SmartMarket Report

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Accelerating Digital Transformation Through BIM

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SmartMarket Report

Accelerating Digital Transformation Through BIM
SmartMarket Report

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Dodge Construction Network

About Dodge Data & Analytics

Dodge Data & Analytics is North America's leading provider of commercial construction project data, market forecasting & analytics services and 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 that help them grow their business. On a local, regional or national level, Dodge empowers its customers to better understand their markets, uncover key relationships, seize growth opportunities, and pursue specific sales opportunities with success. The company's construction project information is the most comprehensive and verified in the industry.

As of April 15, 2021, Dodge Data & Analytics and The Blue Book — the largest, most active network in the U.S. commercial construction industry — combined their businesses in a merger. The Blue Book Network delivers three unparalleled databases of companies, projects, and people.

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Introduction

Digital transformation is sweeping the globe. All industries in every country are deploying an increasing array of digital tools and integrated processes to increase productivity and certainty, reduce risk and more effectively engage all stakeholders in their value networks.

The design and construction industry is no exception. For several decades, companies have been adopting a variety of solutions to improve project outcomes, and a rapidly growing number of these are designed specifically for use by the industry.

Since 2009, Dodge Data & Analytics has been conducting quantitative research studies about the usage and value of design and construction technologies around the world. As adoption has steadily expanded over that time, so have users' capabilities, expectations and creativity at applying digital technologies in innovative ways to derive the most value from the underlying data being captured, created and shared across the project lifecycle.

Autodesk has partnered with Dodge on many of those efforts and is doing so again with this report titled *Accelerating Digital Transformation Through BIM*.

This research spans four continents and gathers the experiences of contractors, architects, civil engineers, and MEP and structural engineers to determine:

- Where they are in their process of digital transformation and how BIM is contributing value to that evolution.
- How they are deploying BIM and in what ways they are leveraging the data from models and processes to improve decision-making and effectively power integrated digital workflows among project team members.

Several key themes emerge from the survey findings.

- A company's BIM intensity (i.e., the percentage of their projects where they use BIM) correlates directly to the progress of their digital transformation, the degree to which they report enjoying benefits from BIM and the ROI (return on investment) they believe their company is receiving on its investments in BIM.
- An even more pronounced correlation appears in the findings related to active use of BIM data for analysis and digital workflows. Companies conducting a higher number of the 22 data-related activities studied often report even greater positive experiences from BIM than those doing most of their work in BIM. And of course, the combination is a powerful and reliable formula for success.
- Other activities that accrue to greater benefits from BIM include use of the cloud and a common data environment for digital workflows.

Looking ahead, the report also explores the growing use of emerging digital technologies and practices in several categories:

- Design Intelligence Tools
  - Model-based simulations, VR/AR/MR, Generative design/outcome-based design, AI/machine learning
- Innovative Construction Methods
  - Design-for-manufacture, Model-driven prefabrication, Industrialized construction
- Jobsite Technologies
  - 3D printing, Reality capture, Model-integrated devices (wearables), Robotics/automated vehicles
- Smart Building Technologies
  - Digital twin, IoT, Sensor, M2M technology, Virtual assistant

All respondents were asked to evalaute where they believe their company is on its journey of digital transformation. While the report shows that there are some variations in the responses between company-types and regions studied, there are more commonalities than difference as the entire industry moves toward a more efficient, connected and productive digital future.

Dodge wishes to thank Autodesk for being a long-standing research partner and supporting this global research study.

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.

TABLE OF **CONTENTS**

This Page and Next Page: Images Courtesy of AutoDesk

Case Studies

Perspectives on the Future of BIM

Data: Executive Summary

BIM Usage and Skills

Current Use of BIM on 50% or More of Projects Compared to Forecast (2-3 years)

The chart at bottom left shows how many BIM users, by company-type, currently use it on most of their projects compared with how many plan to be doing so within two to three years. Findings clearly forecast significant growth by all. (See pages 9-11 for more detail on BIM deployment.)

Engagement With BIM Data

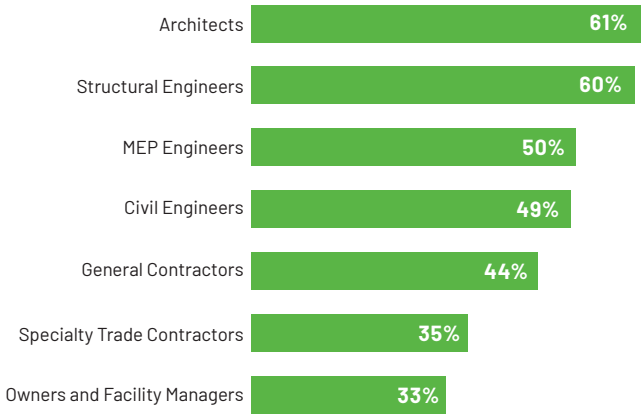
The research evaluated usage of 22 activities that leverage BIM data for improved decision-making and digital workflows. The chart at bottom right shows two levels of engagement with that full set of activities by company-type and size. (See pages 13-16 for more detail on data-related activities.)

Satisfaction With BIM Skill Levels

The chart at right shows how many BIM users are currently satisfied with the level of BIM skills they encounter from each company-type shown. The findings point to a broad industry need to enhance BIM skills across the project team. (See page 49 for more detail on BIM skills and satisfaction.)

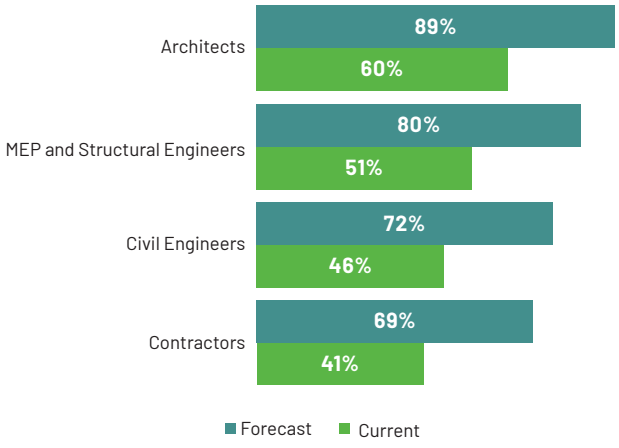
All BIM Users' Satisfaction With BIM Skills of Each Type of Project Team Member

Dodge Data & Analytics, 2021



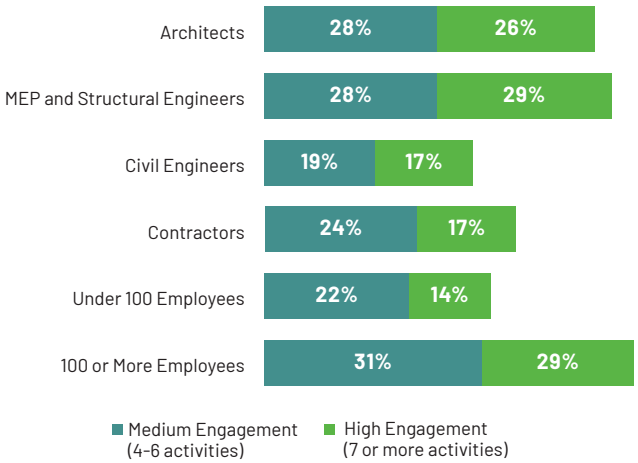
Current BIM Usage on 50% or More of Projects Compared With Forecast (2-3 years)

Dodge Data & Analytics, 2021



Engagement With Data-Related Activities by Company-Type and Size

Dodge Data & Analytics, 2021



Executive Summary

Use of a Common Data Environment

Nearly all BIM users use a common data environment to exchange data with their project teams, with contractors reporting the greatest value from its use. For more information on this and on using the cloud for collaboration, see pages 17–18.

Benefits of BIM

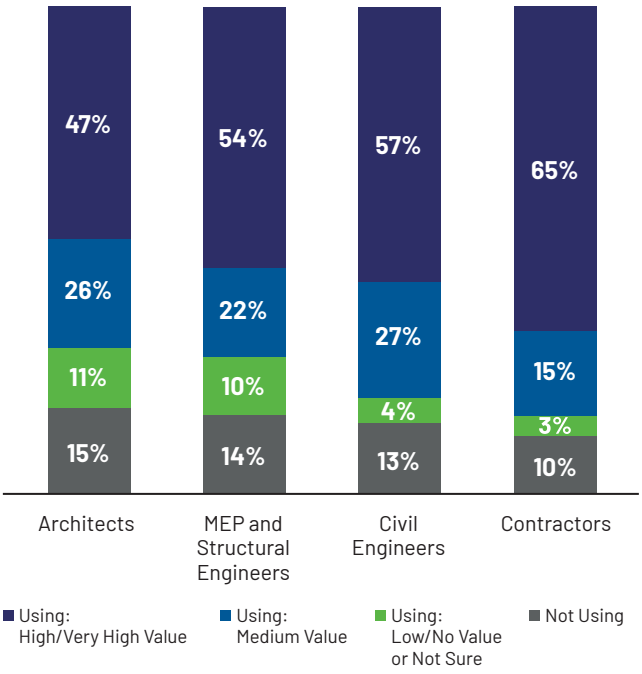
The survey examined BIM users' experience with 41 separate benefits received from their use of BIM. (See pages 22–32 for more detail.)

The findings reveal a strong correlation between BIM intensity and the experience of BIM benefits. The charts at bottom show the top five benefits reported by designers (architects and engineers) and contactors, comparing the percentages doing 25% or less of their work with BIM to those doing more than 75%.

The compelling differences shown in these charts provide an explanation for the findings on the previous page about the dynamic pace at which current users are planning to increase their BIM intensity. More BIM means more benefits.

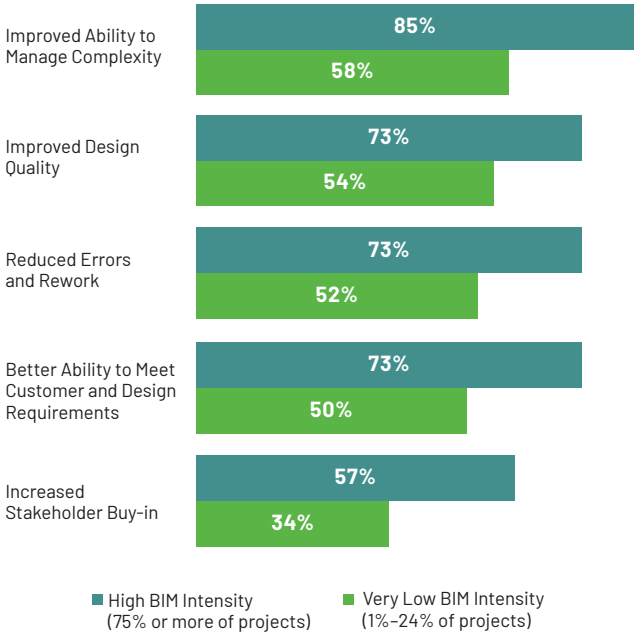
Use and Value of a Common Data Environment by Company-Type

Dodge Data & Analytics, 2021



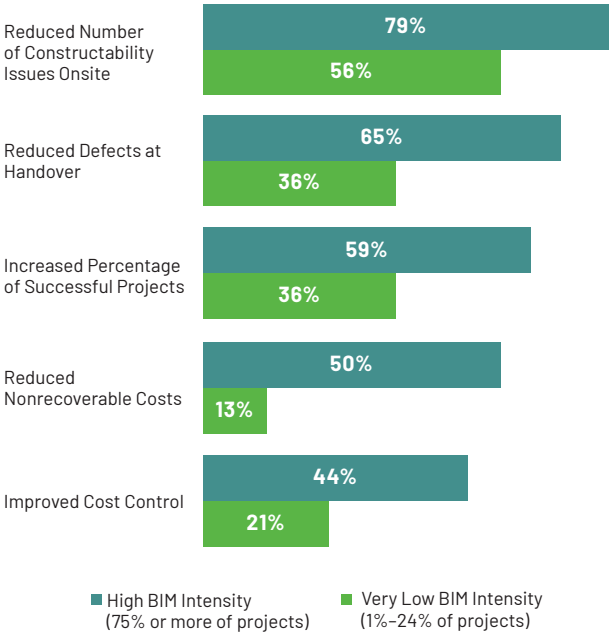
Impact of BIM Intensity on Top Five BIM Benefits for Architects and Engineers

Dodge Data & Analytics, 2021



Impact of BIM Intensity on Top Five BIM Benefits for Contractors

Dodge Data & Analytics, 2021



Executive Summary

Perceived ROI of BIM

There is no standard, globally accepted way to measure the ROI (return on investment) of BIM. In studies of BIM users over the last 12 years, Dodge has asked them to select which of seven percentage ranges they best believe represents their company's ROI on its BIM investments to that point. This is referred to in Dodge reports as the perceived ROI on BIM. The charts on this page combine several of the seven range options into three broad ROI tiers. (See pages 39-43 for more detail on BIM investments and ROI.)

Perceived ROI by Company-Type and Region

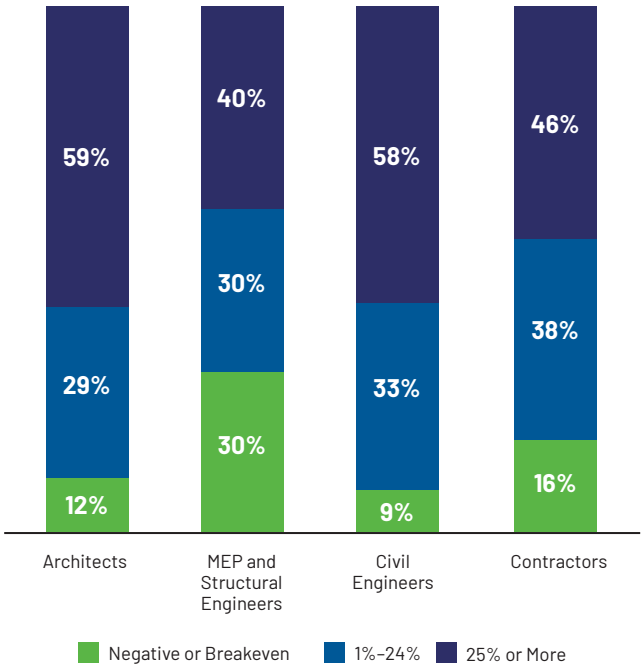
The chart at right shows this analysis by company-type. While architects report somewhat higher ROI than contractors, civil engineers differ notably from MEP and structural firms. This points to a need to focus on helping these professionals engage more successfully with BIM.

The chart at bottom shows the analysis by region and provides the overall response as a baseline for comparison.

- 48% or more report a good (at least a 25%) ROI in every region studied except North America, which also shows the highest number at negative or breakeven (31%).
- This contrasts sharply with France and UK/Ireland, where no users report negative or breakeven.

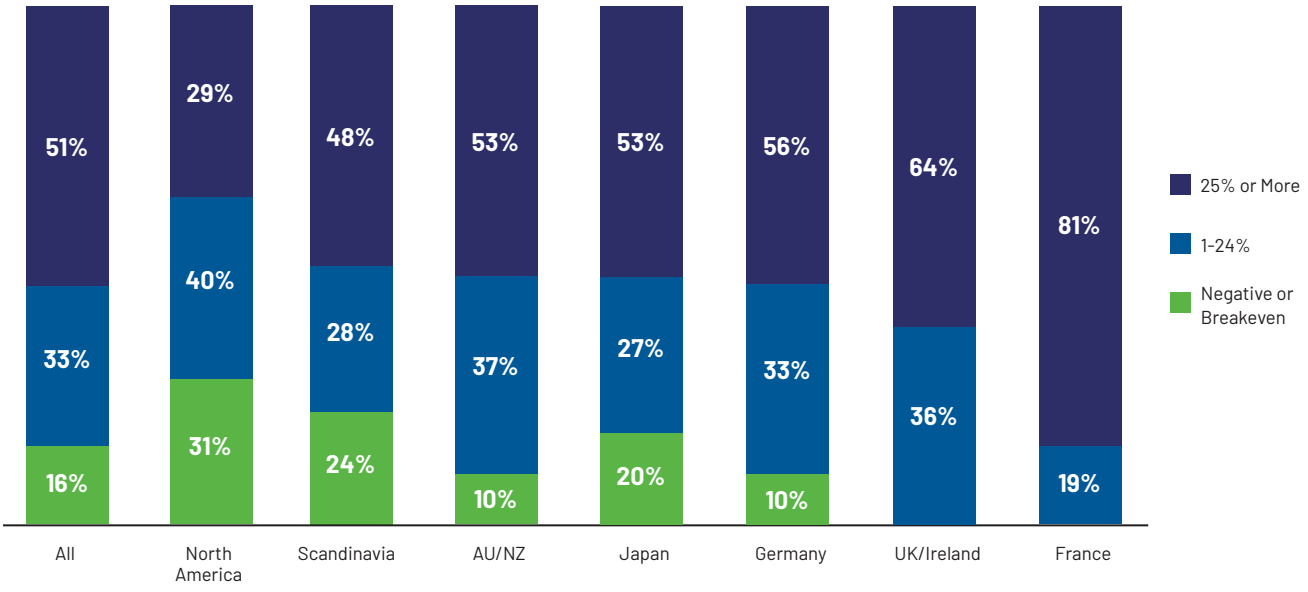
Perceived ROI of BIM by Type of Company

Dodge Data & Analytics, 2021



Perceived ROI of BIM by Region

Dodge Data & Analytics, 2021



Executive Summary

Digital Transformation

While the overall global design and construction industry is clearly going through a comprehensive digital transformation, the pace varies widely by company. All respondents to this survey (BIM users as well as non-users) were asked to assess where they believe their company is in its digital journey from one of four stages shown in the charts on this page. (See pages 48-51 for more detail on digital transformation.)

BIM Users' Progress on Digital Transformation

The chart at right focuses just on BIM users. It compares all BIM users with those using BIM on at least 75% of their projects (high BIM intensity). The findings show how more BIM use correlates directly with overall digital transformation.

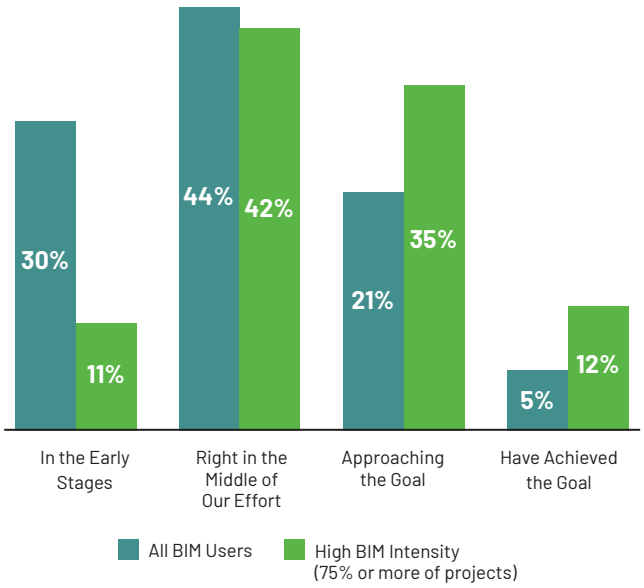
All Respondents' Progress on Digital Transformation by Region

Digital transformation is impacting all companies in the industry whether they are currently using BIM or not. The chart at bottom shows the averages of how all respondents from each region studied believe their transformation is progressing. The aggregate of all responses is also shown for comparison.

