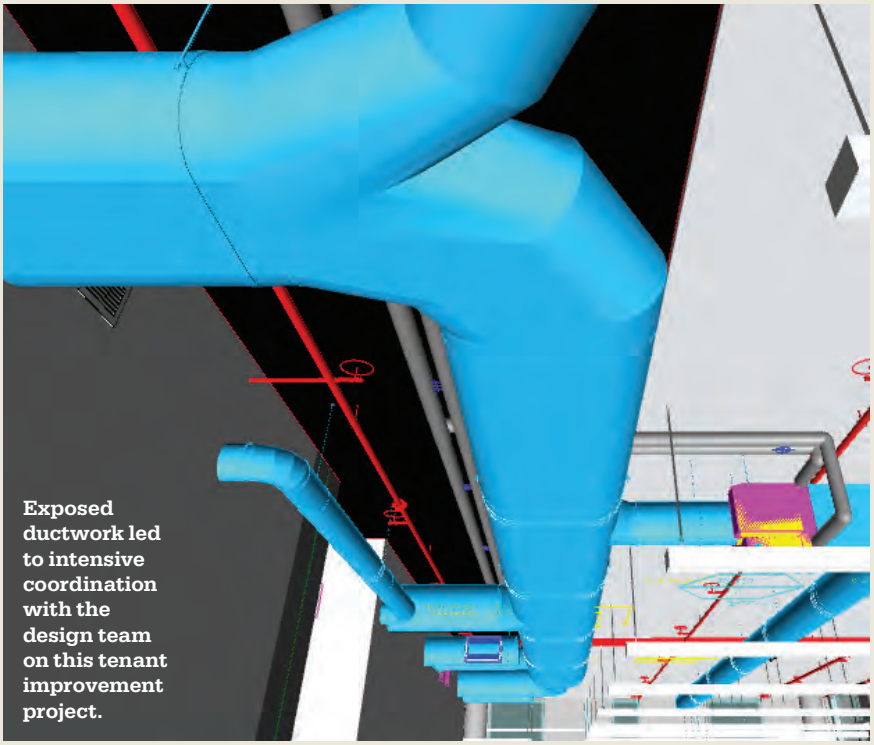
- Gavin Cheetham, AG Coombs, Group BIM Manager
- Richard Drigo, Fredon Air, Group Managing Director
- Joshua Getz, Southland, Senior Director AEC Technologies
- Kyle Holmes, The Brandt Companies, Senior Vice President
- Tim Hopkinson, E. Poppleton and Son, Managing Director
- Kiley Johnson, Western Allied, BIM Manager
- Paul Marsland, NG Bailey, Digital Engineering Manager
- Doug Moore, McKinstry, President
- Tim Moormeier, U.S. Engineering, President
- Ian Pearse, Ellis Air Conditioning, Digital Services Manager
- David Pikey, Hill Group, Vice President for Corporate Technology
- Scott Polsen, Benmax, Managing Director
- Angie Simon, Western Allied, President
- Steve Whitmer, ACCO, BIM Manager and Construction Technology Manager

case study

Taking Coordination to the Next Level

Cloud Service Headquarters Tenant Improvement Project

SAN FRANCISCO, CALIFORNIA



Exposed ductwork led to intensive coordination with the design team on this tenant improvement project.

Image Courtesy of Western Allied Mechanical

As part of the team delivering 730,000-sq-ft of tenant improvement at a new headquarters campus for a cloud storage company in San Francisco, Western Allied Mechanical heavily utilized BIM to communicate with designers, coordinate with trade partners, fabricate system elements in its shop and track productivity in the field.

The 20-month project provides new mechanical systems on 32 floors spread across four interconnected buildings, which will service offices, kitchen and dining areas, multiple meeting rooms and amenity spaces. For its $14 million portion of the project, which is the largest single project tenant improvement in San Francisco history, the company's primary scope was sheet metal, HVAC and mechanical piping.

Coordination With Designer

Working under Principal Builders with HGA Architects, Western Allied began work on the design-build project during estimation. The project was not fully BIM coordinated across all trades, so Western Allied took the lead on coordinating most of the systems in BIM, working extensively with the architect for layout as well as the plumbing and electrical contractors.

The project was the first buildout in the recently completed towers, so the team had to work within an existing core and shell. The sprinkler system was previously installed during initial base building. Western Allied did 3D-scans of all floors to create accurate as-builts in the model.