While there are variations, in general each region is fairly close to the average for all, suggesting that there is more commonality than difference in everyone's path toward our exciting digital future.

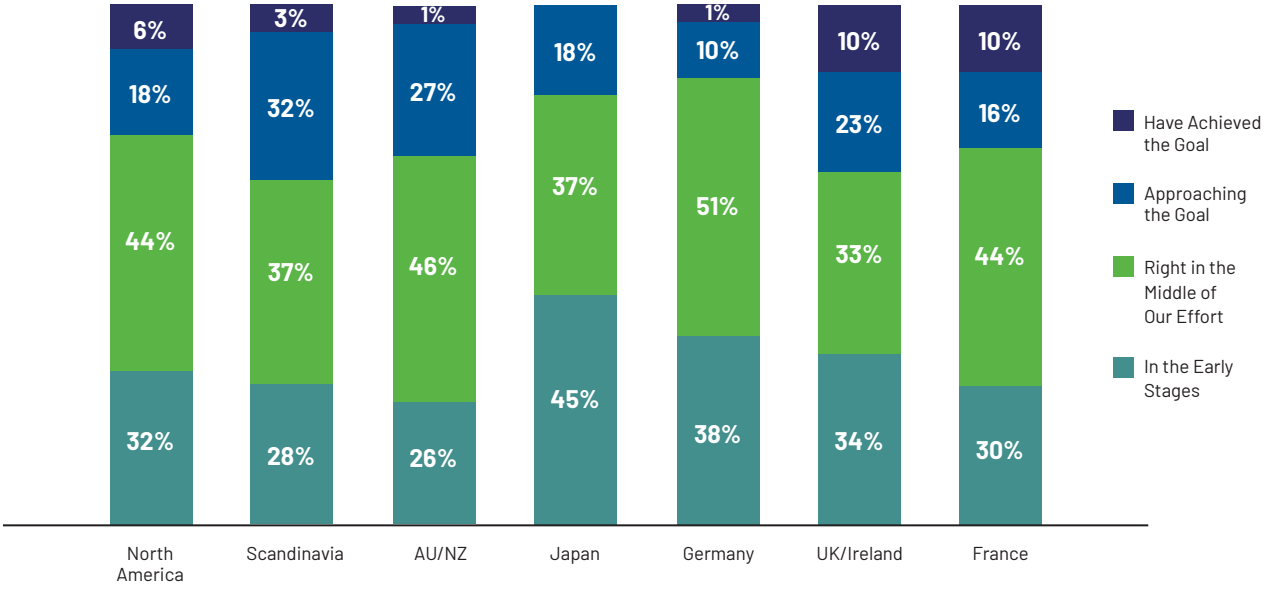
BIM Users' Reported Progress on Digital Transformation

Dodge Data & Analytics, 2021



All Respondents' Reported Progress on Digital Transformation by Region

Dodge Data & Analytics, 2021



Data: Introduction

Dodge Data & Analytics has conducted studies on building information modeling (BIM) for over a decade, examining the business value of BIM by geography (e.g., *The Business Value of BIM for Construction in Major Global Markets 2014 SmartMarket Report)*, type of company (*The Business Value of BIM for Mechanical and HVAC Contractors 2020 SmartMarket Report*) and type of project (*The Business Value of BIM for Water Projects 2018 SmartMarket Report*). In each of these studies, a similar set of questions were asked in order to be able to foster comparisons across the data .

However, since the original business value surveys were designed, BIM use has evolved significantly. The current study, instead of repeating most of the original questions, reflects those changes by exploring the following issues with a newly developed set of questions that better reflect current BIM use and benefits:

- A more thorough understanding of how BIM is being utilized by designers (architects and engineers) and contractors.
- An examination of the degree to which BIM users are working in the cloud or a common data environment.
- A more complete list and intensive measure of specific benefits for designers and contractors from their use of BIM and its related activities.
- An updated review of the ROI of BIM for the companies using it, and how to improve that ROI.
- An examination of BIM usage across project teams, expected BIM skills for each type of company and the degree of satisfaction with the BIM skills encountered in the industry.
- A look at how BIM use connects to the larger issue of digital transformation and the use of other digital tools in the design and construction industry.

Like some of the previous BIM studies, this one also reflects data from a range of global markets, including North America, the UK/Ireland, France, Germany, Scandinavia, Japan and Australia/New Zealand. Where it is most meaningful, comparisons between these regions are shown in order to highlight leadership in BIM and digital transformation and to better understand the global variability of how BIM is implemented and the benefits derived from it.

The findings demonstrate the connection between more intensive use of BIM and its related activities and the experience of critical benefits that strengthen companies and improve project performance. It suggests the pivotal role that BIM plays in the larger strategy of digital transformation.

Note About the Data

The findings in this report are based on an online survey of architects, engineers, consultants and contractors in seven global regions.

- Most of the findings are based on the responses of those who state that they use BIM on at least some of their projects, with special attention paid to differences among those with a lower intensity of BIM use compared with those with a high intensity. Intensity levels are defined as follows:
  - Very Low Intensity: Fewer than 25% of projects using BIM
  - Low Intensity: 25% to 49% of projects using BIM
  - Moderate Intensity: 50% to 74% of projects using BIM
  - High Intensity: 75% or more projects using BIM
- The study includes a measure of engagement by BIM users with 22 BIM-related activities. The analysis of the findings on benefits, ROI and digital transformation also consider the differences among those with low and high engagements in these activities.
  - Low Engagement: Use of 3 or fewer BIM-related activities
  - Moderate Engagement: Use of 4 to 6 BIM-related activities
  - High Engagement: Use of 7 or more BIM-related activities

At times, regional comparisons are deployed. The regional data has been weighted to address a larger response rate of smaller companies in North America than in the other global regions. Weighted data is only used in the regional comparisons.

The majority of the findings reported in this study only feature data from those using BIM. However, even those who do not use BIM were asked the series of digital transformation questions, and their responses are included in the overall totals. The analysis in this section also features the difference in responses between those using BIM and those not using BIM, along with the impact of the intensity of BIM use described above.

Data: Use of BIM
and BIM-Related Activities

BIM Adoption Trends

Dodge Data & Analytics has been studying BIM in the global AEC industry since 2009. Over that time BIM adoption has increased significantly, and as the chart at bottom shows, it is accelerating.

Among all the BIM users surveyed for this report in seven major regions of the world:

- Less than a quarter (22%) are long-term users, having adopted it in 2012 or earlier.
- Over half started in 2016 or sooner, with most of those (37%) coming on board since 2018.

This strong pattern of adoption is an encouraging sign that BIM is taking hold throughout the industry.

Variation by Company-Type

While BIM adoption has increased steadily across the industry, the timing has varied by company-type. The matrix at right shows the percent of current users who began in each of five time periods from which they could select.

- Architects were the strongest early adopters and have maintained a pattern of steady growth since then.
- Contractors were next to show a notable jump in adoption and have sharply increased users in the most recent period. This pattern reflects how models have generated increasing value for coordination, take-offs, scheduling, prefabrication, and other project delivery activities, and are now becoming mainstream tools for contractors.
- About 70% of the engineers have adopted BIM since 2016. The particularly significant jump by civil engineers in the most recent period reflects the rapidly growing use of BIM for infrastructure work.

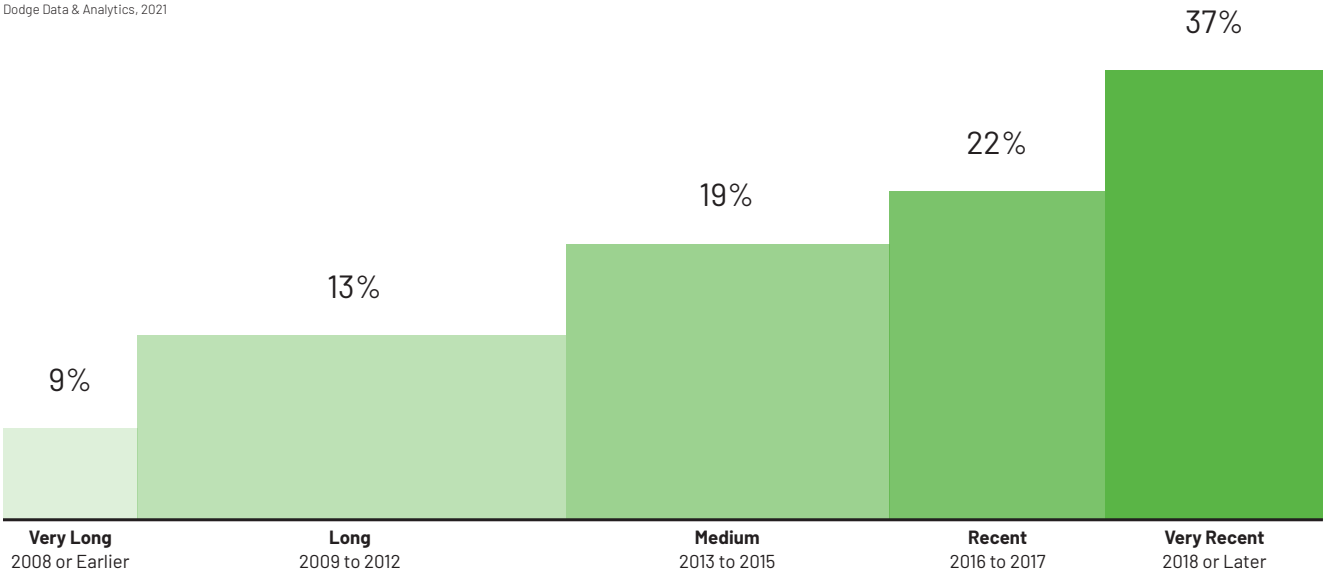
BIM Adoption Timeline by Company-Type

Dodge Data & Analytics, 2021

	Very Long 2008 or Earlier	**Long** 2009 to 2012	**Medium** 2013 to 2015	**Recent** 2016 to 2017	**Very Recent** 2018 or Later
Architects	14%	17%	20%	20%	28%
Contractors	4%	15%	19%	22%	38%
MEP and Structural Engineers	6%	8%	17%	34%	39%
Civil Engineers	5%	5%	19%	30%	41%

Year That Current Users First Implemented BIM

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

BIM Adoption Trends CONTINUED

Variation by Region

Adoption patterns have also varied across the seven regions studied. The matrix at upper right shows when companies currently using BIM in each region first adopted it.

- BIM got a strong start in North America with nearly half (46%) of current users reporting adoption in 2012 or earlier.
- AU/NZ, UK/Ireland, France and Germany show significant increases in adoption starting in 2013 and have grown steadily since then.
- Japan and Scandinavia show the most recent surges.

Variation by Company Size

The chart at lower right shows that, in general, the larger companies adopted BIM earlier, and smaller companies make up the majority of more recent adopters.

- Among current BIM users with more than 100 employees, nearly three quarters (71%) began in 2017 or earlier, and almost a quarter (24%) started before 2013.
- Conversely, almost half (46%) of smaller organizations currently using BIM adopted it relatively recently (2018 or later).

This pattern, where larger organizations lead the way in implementing innovative practices and smaller ones take advantage of their learnings and adopt aggressively somewhat later, aligns with other technology studies conducted by Dodge since 2009 in many regions of the world. The current surge of BIM adoption by smaller organizations serves as a clear indication that BIM is becoming widely accepted as an industry standard across the entire design and construction industry.

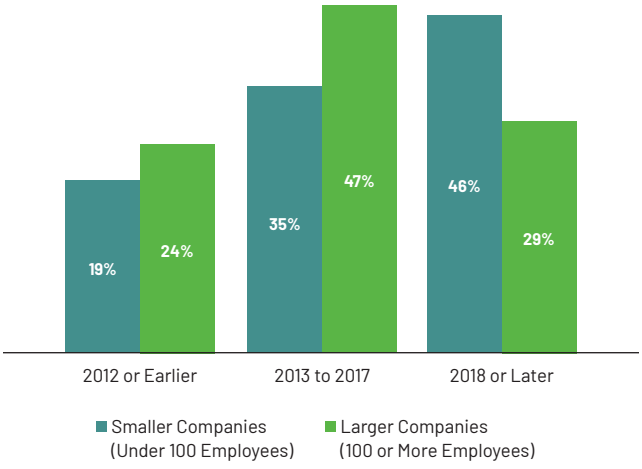
BIM Adoption Timeline by Region

Dodge Data & Analytics, 2021

	Very Long 2008 or Earlier	**Long** 2009 to 2012	**Medium** 2013 to 2015	**Recent** 2016 to 2017	**Very Recent** 2018 or Later
North America	19%	27%	20%	17%	17%
AU/NZ	3%	10%	23%	29%	35%
UK/Ireland	6%	8%	26%	25%	35%
France	6%	6%	19%	28%	41%
Germany	6%	4%	16%	28%	46%
Japan	2%	4%	18%	16%	60%
Scandinavia	3%	8%	8%	23%	58%

BIM Adoption Timeline by Company Size

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Intensity of BIM Use on Projects

While the research findings clearly show BIM adoption is growing, users vary widely in the percentage of projects where they deploy it (referred to in this report as BIM intensity). The Benefits section (pages 26–40) shows how higher BIM intensity relates directly to greater BIM benefits.

BIM Intensity and Years of BIM Use

The chart at lower left shows how BIM intensity increases with the number of years a company uses BIM. This direct relationship is powerful evidence that BIM generates compelling value for users the longer they use it.

Forecast for Future BIM Intensity

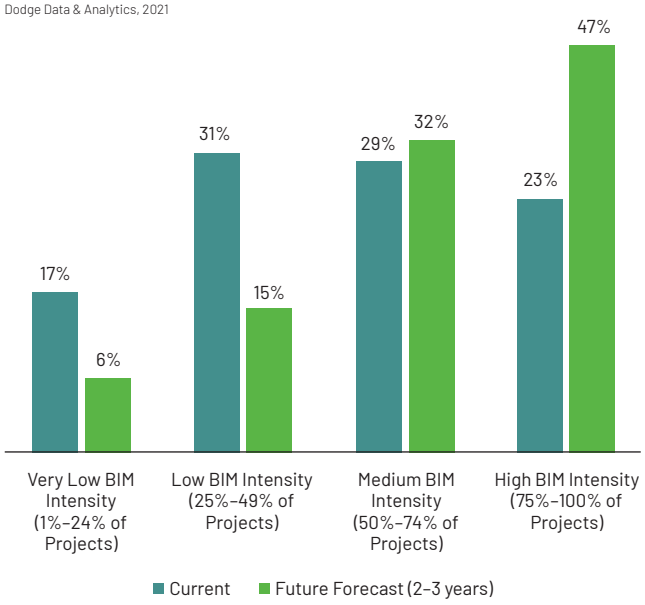
The chart at upper right shows the percentages of users currently at each level of BIM intensity compared with their forecast (2-3 years).

The chart at lower right shows a comparison by region of users currently at high BIM intensity (75% or more of projects) and their forecast (2-3 years).

Both of these analyses point to robust growth for BIM in the next few years.

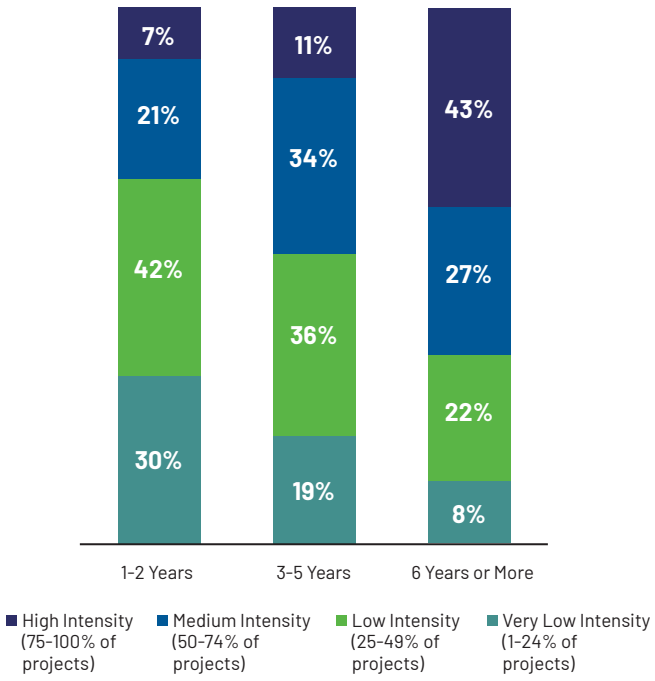
Current BIM Intensity Compared With Forecast (2-3 Years)

Dodge Data & Analytics, 2021



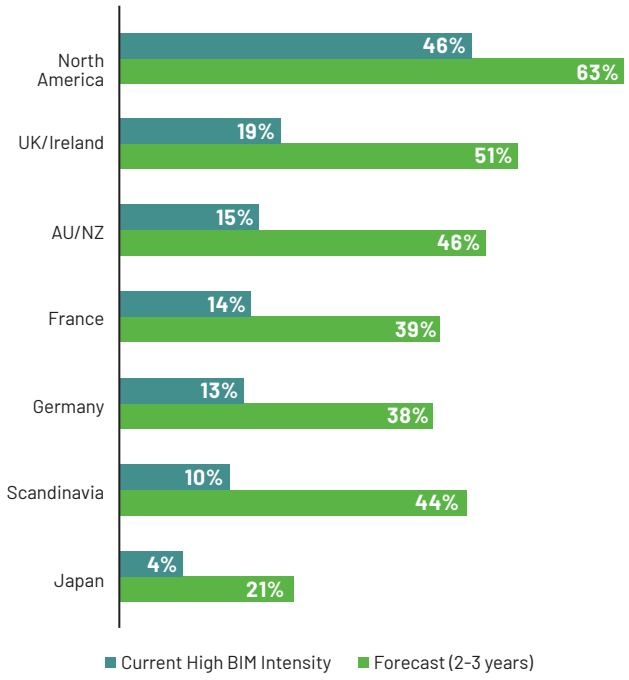
BIM Intensity by Years of BIM Use

Dodge Data & Analytics, 2021



Current High BIM Intensity (75% or More Projects) and Forecast (2–3 years) by Region

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Data-Driven BIM Activities

The power of BIM lies in its ability to leverage model-based data and visualizations to facilitate analysis, improve decision-making, and enhance productivity and collaboration by driving integrated digital workflows.