The complex interior design called for high-end finishes with mostly exposed HVAC. Kiley Johnson, detailing manager at Western Allied, says visualization through its BIM models proved to be a valuable benefit in determining how to balance the architectural look with mechanical requirements.

"This was a very demanding job in terms of the architectural look," says Kiley Johnson, detailing manager at Western Allied. "The architect didn't want any exposed equipment, so we had to jam all of our equipment into small blocks of rooms that had ceilings. In the exposed areas, we installed oval duct with minimal turns. Grills had to be lined up with lights. There were three different groups that looked at routing, register placement and alignment of hangers with lights. It was the most intense architectural review for duct that I've ever gone through."

Johnson says the kitchen areas were particularly difficult because of the space's metal barrel ceiling design. "The points where the ceiling had to be hung were extremely critical," he says. "We had to miss a lot of points with our ducts. Where that was impossible due to duct sizing and equipment, we'd go back and forth on adjustments to the ceiling. That was the best use of the model and the process between us."

Internal Coordination

Internally, Western Allied was able to work within one model from its engineers through to fabrication. Johnson worked with the head of the engineering department, the project manager and the foreman in review sessions to work through cost and constructability issues. All comments were incorporated back into the same model. Because the

CONTINUED

Cloud Service Headquarters Tenant Improvement Project

SAN FRANCISCO, CALIFORNIA

model would also be used for fabrication, it was modeled at LOD 400.

"A lot of times in construction, you have a design set, then you have your shop drawings or as-builts," he says. "Our shop and design drawings, by the time they go out into the field, are exactly the same."

Trade Coordination

Johnson says that Western Allied took the lead on coordination among key trade partners. Considering the architect's design requirements, detailing was critical for coordination. Johnson says that because the plumbing contractor was also detailing for fabrication, the two partners were able to conduct very precise coordination from their respective LOD 400 models. The electrical contractor also modeled its work, but Johnson says it did not need to be as detailed for coordination purposes. "Often, we just needed to coordinate cable trays," he says.

Maximizing Productivity

Western Allied fabricated all elements of its work other than the spiral duct and related fittings. Johnson says files exported from the model were sent directly to the machines at its shop, which automatically conduct a seamless file format conversion for fabrication that requires no additional work.

During installation, crews had limited access in and out of its work areas. All materials had to be transported through the core and shell building's existing elevators. The downside for Western Allied was that it couldn't maximize prefabrication due to those limitations. "The amount of material handling for this was astronomical because we had to fit everything in small elevators. All of our spiral lengths were 8 feet (long) instead of 10 feet so they would fit."

The drawings were detailed to a quarter-inch tolerance, but Johnson says the spiral duct wasn't precut. To keep costs down, the team worked to maximize the amount of material that could be brought up in one load. Duct was delivered at full 8-ft lengths, but because crews were working from data generated by the model there was no need for field measuring. All measurements were taken off lists and cut at stations on each floor.

Johnson says that, given the challenges with site access, the process proved very accurate with at least 97% of what it sent to the field installed without rework. "For a fully coordinated job at least 95% (without rework) is pretty standard," he says. "For a job where we only detail our side and no one else is involved, it's in the 85% range."

The level of detailed modeling and coordination also helped significantly with productivity. All layout was conducted robotically, using data from its models. Crew sizes were limited to three or four workers per floor. "That's low for a job of this size," Johnson adds.

At one point, early in installation, the general contractor had walls constructed on three floors, primarily to show the client a better representation of the space, Johnson says. However, that sequence affected Western Allied's productivity. By leveraging data in the model, Western Allied was able to more accurately track productivity. Comparing data from spaces where walls were installed before mechanical systems with spaces where mechanical systems were installed before the walls, Western Allied was able to compare productivity.

"There was a 30% increase in efficiency that we could track, just based on walls being in the way," he says. "We used the model to show the general contractor the hard numbers, and they were more willing to work with us on that."