BIM Engagement

To determine how model-based data is currently being used, the survey asked about 22 specific data-driven activities in four categories: **Design Analysis, Planning, Construction** and **Emerging** (i.e., activities currently used by only 20% or fewer companies).

For the purposes of this report, the number of these 22 activities being deployed by each respondent is referred to as their level of BIM engagement. For analysis, the distribution of overall findings is divided into three broad categories:

- **Low engagement:** 3 or fewer activities
- **Medium engagement:** 4–6 activities
- **High engagement:** 7 or more activities

Not every activity among the 22 studied is applicable to each of the company-types, but the general trend of engagement across the 22 activities does give a sense of how relatively involved companies are in actively leveraging project data for productive uses.

Variation by Region

The chart at upper right shows how current BIM engagement varies among the seven regions studied.

- Engagement varies significantly between the highest and lowest extremes.
- Other than in AU/NZ, about half of users (from 45 to 57%) are at low engagement.

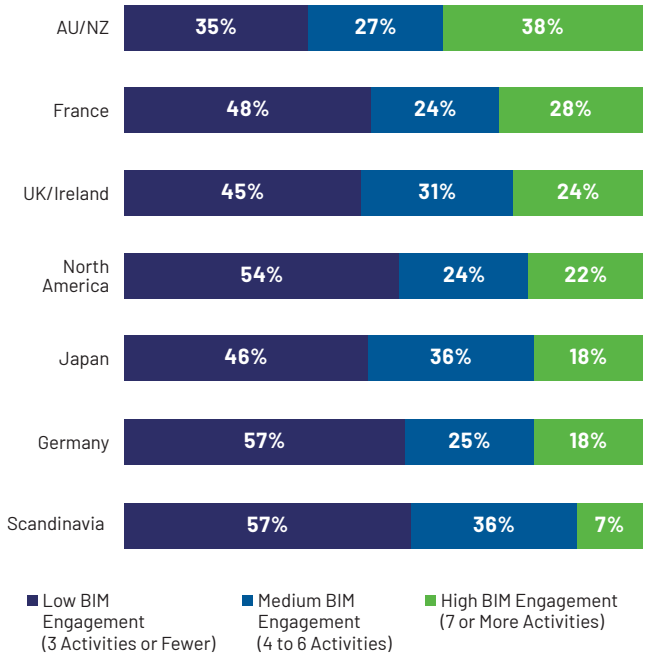
Variation by BIM Duration and Intensity

The chart at lower right shows steady engagement growth over the time that companies use BIM (duration), and as they increase the percentage of projects on which they use it (intensity). This finding clearly shows that BIM experience is a driver for increasingly sophisticated use of project data.

The following pages provide more detail about findings for each category.

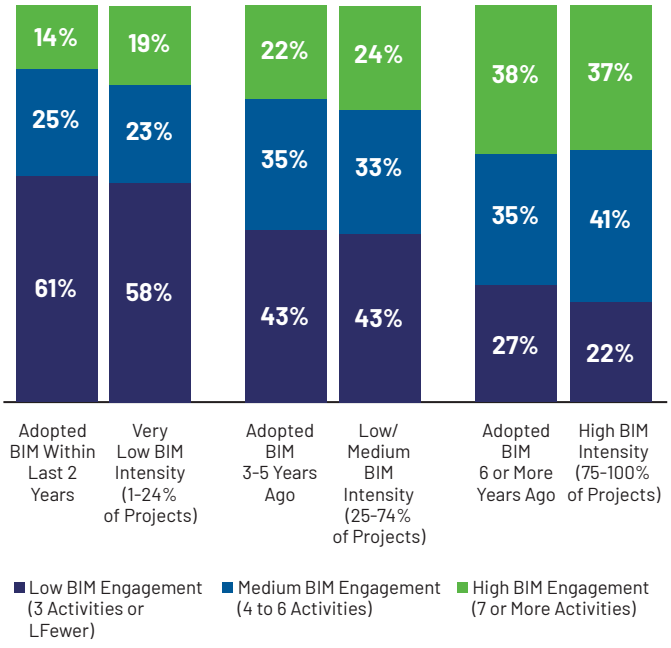
BIM Engagement by Region

Dodge Data & Analytics, 2021



BIM Engagement by Year of BIM Adoption and Current BIM Intensity

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Design Analysis Activities

Design Analysis Activities by Company-Type

Five of the 22 activities studied are primarily related to design. The chart at upper right shows how many companies, by type, report conducting each one.

- Not surprisingly, architects and engineers are more involved with this category of activities than are contractors.
- Using BIM to check design in various ways is the most frequent activity among all designers studied and is consistent across company size.
- All are engaging in sustainability calculations, including civil engineers (21%) and some contractors (9%).
- Interestingly, some contractors are doing energy (12%) and structural (15%) analyses.

Impact of BIM Usage

The chart at lower right shows how many of the companies with the highest levels of BIM engagement, intensity and duration currently deploy these activities.

- High BIM engagement (i.e., use of at least 7 of the 22 activities studied) correlates strongly to deployment of each of these design-related activities.
- High BIM intensity correlates most strongly with design checks, likely because doing more BIM projects correlates to having established internal processes for checking. This suggests the practice should become nearly universal.
- The lower impact of BIM intensity on the other five activities suggests that companies either do that activity or not, so any individual company increasing its intensity does not add more users to the total for any activity.
- Deployment of all of these design-related activities is also notably higher among companies with six or more years of BIM experience.

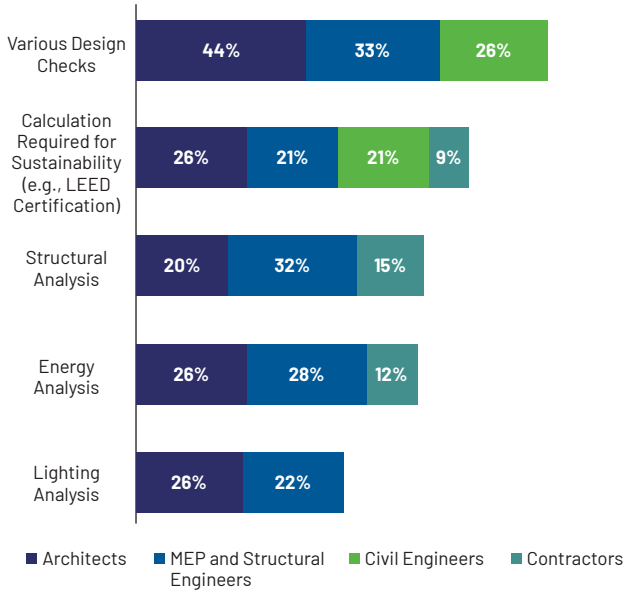
Variation by Region

Regions vary in their levels of engagement with these activities. Notable differences include:

- **Various design checks:** North America and AU/NZ are well above the median, while Japan is significantly below.
- **Lighting analysis:** The same two lead, with France joining Japan below the median as well.
- **Energy analysis:** France is the strong leader here, with Scandinavia and Germany lagging.
- **Sustainability calculations:** Japan is above the median and Germany is least active.
- **Structural analysis:** France, Japan and AU/NZ are above the median, while North America and Scandinavia are below it.

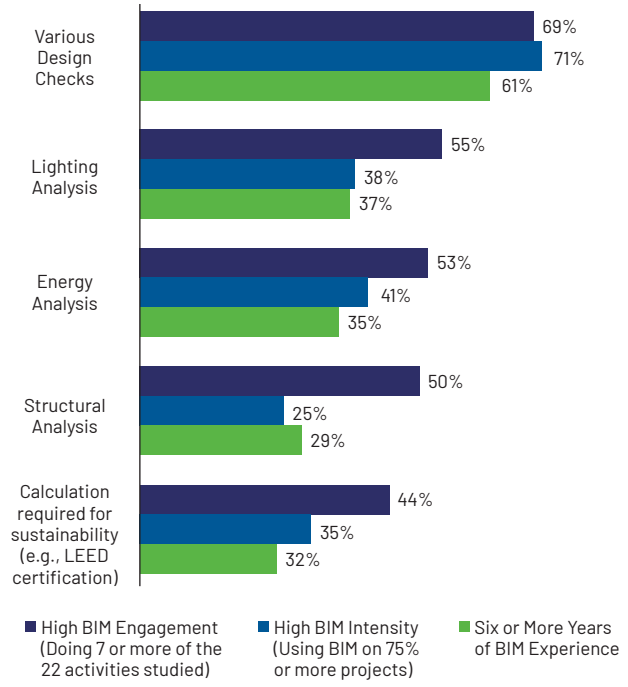
Design Analysis Activities by Company-Type

Dodge Data & Analytics, 2021



Design Analysis Activities by BIM Usage

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Construction Activities

Construction Activities by Company-Type

Six of the 22 activities studied are primarily related to construction. The chart at upper right shows how many companies, by type, report conducting each one.

- The high use of 3D spatial coordination and process visualization aligns with all previous BIM studies by Dodge Data & Analytics. Using dynamic 4D for these should grow as the technology is more widely implemented.

Impact of BIM Usage

The chart at lower right shows how many of the companies with the highest levels of BIM duration, engagement and intensity conduct these activities.

- BIM engagement correlates to greater use of all activities.
- High BIM intensity and experience correlate to more 3D process presentation and spatial coordination, as well as constructability evaluation, suggesting that most BIM users will ultimately adopt these well-established practices.
- A company either does shop drawings or not, so increasing intensity or experience does not add more users to the total.
- BIM experience is more impactful than intensity with the two 4D activities, suggesting that it is a key driver of innovation.

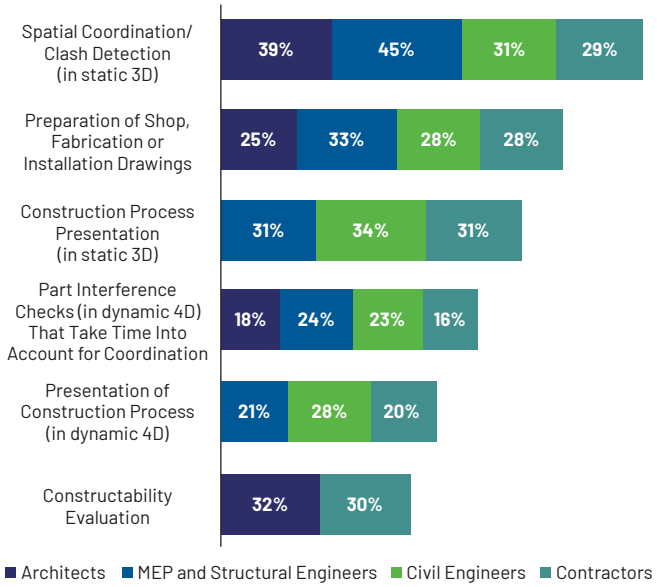
Variation by Region

Construction-related activities show less regional variation than other categories. A few trends emerge:

- **AU/NZ** either leads or scores well in every activity.
- **North America** scores lowest in four of the six.
- **Japan** is the most active region for 3D presentations.
- **Scandinavia** is the lowest region for spatial coordination.
- **France** leads in shop drawings but lags in constructability.
- **Germany** and **UK/Ireland** are mostly in the midrange.

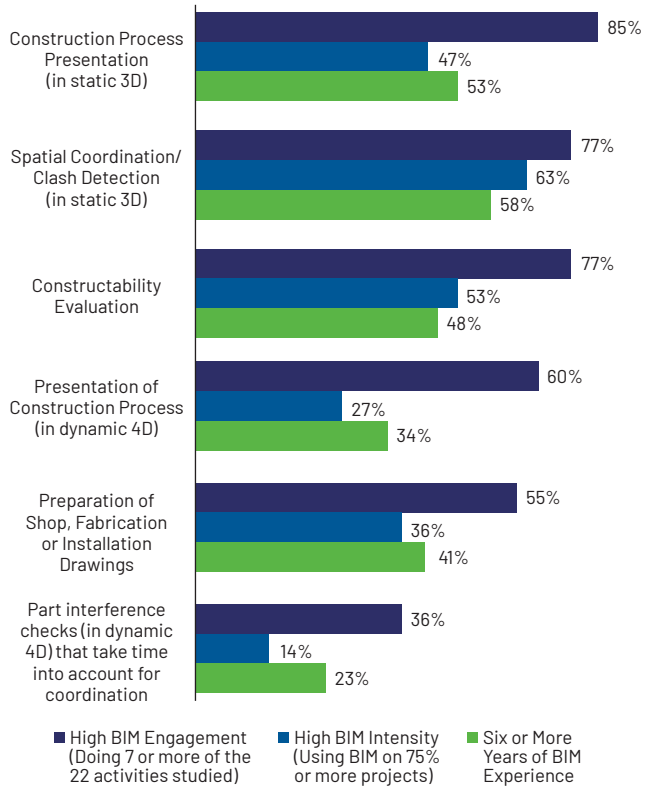
Construction-Related Activities by Company-Type

Dodge Data & Analytics, 2021



Construction-Related Activities by BIM Usage

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Planning-Related Activities

Planning-Related Activities by Company-Type

Five of the 22 activities studied relate to planning. The chart at upper right shows how many companies, by type, report conducting each one.

- The two cost-related activities are used by the highest total number of companies. But while an average of 36% of larger companies (100 employees or more) are doing them, just 22% of smaller ones (fewer than 100 employees) are.
- 40% of architects are using BIM to make space utilization plans and it is second only to design checks (44%) among all the tasks architects report doing.

Impact of BIM Usage

The chart at lower right shows how many of the companies with the highest levels of BIM duration, engagement and intensity deploy these activities.

- Over half of high BIM engagement companies are conducting each of these activities.
- High BIM intensity correlates most strongly with architects using BIM for space utilization plans. Since this is a popular task it makes sense that as firms do more BIM projects, their capabilities would expand to include this.
- BIM intensity has a more muted influence on the other planning-related activities. This again suggests that companies probably either do them or not, regardless of their BIM intensity, so individual companies increasing their proportion of BIM projects does not increase the total number of companies doing them.
- The companies doing BIM for six or more years also deploy these activities more frequently than the norm.

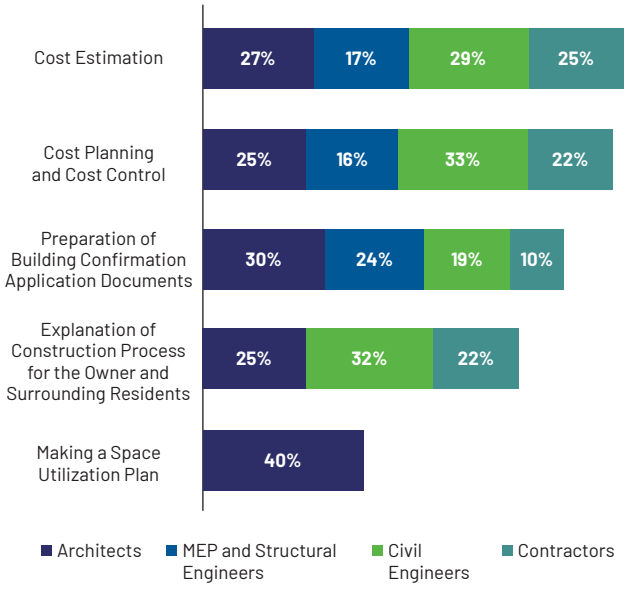
Variation by Region

Regions vary in their levels of engagement with planning-related activities. Notable differences include:

- **Making a Space Utilization Plan:** North America and France are significantly above the median, while both UK/Ireland and Germany show below-median usage.
- **Cost Estimation:** AU/NZ far exceeds other regions and UK/Ireland is also strong. Japan lags the most notably.
- **Cost Planning and Control:** AU/NZ again excels and Germany also scores well. North America shows the fewest users.
- **Construction Process Visualization:** AU/NZ, France and UK/Ireland are each well above the median, while North America and Japan are below.
- **Building Confirmation Documents:** AU/NZ, France and Japan are most active. North America is least active.

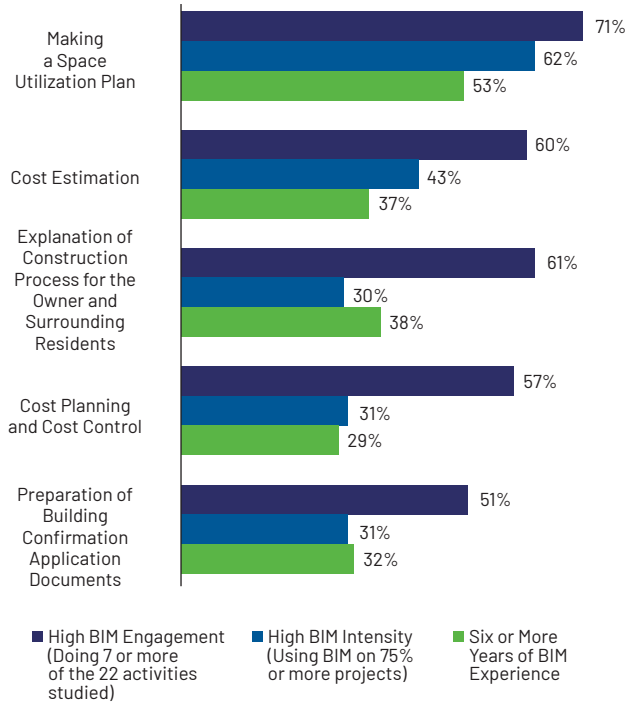
Planning-Related Activities by Company-Type

Dodge Data & Analytics, 2021



Planning-Related Activities by BIM Usage

Dodge Data & Analytics, 2021



Use of BIM
and BIM-Related Activities

Emerging Activities

Emerging Activities by Company-Type

Six of the 22 activities studied are generally less widely used than the other 16, so they are referred to in this report as emerging activities. The chart at upper right shows how many companies, by type, report conducting each one.

- All company-types are active in enabling prefabrication and factory production. This can certainly be expected to grow as the industry takes increasing advantage of design-for-manufacture, offsite production and modular construction.
- Understandably, the MEP engineers contribute to the strong showing (24%) for air-conditioning and ventilation analysis.
- The other four emerging activities are more highly specialized. Each is currently reported by only one company-type and shows relatively few users. But as BIM software companies expand capabilities and users gain more experience, these should also grow in frequency.

Impact of BIM Usage

The chart at lower right shows how many of the companies with the highest levels of BIM duration, engagement and intensity conduct these emerging activities.

- All of the activities are reported by higher percentages of the companies already conducting seven or more.
- Both BIM intensity and the length of time using BIM also correlate to greater use of each emerging activity. This finding suggests that experience triggers innovation.

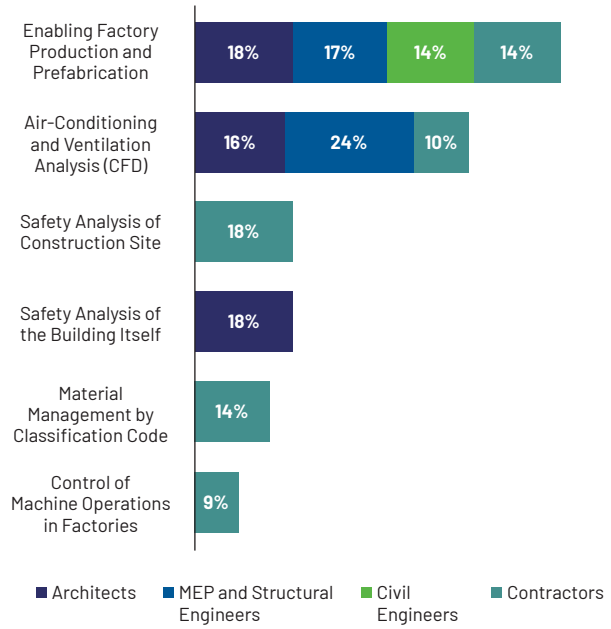
Variation by Region

Regions vary in their levels of engagement with these activities. Notable differences include:

- **Enabling factory production and prefabrication:** AU/NZ, UK/Ireland and Japan are all significantly above the median. North America is far below.
- **Air conditioning and ventilation analysis:** AU/NZ, France and Germany score well. North America and Scandinavia fall well below the median.
- **Safety anlysis of construction site:** AU/NZ, UK/Ireland and Japan are once more all significantly above the median. North America and Germany are notably below.
- **Safety analysis of the building itself:** AU/NZ excels while North America, France, Germany and UK/Ireland lag.
- **Material management by classification code:** AU/NZ and France are advanced, while North America and Scandinavia are at the lowest users.
- **Control of machine operations in factories:** AU/NZ is the leader with strong showing from Scandinavia and France. UK/Ireland and North America are the least active.

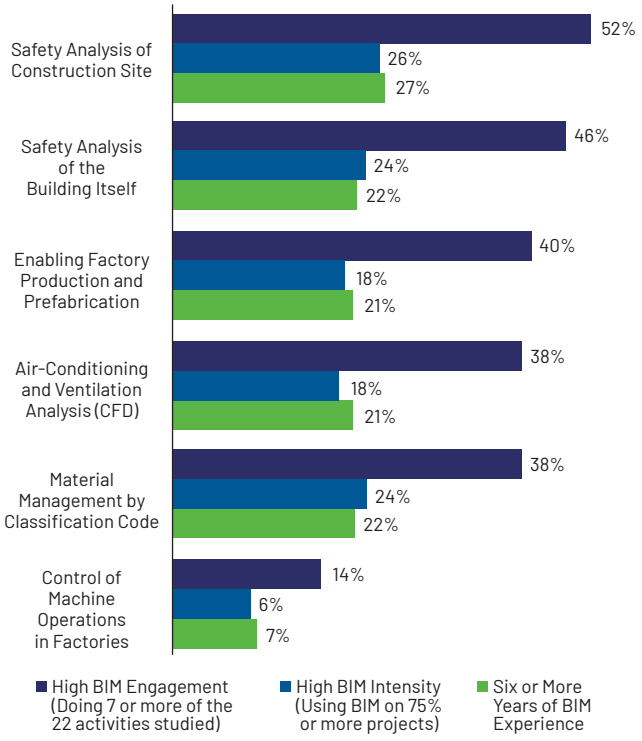
Emerging Activities by Company-Type

Dodge Data & Analytics, 2021



Emerging Activities by BIM Usage

Dodge Data & Analytics, 2021



Data: Collaborative BIM

Cloud-Based Data Exchange

Use of the cloud for data exchange is increasingly critical to successfully enabling integrated digital workflows that optimize the power of BIM. The charts on this page examine findings about use of the cloud for the four types of data exchange workflows featured on the previous page.

Variation by Company-Type

The chart at upper right shows how many of each of the four company-types studied are currently using the cloud for four types of data exchange workflows.

- All company-types are leveraging the cloud for internal and project team data exchanges, but somewhat less so when working with clients.
- Civil engineers are the most active users overall, especially with agencies, perhaps indicating a higher digital capability level at those types of owner organizations.

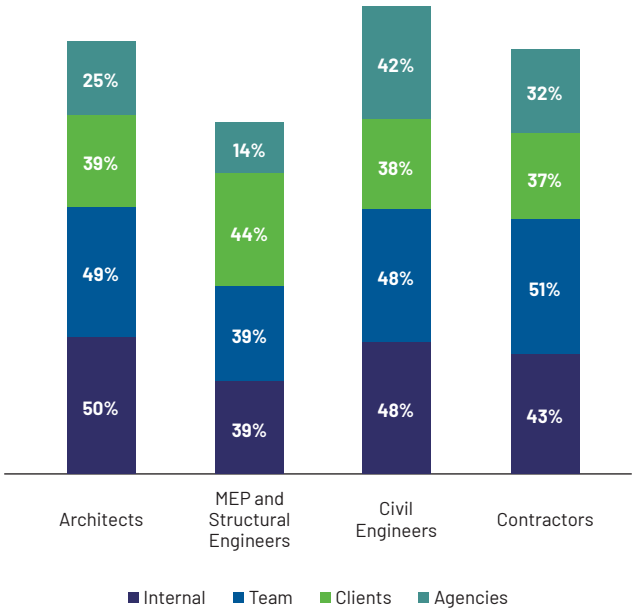
Variation by Region

The chart at bottom shows how many of the companies in each region are currently using the cloud for four types of data exchange workflows and the overall average for each country.

- France, Japan, Germany and North America lag, while AU/NZ and UK/Ireland significantly outpace others.
- The UK BIM mandate may be a driver for the relatively high percentages in UK/Ireland.
- North America's low use with regulatory agencies (16%) suggests an opportunity to learn from other regions, which average 34%.

Use of the Cloud for Data Exchange by Company-Type

Dodge Data & Analytics, 2021



Use of the Cloud for Data Exchange by Region

Dodge Data & Analytics, 2021

	All Regions	France	Japan	Germany	North America	Scandinavia	AU/NZ	UK/Ireland
Internal	47%	39%	37%	41%	47%	41%	59%	65%
Team	50%	39%	37%	43%	54%	48%	56%	65%
Client	40%	34%	37%	36%	36%	42%	49%	53%
Agencies	28%	24%	36%	29%	16%	37%	37%	44%
Regional Average	41%	34%	37%	37%	38%	42%	50%	57%

Collaborative BIM

Common Data Environment

Another important way to leverage the value of BIM and model-based data is to align the full project team in a common data environment (defined for the purposes of this research as the single source of information used to collect, manage and disseminate documentation, the graphical model and nongraphical data for the whole project team).

Use of a Common Data Environment

To determine the current status of this practice, respondents were asked if they use a common data environment to exchange data with their project team, then among those who do, how valuable it is to improving the performance of the project team.

The chart at upper right shows that the majority of respondents from all company-types report using a common data environment and that most find it highly valuable.

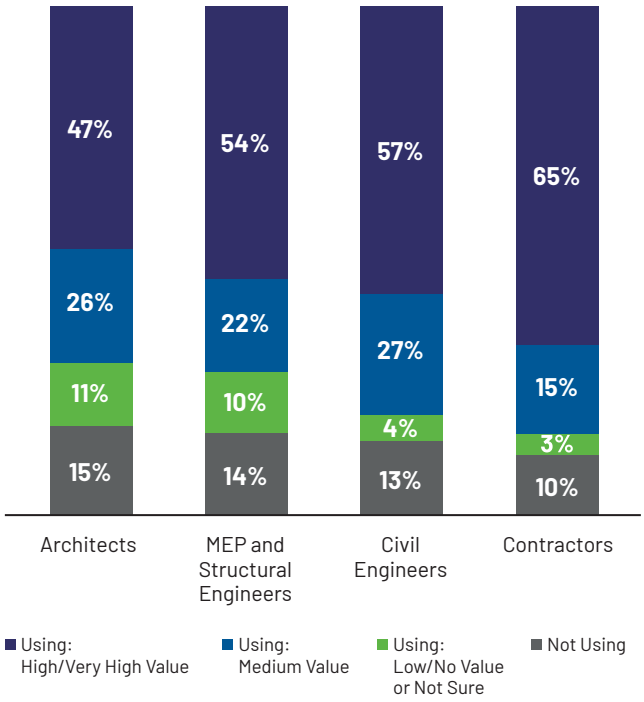
Variations by Region

The chart at bottom shows how the use of a common data environment varies across the regions studied.

- AU/NZ leads the regions in total use and North America lags, but users in both regions show high levels of satisfaction.
- Small percentages of users assign a low value, suggesting that continued adoption and implementation of the cloud for data exchange workflows can be expected globally.

Use and Value of a Common Data Environment by Company-Type

Dodge Data & Analytics, 2021



Use of a Common Data Environment by Region

Dodge Data & Analytics, 2021

	All Regions	Japan	North America	France	Scandinavia	UK/Ireland	Germany	AU/NZ
Using: High/Very High Value	55%	39%	50%	56%	58%	59%	61%	70%
Using: Medium Value	21%	36%	15%	26%	21%	26%	14%	18%
Using: Low/No Value or Not Sure	10%	15%	6%	7%	17%	12%	14%	7%
Not Using	13%	10%	29%	11%	4%	3%	10%	5%

Collaborative BIM

Advanced BIM Usage

The previous sections of this report show wide variations in BIM use by company-types and across the regions studied. The charts on this page identify the percentages of users who can be considered advanced, meaning they:

- Conduct at least four of the 22 data-related activities studied.
- Use both a common data environment and the cloud for digital workflows.
- Deploy BIM on at least 50% of their projects.

Advanced BIM Use by Company-Type

The chart at right shows that architects are the most advanced as a group, though they lag civil engineers and contractors in reporting use of a common data environment.

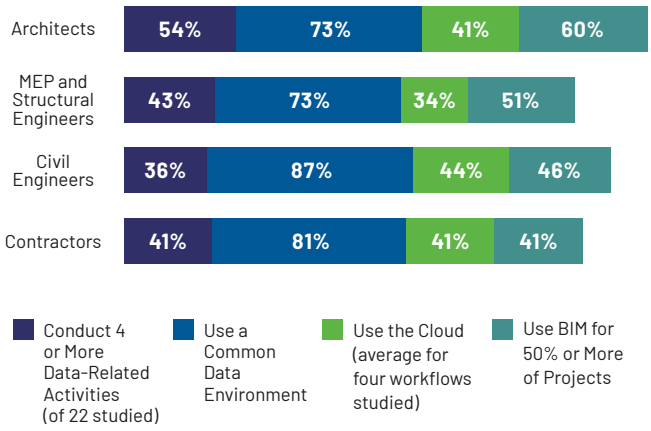
Advanced BIM Use by Region

The chart at bottom reveals several interesting trends among the seven regions studied.

- North America notably leads in high BIM deployment (62%), yet its relatively low ratings for the other three metrics places it well below other regions overall.
- UK/Ireland is first or second highest in all categories, perhaps reflecting the impact of the government BIM mandate in the UK.
- Australia/New Zealand also scores well across all metrics.

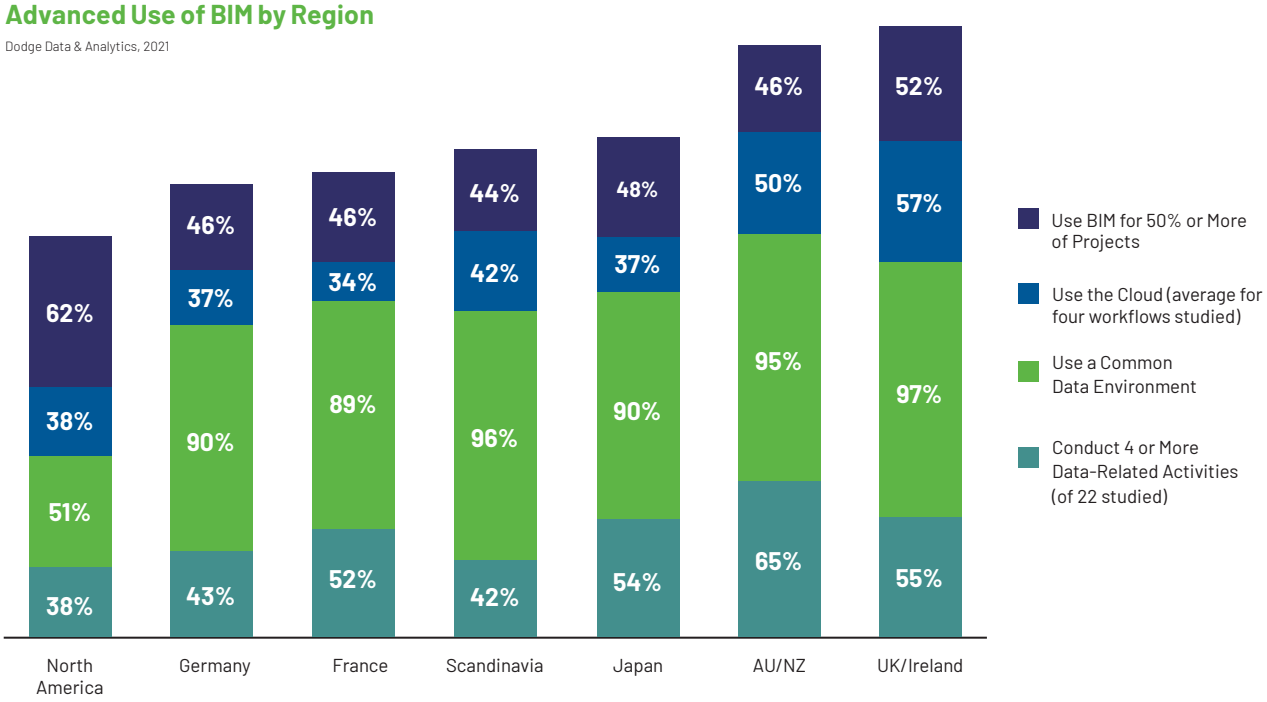
Advanced Use of BIM by Company-Type

Dodge Data & Analytics, 2021



Advanced Use of BIM by Region

Dodge Data & Analytics, 2021



Case Study

Fostering Common Data Environments

HONG KONG, CHINA

As with many things in life, data is better shared. Common data environment software (CDE) offers project teams the ability to share a single source of information in which all of a project's documentation—BIM or 2D, graphic or text—is collected, managed and disseminated across all stages of a project's lifecycle. CDEs can improve collaboration and coordination among project team members, and cut down on errors and duplication of effort, with specific advantages varying across the different stages of a project's lifecycle.

"A common data environment provides a platform where we can share information for collaboration with the least effort," says Ada Fung, chairperson of the Hong Kong Construction Industry Council (CIC)'s committee on BIM. "With a single source of truth, the project team is confident about obtaining the most reliable information." Formed to forge consensus on long-term strategic issues in Hong Kong's construction sector and to provide a channel for communications between industry and government, the CIC serves as a Centre of Excellence for BIM, formulating strategies for market transformation and promoting cross-discipline collaboration and wider adoption of BIM.

Since January 2018, when the Hong Kong government mandated that all state-funded projects with a value over $30 million use BIM, the CIC has been formulating BIM technical standards, providing training and support, and encouraging the private sector to adopt digital technologies as well. As part of that push, the CIC is facilitating understanding and adoption of CDE.

Creating Common Ground

Initiatives include a series of webinars launched to introduce currently available solutions and boost uptake, publication of CIC BIM Standards General Version 2, aligning with the international BIM standard ISO 19650 (which emphasizes CDE functionality as both an information repository and as a complete information management system throughout a project's lifecycle) and a survey of local CDE providers about key aspects of their service. Examples of factors surveyed include alignment with CIC standards, server location, security and various operational details. "Most of the providers can comply," says Fung. "I think this is a good start—that all CDE providers in Hong Kong can meet most of the requirements, and this will develop over time."

Within the Hong Kong government's Development Bureau (of which the CIC is a part), each project will have its own CDE, and each department will have a departmental CDE. The Civil Engineering & Development Department (CEDD), for example, has identified four key strategies for building its departmental CDE: alignment with ISO 19650, standardization of modeling and presentations, collaboration through the establishment of CDE protocols and ongoing development through internal workshops and guidelines. Steps toward alignment with ISO 19650 include enhancing the department's BIM governance process, refining BIM uses in project applications, developing as-built standards with maintenance parties and upgrading current deliverables to ISO 19650 for operations and maintenance. The collaboration strategy also breaks down into action points. These include establishing a collaboration process between projects and the department, developing an enterprise CDE as an interface between projects and in-house applications, and specifying metadata and interfacing standards for model sharing.

Nested Solutions

Once established, all the departmental CDEs will connect to a Bureau-wide BIM data repository (BIMDR) to improve the efficiency of BIM data sharing and dissemination. The BIMDR will collect, validate, extract and exchange BIM data among departments and between BIM and GIS. Shareable BIM models and open GIS format will be converted to enable BIM/GIS integration that can then, for example, facilitate the study and production of 3D digital maps for Hong Kong. For that to happen, harmonization across departments is essential.

The CEDD's BIM Harmonization Initiative is now being run in a new project using data from various government departments responsible for water, sewage, energy, infrastructure and building projects. A consultant is harmonizing the BIM standards and workflows under which these departments will contribute and exchange their BIM models through the BIMDR. "We start off with different departments working together in a new development area, but each has its own standards," says Fung. "It's time for harmonization so that these different departments can communicate across each other."

The BIMDR will in turn form part of a 320-dataset "digital Hong Kong" known as the Common Spatial Data Infrastructure (CSDI). Still in the early stages of development, the CSDI is intended to facilitate the sharing of spatial data among public and private organizations across the territory and to support the development of various smart city applications. Linkage and integration of spatial data will be facilitated through the establishment of CSDI standards, now in development. "The concept is easy," says Alex Ho, the CIC's senior manager for BIM, "but

Fostering Common Data Environments

HONG KONG, CHINA

there's a lot of work to do to align the data definitions, structure and BIM models from different departments and, eventually, from the private sector, too." Standards will cover geotagging of nonspatial data, documentation of data specifications and metadata, conversion of spatial data to an open and machine-readable format and the establishment of an application programming interface (API). The hope is that a common platform for integrating and exchanging geospatial information will lead to reliable spatial data services, enable more efficient use of resources and facilitate Hong Kong's goal of carbon neutrality by 2050.