Johnson says having the unique opportunity to show the real impact of various installation scenarios on productivity was a powerful tool. "Being able to gain those kinds of metrics was one of the best parts of this job," he says. "It's hard to get similar scenarios on a project where you can get that kind of data. This project was a good opportunity for that." ■

stats

Project Facts and Figures

Mechanical Contractor:
Western Allied Mechanical

General Contractor:
Principal Builders

Architect:
HGA Architects

Project Delivery:
Design-build

Duration:
20 months

Estimated Completion Date:
May 2020

Mechanical Construction Budget:
$14 million

case study

Building Backwards With BIM (and Other Smart Moves)

U.S. Engineering on FDA Lenexa

LENEXA, KANSAS

A lab facility is one of the more challenging project types mechanical contractors encounter. The many specialty items—including multiple runs of piping for lab gases, exhaust fans with welded stainless ducts, vacuum systems and valves requiring clearance for ongoing access—in addition to the usual systems, make up a tremendous amount of content that needs to be installed in never-enough space. For the U.S. Food and Drug Administration's renovation and expansion of a lab facility in Lenexa, Kansas, mechanical contractor U.S. Engineering is using BIM to help tackle the challenges in four key ways: coordination, offsite fabrication, out-of-sequence construction and enhanced project management.

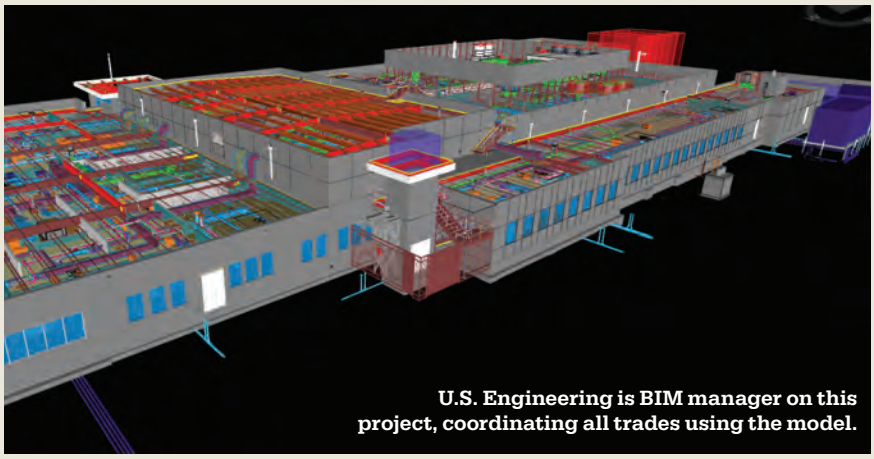
The $48 million facility, expected to be completed in August 2020, expands an existing 35,000 sq-ft building to 60,000 square feet, and will provide four new laboratories, office and support spaces, and a new mechanical penthouse and central utility plant. In addition to U.S. Engineering (USE)'s role as prime mechanical contractor, the company is also serving as BIM manager for the entire project, coordinating its in-house trades—mechanical, piping and plumbing—as well as other trade partners, including steel, electrical, casework, specialty equipment, building controls and fire sprinkler contractors. "The BIM experience we have in-house was a big factor in being able to do that successfully," says Ryan Frazier, USE's Regional Manager of Virtual Construction. And when significant differences between site measurements and the design team's BIM model necessitated an overhaul, U.S. Engineering did that too: sending out a team member with a laser scanner to conduct a scan of existing conditions, and converting that data into an accurate BIM model.

Better Communication Around Clashes

Coordination is one of the best-known advantages of BIM, and both Frazier and USE's project manager Brian Zorbini credit the technology with facilitating a clash-free installation. But communicating clashes to the appropriate detailers, and following up on revisions, can be onerous—with a potentially high price for dropped (or slow) balls. To boost communication on FDA Lenexa, USE piloted a new coordination tool within its project management software. When a clash is detected in the model, the plug-in takes an image of it and assigns its resolution to the appropriate individuals and/or organizations from the project's contact list. "With this software, we were able to make sure that those adjustments were being done in a realistic time frame, and to export reports so that the general contractor could see what was being done," says Frazier. "It was a huge benefit to our group and something that we've continued to adopt across other projects."

Offsite Fabrication

Beyond coordination, one of the most powerful advantages stemming from BIM has been USE's ability to divert work hours from the site to the company's manufacturing facility for cleaner, safer and more predictable production. "Because we've gotten everything as perfect as it can be in the virtual world," says Zorbini, "we're able to prefabricate almost everything that goes up in the air, and have confidence that it's going to fit where it needs to be onsite." BIM-enabled manufacturing is allowing close to a third of USE's estimated work hours to be moved offsite. "That means less people onsite, less safety hazards onsite and more hours spent in a controlled environment at our fabrication facility versus onsite," says Zorbini. "How much BIM has increased our fabrication abilities has got to be the biggest benefit by far." And in fact, Zorbini reports that those abilities



U.S. Engineering is BIM manager on this project, coordinating all trades using the model.