More in Common

Looking ahead to challenges on the horizon, harmonization continues to be the central theme. "People are selecting the most suitable CDE for their project's particular stage, which is logical," says Ho, "but the market right now doesn't really understand that the CDE should cover the whole lifecycle." Currently available solutions consist almost entirely of closed systems, he says, so transitioning from design and construction to operations and maintenance will likely require project teams to transfer data from a CDE selected for the former to another selected for the latter. "If there is no standard and no common protocol, data will be lost, and there will be a lot of work for people to check the data transfer to their own system," Ho says. He draws an analogy to the banking system: "If we needed to be using the same bank in order for one person to transfer money to another, it would be undesirable," he says, "but in CDE, this is the way we do it." Transitioning from one CDE to another entails more than data, adds Fung. "It's also the workflow and logic behind it," she says. From the CIC's perspective, the need to move easily between CDEs is the most significant challenge facing the technology's development. In response, Fung and Ho are hoping to see the emergence of common standards and protocols to which software vendors comply, facilitating data transfer across project stages. "Beyond open BIM," says Ho, "we really need open CDE." ■

Data: Benefits of Using BIM

Business Benefits for Designers From Using BIM

Designers (architects, building engineers and civil engineers) rated the degree to which they experience six business benefits from their BIM use on a five-point scale (no, low, medium, high or very high). The chart at right shows the percentages who rate each as either medium or the combined values for high and very high.

The findings clearly demonstrate that BIM helps designers improve and grow their businesses, with more than three quarters reporting this level benefit for each, and most at a high or very high level. This is particularly true for improved design quality (66%) and improved client satisfaction (61%).

Impact of BIM Intensity

BIM intensity (see page 11) refers to the percentage of a company's projects where they use BIM. Firms with high BIM intensity (i.e., using BIM on 75% or more of their projects) are more likely to experience improved design quality and improved client satisfaction at a high/very high level than those who use BIM less frequently, especially those who employ it on less than one quarter of their projects. These core benefits contribute most to the success of a design firm, so these findings demonstrate the importance, not just of BIM use at all, but of more widely using it on projects to fully achieve the most powerful impact.

Variation by BIM Engagement

The designers who are highly engaged in the data-related activities studied in this report (see pages 12–16) experience three benefits significantly more frequently than those conducting fewer of them . Again, improved design quality and improved client satisfaction are more likely when more deeply engaged with BIM, but also, not surprisingly, they find that they can expand and diversify the services they offer. The ability to be flexible and diversify is becoming increasingly important as factors like pandemics, climate change, and social, economic and political instability drive changes within the global building market.

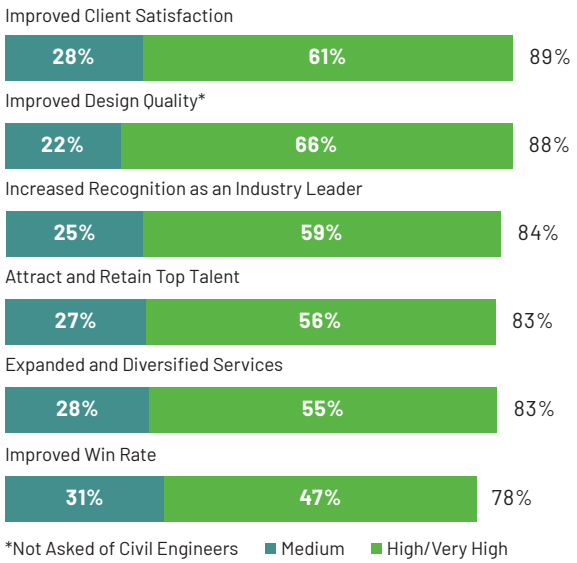
Variation by Type of Company

The following business benefits are experienced at a high/very high level by significantly more civil engineers than architects.

- **Expanded and diversified services** (63% versus 50%)
- **Increased recognition as an industry leader** (70% versus 55%)
- **Attract and retain top talent** (67% versus 54%)

Business Benefits From BIM at Medium and High/Very High Levels (According to Designers)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Level of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Design Quality	54%	65%	65%	73%
Improved Client Satisfaction	61%	50%	65%	70%

Impact of BIM Engagement on High/Very High Level of Benefits

Dodge Data & Analytics, 2021

	Low Engagement (0–3 activities)	Medium Engagement (4–6 activities)	High Engagement (7 or more activities)
Improved Design Quality	60%	67%	74%
Improved Client Satisfaction	52%	69%	67%
Expanded and Diversified Services	47%	53%	71%

Previous research by Dodge on BIM adoption suggests that civil work has lagged in overall BIM use compared with buildings, which may explain why benefits that do not depend on intensity of use are more commonly experienced by civil engineers than by architects or building engineers.

Benefits
of Using BIM

Sustainability Benefits for Designers From Using BIM

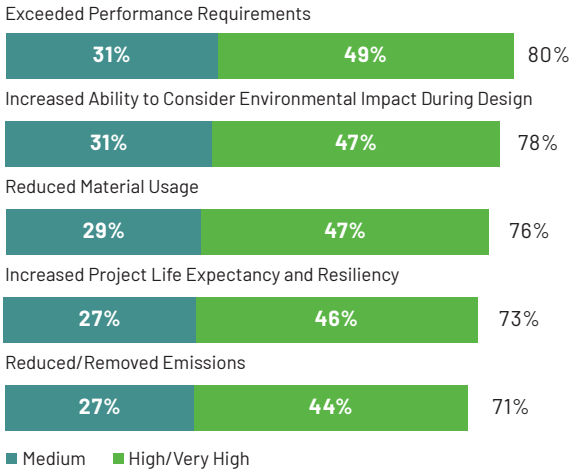
Designers also rated five sustainability benefits. The chart at right shows the medium and combined high/very high ratings.

Similar to their experience with business benefits (see page 22), over 70% of designers also experience sustainability benefits from their use of BIM, particularly at the high/very high level.

- The top benefit experienced is exceeded performance requirements, which demonstrates how wider use of BIM can contribute to improved building performance.
- It is clear that many designers also find great value in how BIM allows them to understand the impacts of their projects during design, reduce the use of materials, increase project life expectancy and resiliency, and reduce emissions. All are given similar ratings, demonstrating that all these issues are both important to designers and addressed well using BIM.
- It is notable that there were no significant differences in the responses of those with low BIM intensity versus those with high BIM intensity, suggesting that many of these benefits are achievable for firms regardless of the percentage of projects where they are using BIM.

Sustainability Benefits From BIM at Medium and High/Very High Levels (According to Designers)

Dodge Data & Analytics, 2021



Variation by BIM Engagement

While BIM engagement across a broad range of projects appears not to be critical to achieving most of these benefits, high engagement does correlate with higher achievement of two benefits: the increased ability to consider environmental impact during design and the increased project life expectancy and resiliency.

Use of tools that can assess factors like daylight, wind impact, airflow and even human passage through the spaces designed can help to better understand the building's impact, as well as allow design choices that will likely expand the lifespan of the building and increase resiliency.

Impact of High Engagement on Achieving High Level of Benefits

Dodge Data & Analytics, 2021

	Low Engagement (0–3 activities)	Medium Engagement (4–6 activities)	High Engagement (7 or more activities)
Increased Ability to Consider Environmental Impact During Design	42%	48%	53%
Increased Project Life Expectancy and Resiliency	44%	41%	56%

Variation by Type of Company

The following sustainability benefits are experienced at a high/very high level by significantly more civil engineers than architects.

- Increased ability to consider environmental impact during design (61% versus 44%)
- Exceeded performance requirements (58% versus 44%)
- Reduced material usage (57% versus 41%)
- Reduced or removed emissions (52% versus 39%)

These findings clearly demonstrate the value that civil engineers find in BIM for improving the sustainable performance of their projects. As BIM and GIS are better able to be used in concert, civil engineers may increasingly find that factors like reduced material usage or reduced or removed emissions are benefited by designing their projects using BIM and its tools, as the findings of the recent *Business Value of GIS for Design and Construction SmartMarket Report* demonstrate.

Benefits
of Using BIM

Risk Reduction Benefits for Designers From Using BIM

Designers also rated six risk reduction benefits. The chart at right shows the medium and combined high/very high ratings.

Over three quarters of the designers report experiencing these BIM benefits at a medium level or higher, with the majority at the high/very high level.

Taken together, these findings clearly demonstrate that BIM use significantly reduces the inherent risks of a construction project, whether those risks involve avoiding errors and rework, getting key stakeholder buy-in or ensured business continuity through increased resiliency.

Variation by BIM Intensity

As the table at mid-right shows, BIM intensity correlates directly with achieveing high/very high levels of risk reduction benefits for design firms.

- High BIM intensity has the biggest impact on improving the ability to manage complexity, reduce errors and rework and improve the ability to meet customer and design requirements.
- Even medium levels of BIM intensity correlate with experiencing increased stakeholder buy-in and ensured business continuity at a high/very high level.

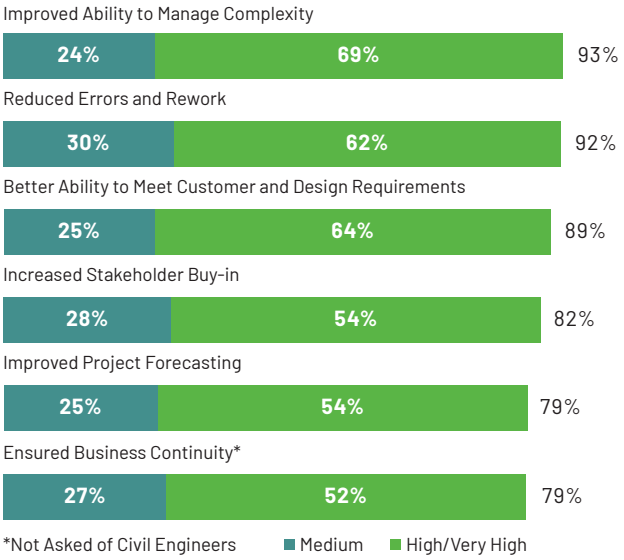
Variation by BIM Engagement

Design firms that are highly engaged with data-related activities far more frequently report experiencing increased stakeholder buy-in and reduced errors and rework at a high/very high level compared with those at low engagement.

Even medium engagement is enough to support the improved ability to manage complexity, with over three quarters of both those with medium and high engagement reporting that they experience this at a high/very high level, compared with 59% of those with a low degree of engagement.

Risk Reduction Benefits From BIM at Medium and High/Very High Levels (According to Designers)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Increased Stakeholder Buy-in	34%	60%	57%	57%
Improved Ability to Manage Complexity	58%	63%	68%	85%
Reduced Errors and Rework	52%	56%	63%	73%
Better Ability to Meet Customer and Design Requirements	50%	64%	64%	73%

Impact of BIM Engagement on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Low Engagement (0–3 activities)	Medium Engagement (4–6 activities)	High Engagement (7 or more activities)
Increased Stakeholder Buy-in	50%	55%	61%
Improved Ability to Manage Complexity	59%	78%	78%
Reduced Errors and Rework	55%	64%	71%

Benefits
of Using BIM

Operational Efficiency Benefits for Designers From Using BIM

Designers also rated five operational efficiency benefits. The chart at right shows the medium and combined high/very high ratings.

Similar to the other benefits that designers experience from BIM, very high percentages report at least a medium level of operational efficiency benefits, and among those, the majority are at a high/very high level.

Most notable is improved team collaboration, which is the most highly rated benefit for designers from BIM in the study. In all the research conducted by Dodge on BIM, improved collaboration has consistently been widely recognized as a top BIM benefit.

As a whole, the findings demonstrate that use of BIM improves the efficiency of the processes of designers in a significant way, including increasing their workload capacity, reducing overall design time and helping to create safer environments for the construction process.

Variation by BIM Intensity

BIM intensity correlates most strongly to two risk-reduction benefits.

- Design firms doing at least 50% of their work with BIM report higher levels of improved team collaboration. This makes sense because higher BIM usage increases the likelihood of working with other team members who have BIM experience and are capable of and interested in digital collaboration.
- Increased workload capacity also correlates to higher BIM intensity. This suggests that as usage increases, skills and efficiency also improve, generating a positive effect on productivity.

Variation by BIM Engagement

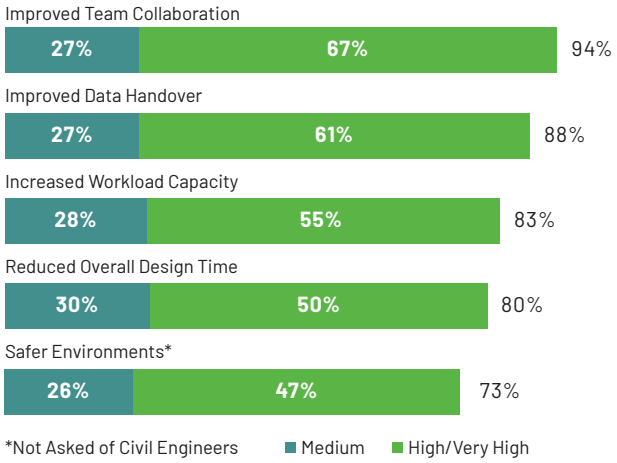
This is the only category of benefits with no significant differences by the degree of BIM engagement. This may be because the benefits generated from data-related activities accrue more directly to improving projects than to company operational performance.

Variation by Type of Company

More civil engineers report reduced overall design time (65%) and increased workload capacity (63%) at a high/very high level compared with building engineers (39% and 46%, respectively). Significantly fewer architects report reduced overall design time at that level as well. Again, with use of BIM for civil construction lagging behind building, it is possible that civil engineers may be noting operational efficiencies that others with longer BIM history may now take for granted.

Operational Efficiency Benefits From BIM at Medium and High/Very High Levels (According to Designers)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Team Collaboration	60%	56%	71%	77%
Increased Workload Capacity	42%	55%	60%	56%

Benefits
of Using BIM

Benefits for Designers From Using BIM by Region

To compare the findings across the seven regions included in the study, their average ratings for each benefit were converted to a 100-point index. The average score for each of the four categories are shown in the charts below.

Business Growth Benefits

The top three regions for this category are Scandinavia, Japan and Australia/New Zealand.

- All three report particularly high scores for improving design quality.
- Scandinavia also scores very highly on attracting and retaining top talent, Japan on improved win rate and Australia/New Zealand on improved client satisfaction.

Sustainability Benefits

The top two regions for this category are Scandinavia and Japan. North America has the lowest average.

- Japan's designers have particularly high ratings for increased ability to consider environmental impact during design and exceeding performance requirements.
- Scandinavia has consistently strong scores for all sustainability benefits, but the two highest are reduced material usage and reduced or removed emissions.

Risk Reduction Benefits

Strong index scores are seen for most regions here, with Scandinavia on top. North America and the UK/Ireland lag a bit behind the others.

- There are a few average index scores of 80 or above in this category: better ability to meet customer and design requirements in Scandinavia, improved project forecasting and improved ability to manage complexity in Japan, and reduced errors and rework in Australia/New Zealand.

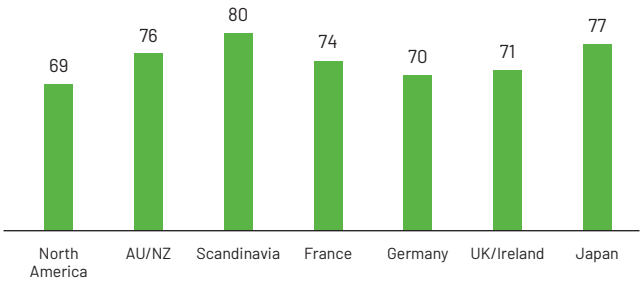
Operational Efficiency

Scandinavia, Japan and Australia/New Zealand all have top scores for this category, and North America has the lowest.

- The highest rating for operational efficiency benefits is a score of 82 in Scandinavia for increased workload capacity.

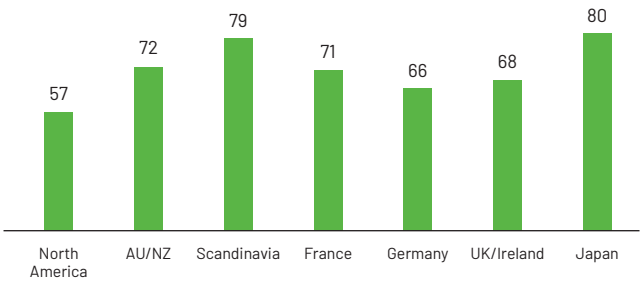
Business Growth Benefits (Average Index Score)

Dodge Data & Analytics, 2021



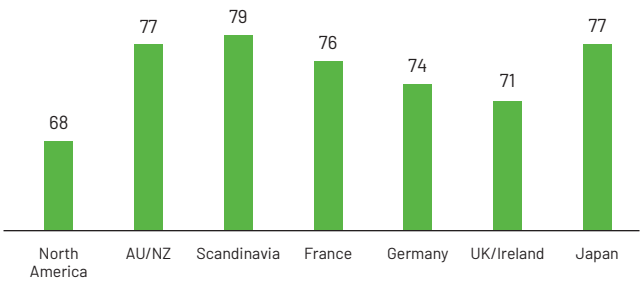
Sustainability Benefits (Average Index Score)

Dodge Data & Analytics, 2021



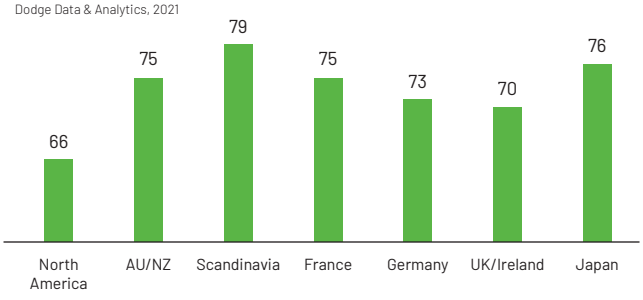
Risk Reduction Benefits (Average Index Score)

Dodge Data & Analytics, 2021



Operational Efficiency Benefits (Average Index Score)

Dodge Data & Analytics, 2021



Benefits
of Using BIM

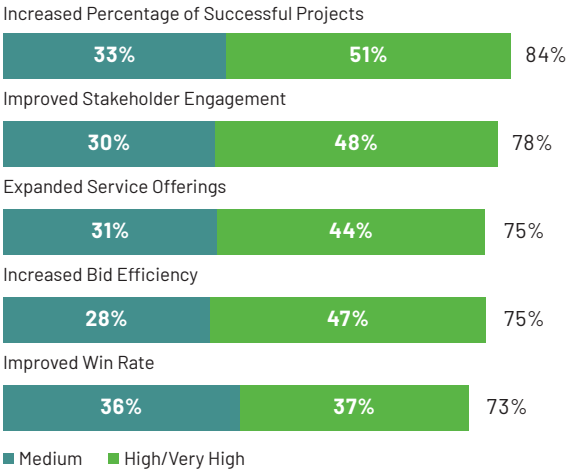
Business Benefits for Contractors From Using BIM

Contractors who use BIM were asked to rate the degree to which they experience five business benefits from their BIM use on a five-point scale (no, low, medium, high or very high). The chart at right shows the percentages who rate each as either medium or the combined values for high and very high.

- As with designers (see page 22), the vast majority of contractors (around three quarters or more) find a medium or higher degree of benefit for each of these five.
- An increased percentage of successful projects is the top overall benefit experienced at a medium or higher level. This top rating is a powerful testament to BIM's contribution to overall business health and success.
- Nearly half of all respondents experience the top four of these benefits at a high/very high level, demonstrating that many contractors experience a significant business value from their use of BIM.

Business Benefits From BIM at Medium and High/Very High Levels (According to Contractors)

Dodge Data & Analytics, 2021



Variation by BIM Intensity

The table at middle demonstrates how BIM intensity influences the percentages reporting high/very high ratings for several of the business benefits measured. Contractors implementing BIM on at least half of their projects (medium or high intensity) outperform those less frequently deploying it, particularly those in the very low intensity tier.

The slight decline in percentages among those at the highest level may be because they no longer have a sufficient sample of recent projects that do not use BIM to fully evaluate what level of incremental benefit they are currently achieving from BIM. For them BIM may be regarded simply as the way they do business. But those at medium intensity still have a substantial share of projects not using BIM, and can better understand the full benefits they are able to achieve from its use.

Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Win Rate	13%	42%	47%	35%
Improved Stakeholder Engagement	21%	52%	61%	50%
Increased Percentage of Successful Projects	36%	49%	61%	59%

Variation by BIM Engagement

Contractors who engage in a high level of data-related activities are far more likely to report a high/very high level of improved stakeholder engagement, and even a medium level in these activities has a positive impact on improving win rate and increased bid efficiency.

Impact of BIM Engagement on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Low Engagement (0–3 activities)	Medium Engagement (4–6 activities)	High Engagement (7 or more activities)
Improved Win Rate	27%	43%	44%
Increased Bid Efficiency	38%	53%	54%
Improved Stakeholder Engagement	40%	46%	64%

Quality Benefits for Contractors From Using BIM

Contractors also rated four quality-related benefits. The chart at right shows the medium and combined high/very high ratings.

The findings clearly demonstrate that contractors who use BIM believe it improves quality performance, with over 80% reporting medium or higher levels of impact in all four categories studied. Also important to note is that over half of contractors give high/very high ratings.

Variation by BIM Intensity

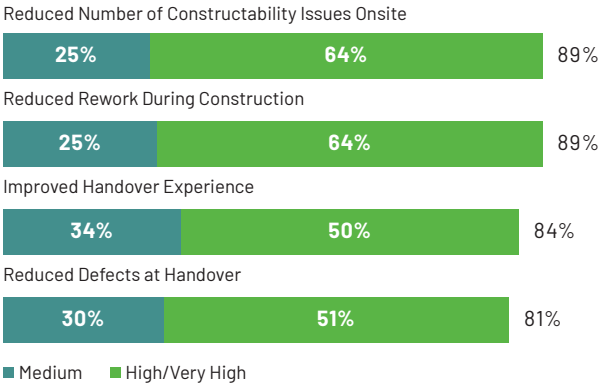
Higher BIM intensity correlates to high/very high ratings for the quality benefits shown in the table at middle. Interestingly, contractors in the low intensity group (25%–49% of projects) score highest for an improved handover experience. And well over half of those at the lowest level of BIM intensity report reduced number of constructability issues onsite. These findings suggest that some benefits can emerge early in a company's BIM journey.

Variation by BIM Engagement

Contractors at medium or high engagement with the data-related activities studied more frequently report that BIM has a high/very high impact on reducing the number of constructability issues onsite. That makes sense because many of these activities help with both the accuracy of the design and better understanding of the site before construction begins, therefore contractors conducting them are likely to be better prepared to deal with any site-related issues.

Quality Benefits From BIM at Medium and High/Very High Levels (According to Contractors)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Reduced Number of Constructability Issues Onsite	56%	58%	69%	79%
Reduced Defects at Handover	36%	49%	57%	65%
Improved Handover Experience	31%	61%	47%	53%

Impact of BIM Engagement on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Low Engagement (0–3 activities)	Medium Engagement (4–6 activities)	High Engagement (7 or more activities)
Reduced Number of Constructability Issues Onsite	55%	70%	70%

Cost Control Benefits for Contractors From Using BIM

Contractors also rated four cost control benefits. The chart at right shows the medium and combined high/very high ratings.

As with the quality benefits, cost control benefits are widely experienced by contractors using BIM. Over 70% report that they experience them at a medium or higher level, and a majority of those give the top ratings.

In this case, the percentages reporting these benefits are remarkably consistent, suggesting that all contractors should be able to rely on achieving them.

Variation by BIM Intensity

BIM intensity correlates to high/very high ratings for the three benefits shown in the table at middle. In each case, even a low level of BIM intensity (25% to 49%) leads to a much higher rating than the very low intensity one. This suggests that these benefits are achievable relatively early in a company's usage of BIM.

Variation by BIM Engagement

There are no significant differences in the responses based on their use of the data-related activities studied.

Variation by Size of Company

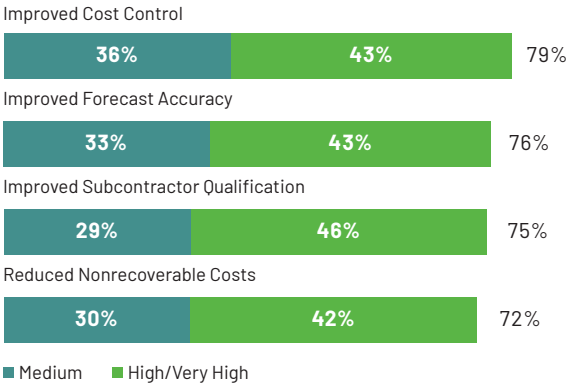
Midsize contractors (100 to 499 employees) are most strongly experiencing some cost control benefits from BIM at a high/very high level.

- **Nonrecoverable costs:** 62% of midsize companies, compared with 44% of larger ones and 31% of smaller ones.
- **Improved subcontractor qualification:** 60% of midsize companies, compared with 42% of larger and smaller ones.

It is possible that midsize companies have fewer resources to dedicate toward cost control than larger companies and more complicated cost control issues than smaller ones, leading them to benefit most in this area from the use of BIM.

Cost Control Benefits From BIM at Moderate and High/Very High Levels (According to Contractors)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Subcontractor Qualification	28%	51%	53%	44%
Reduced Nonrecoverable Costs	13%	48%	51%	50%
Improved Cost Control	21%	48%	53%	44%

Benefits
of Using BIM

Schedule Benefits for Contractors From Using BIM

Contractors also rated four schedule benefits. The chart at right shows the medium and combined high/very high ratings.

As with quality and cost, these findings show that the vast majority are achieving measurable schedule benefits from BIM. And again, the larger share are at high/very high levels. The consistency of percentages also sugests that these should be reliably achievable benefits for all contractors.

Variation by BIM Intensity

The most pronounced differences in the percentages of contractors reporting high/very high ratings are between those at very low intensity (1%–25% of projects) and those at higher levels. This suggests that these benefits are relatively easy to achieve even with moderate deployment of BIM.

Variation by BIM Engagement

Similar to the cost control benefits, there are no significant differences in response by the number of data-related activities conducted.

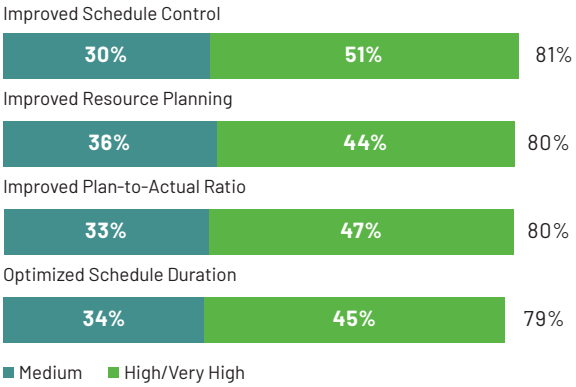
Variation by Size of Company

Again, similar to the cost control benefits, several schedule benefits are more frequently experienced at a high/very high level by midsize contractors, including the following.

- **Optimized schedule duration:** 55% of midsize companies, significantly higher than 35% of very small companies and directionally higher than small (50%) or large (40%) companies.
- **Improved schedule control:** 62% of midsize companies, significantly higher than 39% of large companies and directionally higher than smaller ones (53%).
- **Improved resource planning:** 62% of midsize companies, significantly higher than very small (31%) and large (39%) companies and directionally higher than small ones (45%).

Schedule Benefits From BIM at Moderate and High/Very High Levels (According to Contractors)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Plan-to-Actual Ratio	31%	49%	53%	50%
Improved Schedule Control	36%	58%	57%	47%

Benefits
of Using BIM

Health and Safety Benefits for Contractors From Using BIM

Contractors also rated five health and safety benefits. The chart at right shows the medium and combined high/very high ratings.

Though reported by a lower overall percentage of contractors than the three previous categories of benefits, the majority are still experiencing measurable health and safety benefits from BIM. Also varying from the pattern of the previous contractor benefits, the percentages of those at a medium level are much closer to those at high/very high.

There is also a bigger range between the total percentages of medium and high/very high ratings.

- **The most frequent health and safety benefit reported is reduced number of man-hours onsite.** This corresponds to the high scores for resource planning and emphasizes the importance of using BIM to manage the jobsite better.
- **Improved safety awareness is also frequently reported.** Use of BIM can provide better insight into the project design as well as the site conditions, which can allow for better safety planning.
- **Reduced insurance premiums is least frequently reported.** This aligns with a Dodge study titled *Using Technology to Improve Risk Management*, in which many insurance companies say they are waiting for more quantitative proof of technology's impact on risk reduction before reducing premiums based just on its use by their customers.

Variation by BIM Intensity

As the table at right reveals, for all five of the health and safety benefits, engagement beyond a low level with BIM yields a much greater likelihood that contractors will experience these benefits at a high level. This is consistent with previous findings from other studies conducted by Dodge that suggest that recognition of the health and safety benefits from BIM tends to come from those who have moved beyond a superficial engagement with it.

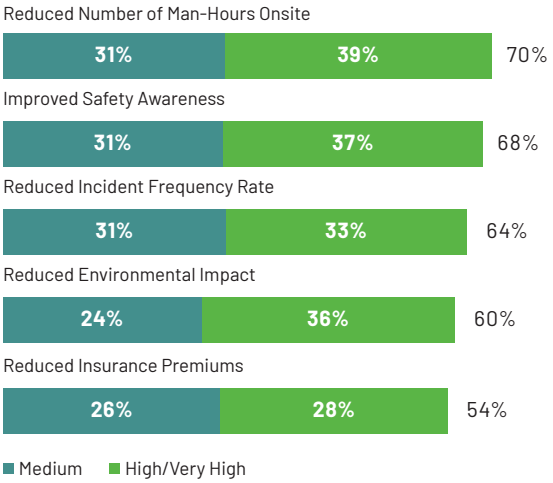
This finding is critical because contractors have always placed great weight on safety improvements and may be more likely to prioritize ways to improve health in the post-Covid era. Understanding that the majority of contractors experience these benefits at a medium or higher level, and that one third to one half of those using BIM on more than 25% of their projects report significant improvements may help contractors see critical value beyond just cost and schedule in their investments in BIM.

Variation by Size of Company

Midsize companies most frequently report high levels of several health and safety benefits from BIM.

Health & Safety Benefits From BIM at Moderate and High/Very High Levels (According to Contractors)

Dodge Data & Analytics, 2021



Impact of BIM Intensity on High/Very High Levels of Benefits

Dodge Data & Analytics, 2021

	Very Low Intensity (1%–24% of projects)	Low Intensity (25%–49% of projects)	Medium Intensity (50%–74% of projects)	High Intensity (75%–100% of projects)
Improved Safety Awareness	21%	45%	41%	32%
Reduced Insurance Premiums	5%	38%	33%	24%
Reduced Number of Man-Hours Onsite	13%	49%	45%	35%
Reduced Incident Frequency Rate	10%	39%	43%	32%
Reduced Environmental Impact	5%	44%	53%	26%

- **Reduced insurance premiums:** 47% of midsize companies versus all other sizes at 25% or less.
- **Reduced number of man-hours onsite:** 53% of midsize companies, significantly more than very small (31%) or large (28%) companies.
- **Reduced incident frequency rate:** 45% of midsize companies, significantly more than very small companies (24%) and notably more than small (36%) or large (32%) ones.

Benefits
of Using BIM

Benefits for Contractors From Using BIM by Region

To compare the contractor benefits by region, a similar approach to the one used to understand the designer benefits was employed: their average ratings of each benefit were converted to a 100-point index. Since there were fewer contractors than designers who responded to the survey, though, the comparison is on a broadly regional basis, between North America, Europe (including the UK) and the countries in the eastern hemisphere (Japan, Australia and New Zealand).

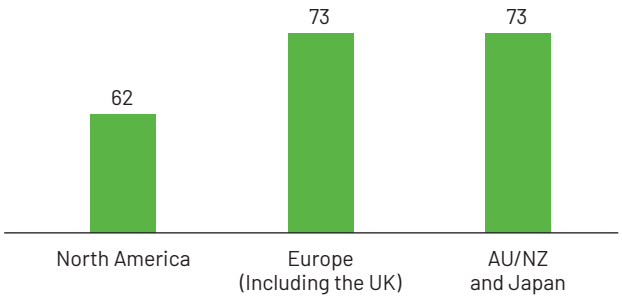
These findings show the following:

- North American contractors tend to report lower business growth and cost benefits, but they are particularly enthusiastic about the quality benefits they derive from BIM. These findings correspond with the lower use of BIM activities reported in North America, which clearly have the biggest impact on cost and business-related benefits.
- Contractors from Europe more frequently report cost benefits from BIM than the other two regions, but their general score for cost benefits matches their score for business growth and quality benefits.
- Other than cost benefits, the findings from Australia/New Zealand and Japan correspond closely to the findings from Europe.

The findings suggest that North American contractors may need to engage more intensively with BIM and its tools to remain competitive in a global market.

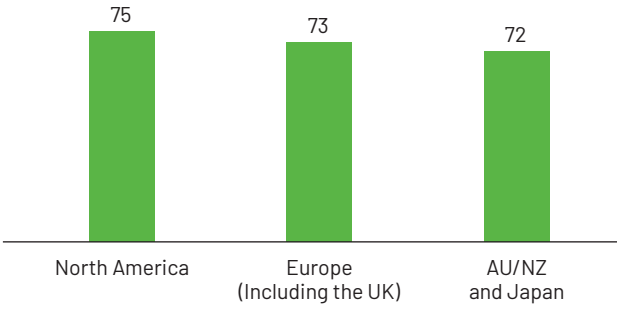
Business Growth Benefits

Dodge Data & Analytics, 2021



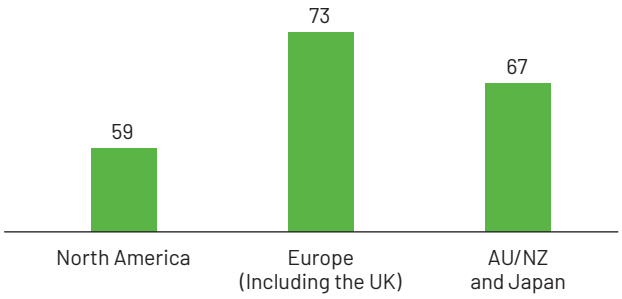
Quality Benefits

Dodge Data & Analytics, 2021



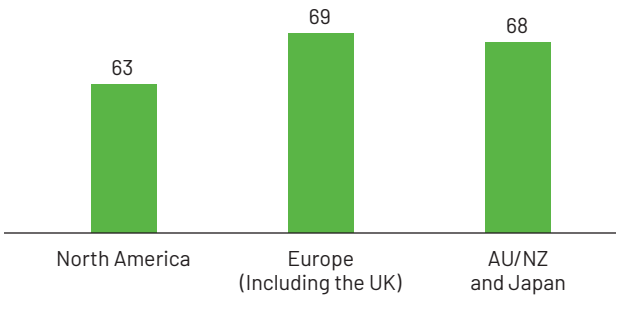
Cost Benefits

Dodge Data & Analytics, 2021



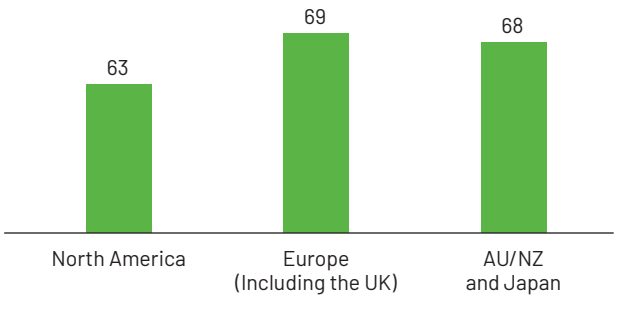
Schedule Benefits

Dodge Data & Analytics, 2021



Safety Benefits

Dodge Data & Analytics, 2021



Benefits
of Using BIM

Degree to Which the Value of BIM Is Being Experienced

In addition to asking designers and contractors about the tangible, measurable ways in which BIM provides value, shown over the preceding pages, they were also asked to share their overall sense for how much of BIM's potential value they are currently experiencing.

Responses are largely influenced by a company's level of BIM intensity (the percentage of projects where they use BIM), so those findings are shown in the chart at bottom.

- Even among the least intense BIM users (fewer than a quarter of projects), the percentages believing they are getting no meaningful value from BIM are very small.
- As users increase their deployment of BIM, there is a dramatic shift from percentages believing they are just getting started receiving BIM benefits and those reporting a lot of value and still seeing more to gain. This clearly indicates that higher intensity generates greater value.
- The small percentages in all tiers of BIM intensity who believe they have reached the maximum level of BIM benefits is also small. This is a positive sign that most users are not willing to be complacent with what they have achieved and will continue to innovate and optimize.