Image courtesy of U.S. Engineering

Kansas City Business Journal, March 12, 2018

CONTINUED

U.S. Engineering on FDA Lenexa

LENEXA, KANSAS

were the overwhelming factor in USE winning this contract.

In addition to supporting shop-based fabrication, BIM also supports USE's approach to productivity onsite. For each predefined component of the work, BIM provides the basis for assembling a kit of tools and materials specific to the job. So when USE sends a crew out, those workers have exactly what they require for their particular scope. With no need to pull from multiple bins and stacks throughout the site, the crew can work more efficiently.

Out-of-Sequence Construction

"Traditionally we like to install our services starting in the mechanical room, or at the source equipment for whatever service we're providing, and build out," says Zorbini. That way the largest systems are installed first, with branches and run-outs for piping or duct work continuing from the mains into the labs. But the general contractor, San Diego-based Lusardi Construction, saw that if USE could start in the lab areas and build backward, the casework, tile, flooring and other finish trades could get into the labs while USE was finishing up in the mechanical room. Given that USE will need to be in the mechanical room for about two months, the schedule advantage of having them build out of sequence is clear.

"Before this job, I would have put up a much larger fight not to build in reverse," says Zorbini. "But with BIM, we were able to install the branches first, and know that when our mains did get installed, we would be in the right location." With the work about two thirds complete, and no missed marks so far, "we now know that it is possible to build backwards," he says.

Enhanced Project Management

"Where USE goes above and beyond is the intellectual data that lives within our models, which are typically developed to LOD 400," says Frazier. (BIM standards for level of development [LOD] range from 100 through 500.) From the perspective of project management, a data-rich model makes scheduling easier and more accurate. For example, each fitting, valve or length of pipe in the model has a number of work hours associated with it. "As soon as Ryan had all of our content into a model—not coordinated, not final routed, but just so we knew 75% to 85% of the content we would have to install—I could just highlight things and pull actual work hours that are truly assigned to those individual buckets of work," says Zorbini.

As well as using BIM upfront to help build the schedule, Zorbini is now using it to track progress on the project. USE field leaders can simply point out on the screen what's in and what's not. Then and there, Zorbini highlights completed work in green, work in progress in red and leaves work not started grey, for a vivid and accurate progress schedule. "The visual aid component that BIM provides is just tremendous," he says. "You can ask someone what they've got done, and they can try to tell you, but if you put a picture up, it's easy."

That works for clients too, says Zorbini. "It just provides so much more comfort to our customers when we can tell them we know we're 42% complete because I've tracked every component in BIM." ■

stats

Project Facts and Figures

Project Location:
Lenexa, Kansas

Project Area:
60,000 square feet

Construction Start:
Shell September 2018; Tenant improvement May 2019

Anticipated Completion Date:
August 2020

Cost:
$48 million (source: *Kansas City Business Journal*)

USE Contract:
+$18 million

Client:
U.S. Food & Drug Administration (FDA)

Owner:
Easterly Government Properties (EGP)

Architect:
HKS Architects, Inc.

Structural Consultant:
PMA Structural Engineering

Mechanical Consultant:
Henderson Engineers

Electrical Consultant:
Henderson Engineers

General Contractor:
Lusardi Construction Company

Mechanical Contractor:
US Engineering Construction

Electrical Contractor:
Capital Electric

Building Controls:
Johnson Controls Inc. (JCI)

Methodology:

Business Value of BIM for Mechanical and HVAC Construction Study Research

Dodge Data & Analytics conducted the *2019 Business Value of BIM for Mechanical and HVAC Construction Study* to explore BIM used for MEP in construction and fabrication, and the benefits and challenges of these practices. The perspectives of BIM MEP users and nonusers were included.

Research

The research was conducted in December 2019 using an online survey. The survey data was collected from three sources:

- **The Dodge Data & Analytics Contractor Panel**
- **Members of the Mechanical Contractors Association of America**
- **Members of the Sheet Metal and Air Conditioning Contractors' National Association**

Respondents

The survey had a total of 135 responses. 122 of the respondents reported that they use BIM for mechanical construction, and the analysis in the report is based on their responses. The total of 13 non-user responses were not sufficient to support a statistically meaningful analysis, so they are not included in the report.