Variation by Company-Type

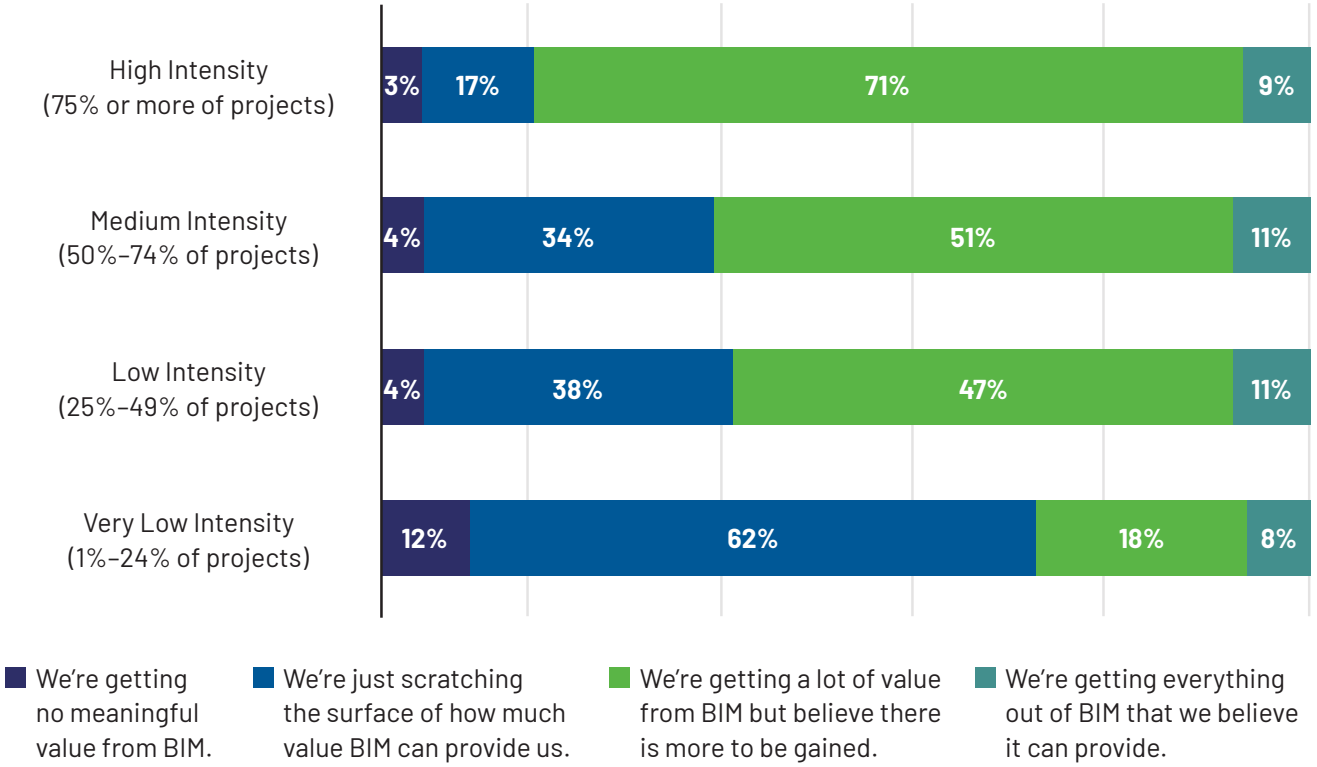
Architects have the highest percentage (54%) who state that they get a lot of value from BIM but believe there is more to be gained. Their responses are slightly higher than the engineers, but even more so for the contractors (45%).

Variation by Company Size

Large companies with 500 or more employees are far more likely to report that they get a lot of value out of BIM with more to be gained (60%) than do smaller companies. This makes sense because they tend to have higher BIM intensity.

Value of BIM by Level of BIM Intensity

Dodge Data & Analytics, 2021



Impact of BIM on Design/Construction Industry Sustainability and Resiliency

The analysis tools that can be used with a BIM model are a critical part of how BIM can improve the sustainability and resiliency of design and construction projects.

On page 23, designers were asked to evaluate several specific sustainability benefits they have been able to achieve through use of BIM. However, use of BIM has also had a broader impact on sustainability by driving awareness and prioritization of project performance and enabling more ambitious goals for sustainability and resiliency. That broader impact is felt across the industry and is difficult to ascertain just from the review of the specific benefits.

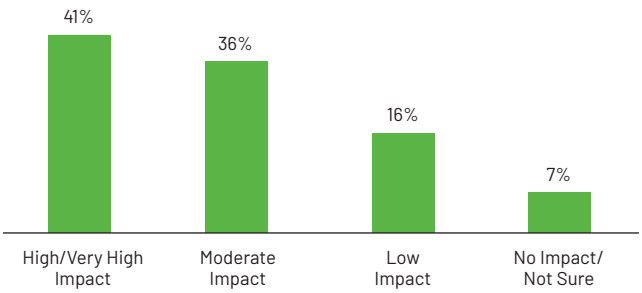
Therefore, all respondents were asked to rate what they believe will be the overall impact of using BIM on the sustainability and resiliency in design and construction over the next two years. The findings represented in the chart at right clearly indicate that nearly all design and construction professionals expect BIM to help the industry improve in these areas, with the highest percentage (41%) expecting a high/very high impact.

Variation by Company-Type

Fewer contractors (31%) expect a high/very high impact from BIM on these areas than do architects and building engineers (both 47%). This is likely due to wider use of analysis tools by these designers than by the contractors.

Impact of Using BIM on the Sustainability and Resiliency of Design and Construction in the Next Two Years

Dodge Data & Analytics, 2021



Benefits
of Using BIM

Top Means of Increasing Benefits Experienced From BIM

The findings on the specific benefits that designers and contractors experience from BIM, on pages 22 to 32, clearly demonstrate that BIM is adding value to the design and construction industry. However, they also reveal that many could increase the degree to which they experience those benefits.

In order to better understand how to increase the benefits experienced from BIM use, respondents were asked to select the top three means of doing so from each of the following:

- A list of seven industry resources
- A list of six technical and business factors

Industry Resources

The findings on the top industry resources in the chart at right reveal a tight cluster of four top ones related to BIM capabilities and usage across the project team.

- Nearly half (47%) cite more clearly defined BIM deliverables to help all team members more effectively contribute.
- Tied for the top spot at 47% is more internal staff with BIM skills. Despite industry use of BIM for decades, staff with BIM skills are still a high priority. This may also contribute to why so many believe that they can get more value from BIM than they are currently receiving (see page 33).
- 41% believe that owners asking for BIM would add value. Certainly, BIM requirements by owners would also help ensure that BIM is used by all members of the project team.
- 41% also are looking for BIM skills beyond their own firms. More information about how the designers and contractors regard the BIM skills of other project team members can be found on page 44.

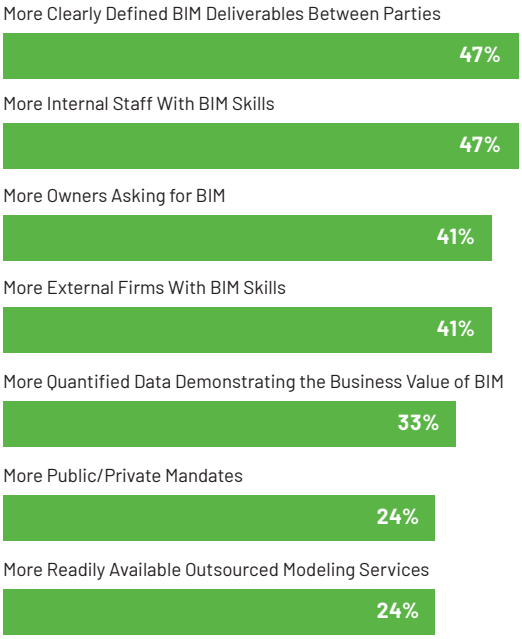
Between about one quarter to one third select the three remaining factors in their top three, revealing that all are important to a number of industry professionals. Two out of three of these factors are ones that would drive wider use of BIM in the industry: more quantified data demonstrating the business value of BIM and more public/private mandates. Some also consider greater access to outsourced modeling services an influential factor, probably because it helps to offset the need for more internal BIM skills and allows access to specialized BIM capabilities on an as-needed basis.

Variation by BIM Engagement

The highest percentage (55%) of those with low BIM engagement (using BIM on fewer than 25% of their projects) select more owners asking for BIM as one of the top ways they would get more value out of BIM.

Most Important Industry Resources for Increasing Benefits Experienced From BIM (Selected in the Top Three)

Dodge Data & Analytics, 2021



Top Means of Increasing Benefits Experienced From BIM CONTINUED

Technical and Business Factors

When selecting their top three technical and business factors that would help increase the benefits they can experience from BIM, design and construction professionals place the highest priority on two technical factors. Citing these factors suggests that they still see the need for technology improvements to get the most out of BIM.

- **Improved interoperability between software applications:** While this is a less prominent issue than when Dodge first began researching BIM over a decade ago, it is still a top technical factor. The ability to seamlessly integrate BIM with other applications, like GIS, would continue to increase its value to users.
- **Improved functionality of BIM solutions:** While there are a number of applications that help provide tools to use BIM (see pages 12 to 16), nearly half of users believe that improving their functionality would increase the value of BIM overall.

The third most important factor is more BIM training and support, which would be considered a business factor, rather than a technical one. The importance of this factor corresponds to the need for more internal staff with BIM skills reported under the industry resource factors (see page 35), and together, they demonstrate that the industry still needs further education and support on the use of BIM.

Over one third (37%) place more contracts that support BIM and collaboration in their top three. This also corresponds to the previous finding of the industry resources factors that overall team use of BIM is critical to derive the most value from it.

Finally, industry professionals are also looking for ways to make using BIM easier, from more product manufacturer BIM content to more integration of BIM data with mobile applications.

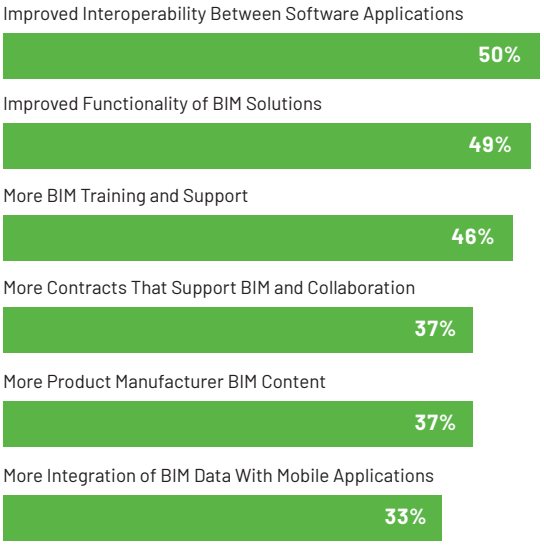
Variation by Company-Type

There are two notable variations by company-type.

- **Architects:** Far more architects (47%) believe that more product manufacturer content for BIM would increase their ability to experience benefits from BIM than do engineers or contractors.
- **Building Engineers:** 68% would get greater value from BIM with improved interoperability between software applications.

Most Important Technical and Business Factors for Increasing Benefits Experienced From BIM (Selected in the Top Three)

Dodge Data & Analytics, 2021



Variation by BIM Intensity

The highest percentage (63%) of those who have a low level of BIM intensity (fewer than 25% of projects using BIM) believe that they would be able to experience more benefits if they had more BIM training and support.

The highest percentage (61%) of those with a very high level of BIM intensity (75% or more of projects using BIM) would see increased value from BIM with improved interoperability between software applications.

Case Study

Vigentina 9 Office Building

MILAN, ITALY

Delivering new commercial office space within a dense urban core often presents design and construction teams with significant challenges. For the Vigentina 9 project in Milan, design firm Lombardini22 was tasked with the added complication of meeting the demands of local historical review board officials. In addition, the developer needed the project designed and completed on a tight timeline. With no room delay, the Lombardini22 team chose to heavily leverage BIM from the earliest stages of the project to help meet its ambitious goals.

Need for BIM Model and Point-Cloud Survey

"BIM was not required, but from the beginning we decided to approach the project with BIM from the feasibility study," says Andrea Meneghelli, project architect and BIM coordinator with Lombardini22. "Of course, there was an increase in information over time, but from the beginning [the model] was always evolving."

Meneghelli says the team needed detailed models early in order to meet the Commission for Cultural Heritage's strict guidelines—a hurdle it had to clear prior to submitting for a building permit. The existing 60,000-sq-ft building on the site, which opened in the 1960s, was not deemed historic, but the final design needed to fit within the historic context of the neighborhood, including the 16th-century Church of Santa Maria al Paradiso, which faces the building on one elevation.

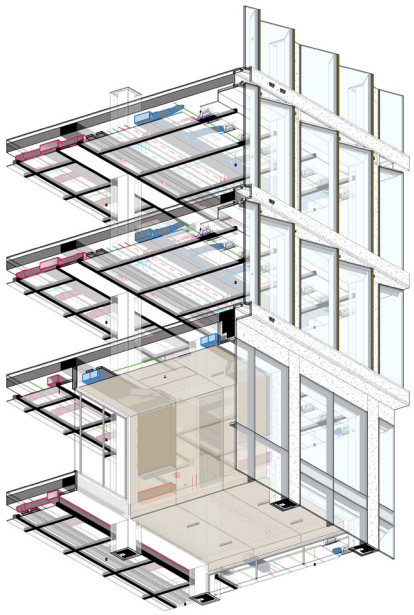
The building itself was approved for full demolition, but Meneghelli says the team decided instead to retain the existing structure, fully reconstructing the interiors and adding a new facade. He says the strategy would help reduce the construction schedule and keep the project on track.

Between the need to fit within the historical context of the neighborhood and the need to design around an existing structure, the team decided to conduct a point-cloud survey that would incorporate valuable details into its models.

"Being an historical site with a church just in front of the building... we had to prove how the design of the facade would work within the context," Meneghelli says. "The model and survey were needed in order to give a sense of the project."

Aiding the Approval Process

Unsure about how the project would be received by the commission, the team created two designs—one ambitious option and a more conservative one. Although the commission did not approve its first design, the team had its conservative option ready to submit quickly. Meneghelli says that being able to easily share common data between the two designs saved precious time on the project. He estimates that having to submit a new design to the commission using traditional methods would have added up to 30% more time.



The project team was able to tweak the model to increase its sustainability goals from achieve LEED Gold certification to LEED Platinum, including a redesign of the façade to reduce solar gain.

Project Facts and Figures

Project Name
Vigentina 9

Project Location
Milan, Italy

Designer
Lombardini22

Type of Project
Renovation (preserved structure)

Groundbreaking
February 2020

Completion
May 2021

Occupancy
November 2021 (estimated)

Images Courtesy of Lombardini22

Vigentina 9 Office Building

MILAN, ITALY

"We were able to retain some ability to make changes until the last day," he adds.

The final design called for reworking the four-level building's floor plans, including the removal of multiple existing sets of stairs to create additional open spaces and the construction of a new staircase. Other elements include renovation of a basement garage, new bathroom blocks, a new lobby and removal of several existing partitions to further open up the layout. Mechanical and electrical systems were also fully reconfigured.

The permit was submitted in November 2019. Although permitting authorities did not accept BIM models, Meneghelli says the team was able to provide more detailed 2D plans by using data from the models. The team was able to continue refining its design, while site demolition was underway with construction beginning in February 2020.

Consistent Project Data

Several of Lombardini22's in-house disciplines were engaged in the Vigentina 9 design—including mechanical, electrical and plumbing—which helped with seamless integration between various models. Structural engineering was handled by an outside firm and Meneghelli says Lombardini22 modeled those drawings to add them to its model. Ultimately, Meneghelli says elements of their design models exceeded LOD 300, even though they were not used by the construction team. He says the firm was able to use the detailed model for clash detection, taking on some efforts typically carried out by contractors during preconstruction. "It was a more proactive approach to the design," he says. "We could fix issues earlier."

The project team retained the existing structure, fully reconstructing the interiors and adding a new facade.

Data management was also a critical component of Lombardini22's strategy for keeping the project on schedule. Although the firm was the only member of the project team that directly worked in the BIM models, Meneghelli says the firm was able to clearly communicate with multiple other parties and expedite decision-making via cloud-based databases. In addition, he says the model proved helpful in cost controls, life safety and calculating LEED credits.

Achieving Tenant Goals

The project was originally designed to achieve LEED Gold certification, but after a tenant was secured for the project, Lombardini22 was asked to aim for LEED Platinum. "We used the model for fine-tuning to achieve Platinum," Meneghelli adds, noting that the team was a ble to further improve indoor air quality, as well as stormwater management, and redesign the façade to reduce solar gain.

When the tenant joined the team, the firm's detailed modeling efforts also proved valuable in designing the fit-out. "The fit-out was done by a colleague of mine," Meneghelli recalls. "We had a specific advantage because [my colleague] was able to work from our model."

Base building construction was completed on schedule in mid-May 2021 with occupancy scheduled for November 2021.

Overall, Meneghelli says the main advantage of its BIM strategy was "being adaptable to different scenarios without having to throw anything away." He adds that the ability to leverage a detailed model and make decisions quickly proved particularly important in expediting permitting and approvals. Meneghelli also notes that having consistent project data helped the multiple disciplines that worked from the models meet the project's aggressive timeline.

"We could all work together, which is a big savings from a design point of view," he adds. ■

Images Courtesy of Lombardini22

Data: BIM Investments & ROI

Investments in BIM

To determine where companies will be investing in their BIM programs over the next two years, respondents were asked to identify their top three investment targets from a list of seven shown in the charts on these two pages. The findings in the charts are:

- Divided between technologies and processes
- Indexed on a scale of 1–100 for ease of relative comparison

Technology-Related BIM Investments

This category focuses on investments in software, hardware, and the customizations and content that optimize their use.

Variation by Length of Time Using BIM

The chart at upper right shows how plans for technology-related investments vary by the length of time a company has been using BIM. The findings suggest a natural evolutionary cycle of BIM investment from an initial adoption period, into a middle stage of program expansion, then stabilizing for the long run.

- The newest BIM users have the highest focus on content libraries, which makes sense as a high need during that early stage of engagement.
- Companies in the midrange of duration are actively expanding their BIM programs, therefore they are the most active overall and lead in software and customization.
- Following this cycle, hardware investments increase directly with duration, which makes sense because as companies become more engaged they need more robust devices to support increasingly sophisticated uses of BIM.
- And conversely, the need for content decreases over time, reinforcing that it is primarily an early-stage investment.

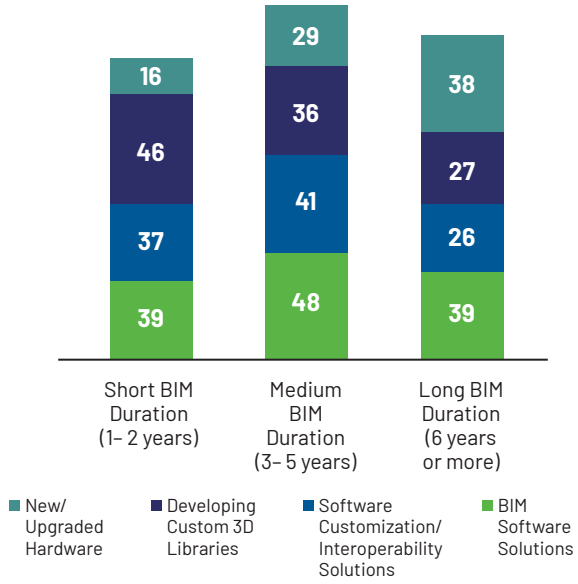
Variation by Company-Type

The chart at lower right shows how plans for technology-related investments vary by company-type, regardless of BIM duration.