Respondents were required to:

- **Be employed construction professionals at contracting firms that provided sheet metal/ducting, mechanical piping or plumbing services**
- **Work on nonresidential building projects; have conducted construction projects in the US in the past five years**
- **Know about the frequency of BIM use for mechanical at their company.**

TYPE OF COMPANY

Much of the analysis conducted in this study looks at responses by four types of companies. Each was placed in the category if 50% or more of their work fell into each category:

- **Sheet Metal/Ducting: 12% of total respondents using BIM**
- **Mechanical Piping: 39% of total respondents using BIM**
- **Plumbing: 19% of total respondents using BIM**
- **Multi-Trade (companies for which sheet metal/ducting, mechanical piping or plumbing do not make up more than 50% of their total work): 30%**

SIZE OF COMPANY BY ANNUAL REVENUE

Survey responses were also analyzed based on the size of the company. 114 respondents provided this information.

- **Revenue of under $10 million: 11%**
- **Revenue of $10 million to under $50 million: 28%**
- **Revenue of $50 million to under $100 million: 31%**
- **Revenue of $100 million and over: 30%**

REGION

In addition, the findings were analyzed based on regional variances according to the regions in which the contractors worked in the past five years. The four regions are those defined by the US Census.

- **Northeast (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont): 19%**
- **South (Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia): 12%**
- **Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin): 30%**
- **West (Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming): 17%**
- **Works in more than one region: 21%**

Advisory Council Interviews

The report also includes information from qualitative research conducted as a series of in-depth interviews with 14 members of an advisory council established by the Air Conditioning and Mechanical Contractors' Association (AMCA) of Australia. Participants were selected by AMCA based on their leadership in the use of BIM for mechanical construction and HVAC, and they were located in Australia, the UK and the US. Insights from members of the advisory council are also featured in sidebar articles and case studies in the report. The in-depth interviews were conducted by phone during July and August 2019, and lasted between 25 and 60 minutes. Each interview included a set of questions on their levels of experience with BIM and various specific uses, the top benefits they have experienced from BIM, the challenges they face (both internally and across teams) in using BIM and their vision of the future. The list of participants is included on page 54. ■

Resources

Organizations, websites and publications to help you get smarter about the value of BIM for mechanical and HVAC Construction.

DODGE DATA & ANALYTICS

Dodge Data & Analytics
Main Website: **www.construction.com**
Dodge Construction Central: **www.construction.com/products**
Market & Competitive Intelligence: **www.construction.com/products/construction-market-data**
Sweets: **www.construction.com/products/sweets**
SmartMarket Reports: **www.construction.com/toolkit/reports**

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Finally, we thank all those who participated in the case studies, interviews and articles for sharing their insights, data and images to help the industry learn more about this vital topic.

MCAA Mechanical Contractors Association of America

www.mcaa.org

Pinnacle Infotech

www.pinnaclecad.com

Premier Partners

Mechanical Contractors Association of America: **www.mcaa.org**
Pinnacle Infotech: **www.pinnaclecad.com**

Supporting Partner

Autodesk: **www.autodesk.com**

Contributing Partners

Air Conditioning & Mechanical Contractors' Association (AMCA): **www.amca.com.au**
Innovative Construction Technology: **www.icttracker.com**

Association Research Partner

Sheet Metal & Air Conditioning Contractors' National Association: **www.smacna.org**

Other Resources

BIM Forum: **bimforum.org**
bimSCORE: **www.bimscore.com**
buildingSMART International: **www.buildingsmart.org**
National Institute of Building Sciences: **www.nibs.org**

Design and Construction Intelligence

SmartMarket Report

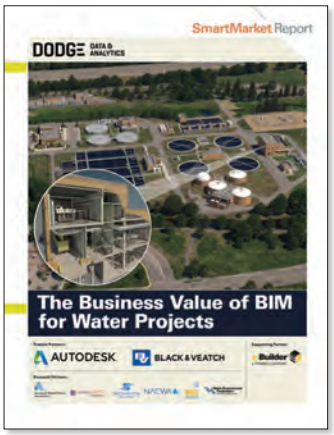
www.construction.com/toolkit/reports

Dodge Data & Analytics SmartMarket Reports™

Get smart about the latest industry trends.

For more information on these reports and others, visit

www.construction.com/toolkit/reports



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