- **Architects:** They are primarily focused on upgraded hardware and developing custom 3D libraries of content.
- **MEP and structural engineers:** Showing the most active plans for technology-related investments overall, they are particularly targeting software, customization and content.
- **Civil engineers:** Ranking second overall, they are also focused on software and content, though less interested in customization.
- **Contractors:** While highly focused on software and customization, they are lowest on content, likely because they have less frequent need to author models.

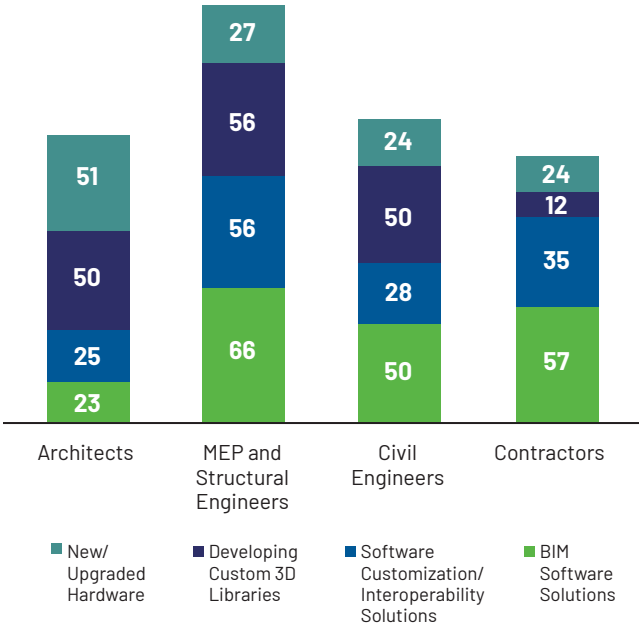
Technology-Related BIM Investments by Length of Time Using BIM (1–100 scale)

Dodge Data & Analytics, 2021



Technology-Related BIM Investments by Company-Type (1–100 scale)

Dodge Data & Analytics, 2021



BIM Investments & ROI

Investments in BIM CONTINUED

Process-Related BIM Investments

This category focuses on BIM training and the development of internal and external collaborative processes that optimize the value of BIM for integrated digital workflows. Although these represent only three of the seven options from which respondents identified their top three investment targets, each scores notably higher than any of the technology-related investments. This highligts the importance BIM users place on this overall category of investment.

Variation by Length of Time Using BIM

The chart at upper right shows how plans for process-related investments vary by the length of time a company has been using BIM. When compared with the evolutionary cycle of technology-related investments, which peak in middle years, these findings clearly show that processes become increasingly important to continue adding value to BIM programs.

While investment in training is relatively consistent over time, the focus on collaborative processes steadily grows. This suggests that as companies continue to use BIM, they increasingly appreciate its critical contribution to facilitating integrated digital workflows that improve multiparty decision-making and project outcomes for all stakeholders.

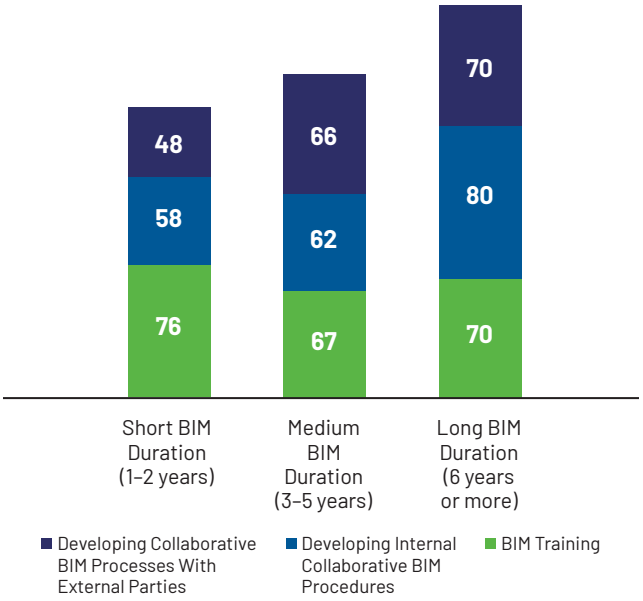
Variation by Company-Type

The chart at lower right shows how plans for these investment types vary by company-type, regardless of BIM duration.

- All company-types show keen interest in collaborative processes, especially civil engineers, who are the most active overall among the company-types.
- Interestingly, MEP and structural engineers, while most active in technology-related investments, are least active in this category, with a particularly low focus on BIM training. This may suggest that these companies would benefit from a greater focus on training to optimize their technology investments. (See page 41 for more detail on MEP and Structural Engineers' perception of the return on their investments in BIM.)

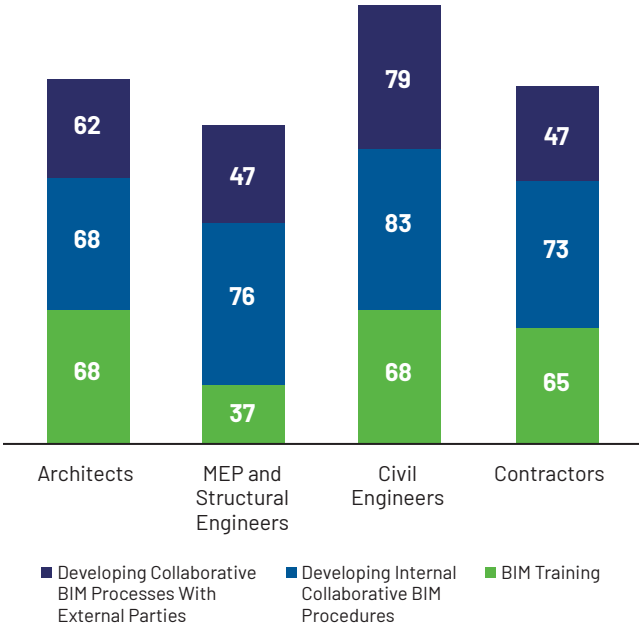
Process-Related BIM Investments by Length of Time Using BIM (1–100 scale)

Dodge Data & Analytics, 2021



Process-Related BIM Investments by Company Type (1–100 scale)

Dodge Data & Analytics, 2021



BIM Investments & ROI

Perceived ROI on BIM

There is no standard, globally accepted method for calculating the ROI (return on invetsment) on BIM. So respondents were asked, when considering the investments their company has made and the value their company has experienced, to select a range that best reflects their current perceived ROI on their overall investment in BIM.

Variation by BIM Intensity and Duration

The chart at upper right shows how the percentage of companies reporting very high (50% or better) ROI increases based on the percentage of projects where BIM is deployed (intensity) and the number of years a company has been using BIM (duration).

Although both show meaningful impacts, the findings indicate that ROI correlates more to BIM intensity than to BIM duration. This is meaningful because while users cannot change the date they began using BIM, they have control over the percentage of their projects where they implement it, putting ROI improvement within reach of all users.

Variation by Company-Type

The chart at lower right shows the responses for all levels of ROI divided by the four types of companies studied.

- Overall, architects report the best ROI. This aligns with findings about their longer duration (see page 9) and higher intensity (see page 4).
- Civil engineers and architects have almost equal percentages reporting high or very high (25% or more) ROI.
- MEP and structural engineers show the highest percentages at either breakeven or negative. This also aligns with findings on duration (see page 9) and intensity (see page 4).

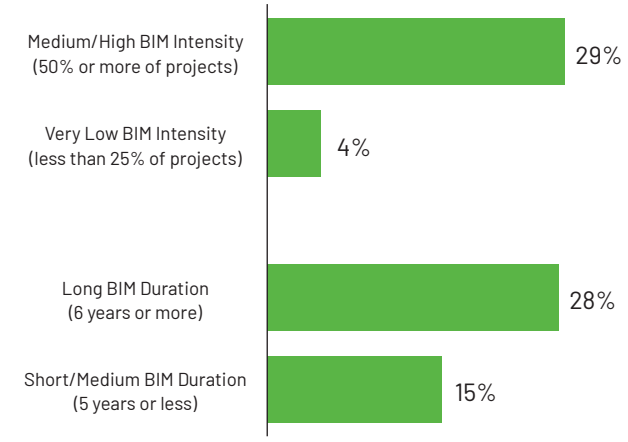
Variation by Region

There are some variations in perceived ROI by region.

- **Negative or breakeven:** North America (31%) leads, followed by France (24%) and Germany (20%). UK/Ireland and AU/NZ each report only 10%, and no users in either Scandinavia or Japan report this level.
- **Positive ROI but less than 50%:** This is the most frequently reported level, ranging from 51% in North America to 81% in Japan. Not surprisingly, it is led by the four regions noted above that have few or no users reporting negative or breakeven.
- **50% ROI or greater:** Scandinavia (25%), Germany (23%) and UK/Ireland (23%) lead in this category with AU/NZ the lowest (13%).

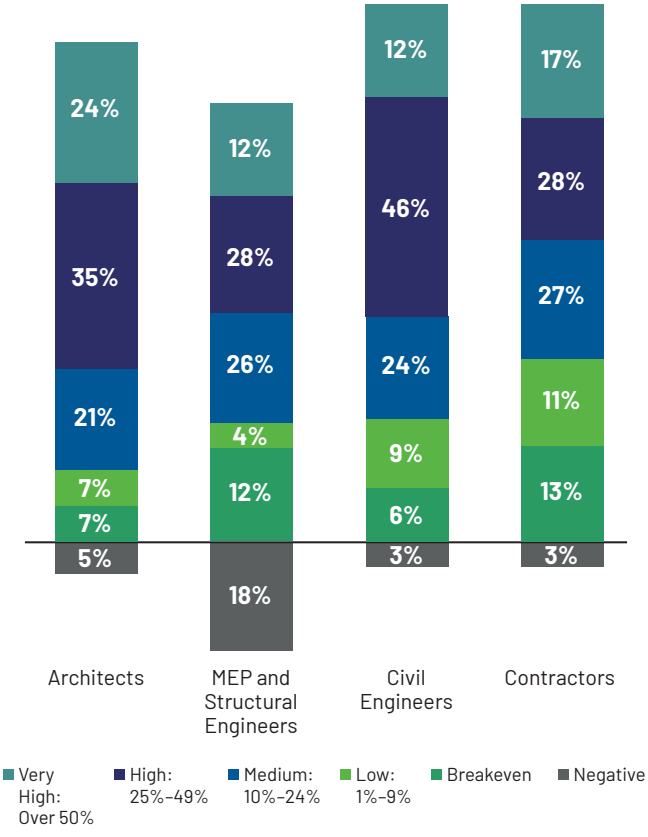
Impact of BIM Duration and Intensity on Achieving 50% or Higher ROI

Dodge Data & Analytics, 2021



Perceived ROI on BIM by Company-Type

Dodge Data & Analytics, 2021



BIM Investments & ROI

Frequency of Formally Measuring BIM ROI

Although there is no standard, globally accepted method for calculating ROI (return on investment) for BIM, about 80% of the companies surveyed report that they have developed their own approach to formally measure ROI and apply it to some percentage of their projects. The charts on this page evaluate that practice.

Variation by Company-Type

The chart at bottom left shows the differences in frequency between the four types of companies studied compared with all respondents.

- Very few users are formally measuring ROI on more than 75% of their projects, but most are doing so on 25% to 75% of their projects. This is particularly true for civil engineers, where over two thirds (68%) report measuring at that frequency.
- While frequency is generally consistent between architects and contractors, the two types of engineers surveyed represent the two extremes, with civil engineers the highest and MEP and structural engineers the lowest.

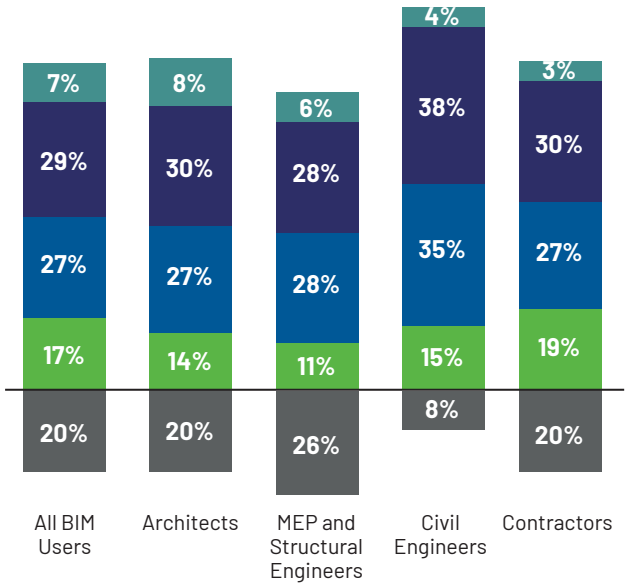
Variation by BIM Intensity

The chart at bottom right shows the differences in frequency between companies based on the percentage of their projects where they use BIM (intensity).

The pattern shows that formal measurement of ROI peaks among companies doing 25% to 50% of their projects with BIM, and declines after that, particularly among the highest intensity group (75% or more projects with BIM). This suggests that with greater experience, users come to accept that BIM is making a positive contribution and feel less of a need to formally measure its ROI. This finding is consistent with other technology-related studies conducted by Dodge over the years.

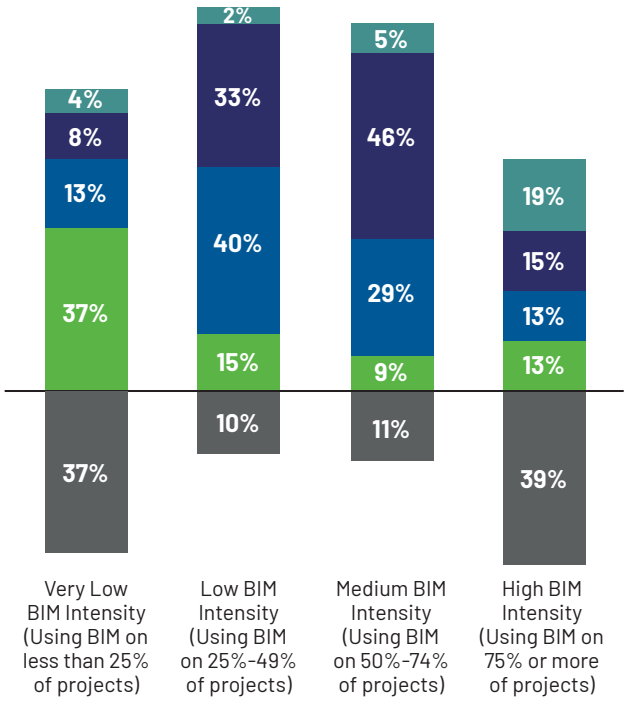
Frequency of Measuring ROI by Company-Type

Dodge Data & Analytics, 2021



Frequency of Measuring ROI by BIM Intensity

Dodge Data & Analytics, 2021



VERY HIGH 75%–100% of projects
HIGH 50%–74% of projects
MEDIUM 25%–49% of projects
LOW 1%–24% of projects
NONE Do not measure ROI

BIM Investments & ROI

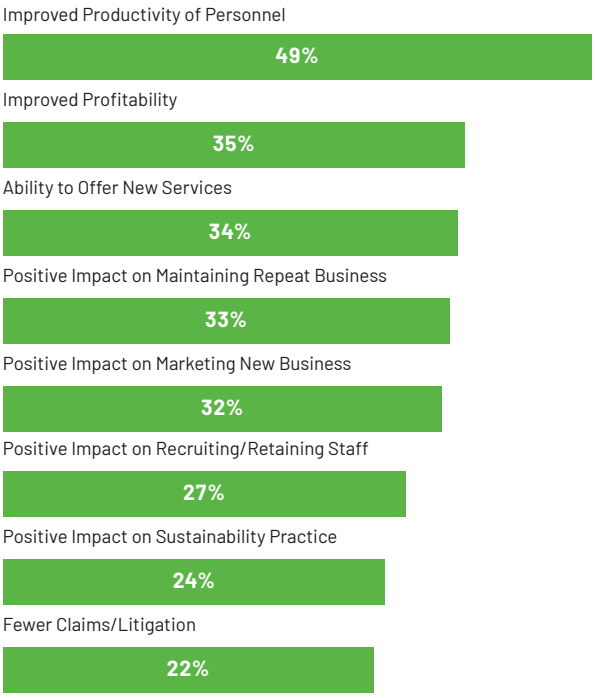
Business Benefits of Improving ROI on BIM

As shown on the previous page, increased use of BIM correlates directly to higher ROI. To relate this increased ROI to improved business health, respondents were asked to select the top three internal benefits, from the list of eight shown in the chart at right, they have experienced as a result of improving their BIM ROI.

Each of the eight was identified by at least 20% of respondents, indicating that companies are enjoying a wide variety of business benefits as they increase their ROI on BIM.

Top Internal Benefits From Improving ROI on BIM (Percentage Selecting Each as Among Top Three From List)

Dodge Data & Analytics, 2021



Variation by Company-Type

Each company-type in the study reports different levels of improved business benefits.

- **Architects:** They are within three percentage points of the averages shown in the chart for all eight internal benefits.
- **MEP and structural engineers:** This group reports a major impact on offering new services (47%) and is well above average on marketing new business (39%), but notably lags on improved profitability (25%).
- **Civil engineers:** These engineers are significantly above average for positive impacts on recruiting/retaining staff (46%), marketing new business (42%), sustainability (32%) and offering new services (42%). But this is offset by very low ratings for productivity (34%) and profitability (27%), which are the two most frequently reported across all respondents.
- **Contractors:** This group reports above-average impacts on profitability (43%), productivity (53%) and maintaining repeat business (37%), but lags on sustainability (18%).

Variation by Region

The business benefits of improved BIM ROI also vary by region.

- **North America:** Productivity (63%) far exceeds the global average and profitability (39%) also rates strongly here. Unfortunately the other six benefits are reported at below-average frequencies, especially sustainability (13%).
- **Australia/New Zealand:** Similarly strong in productivity (52%) and profitablity (42%) this region also comes in above average for fewer claims/litigation (28%). Only marketing new business (27%) falls significantly short of the average.
- **Scandinavia:** This region leads all others in reporting the positive impact on sustainability (37%). It is also notably above average for marketing new business (38%) and maintaining repeat business (33%).
- **France:** Although France has by far the fewest reporting a positive impact on productivity (30%), it boasts above-average ratings for positive impacts on maintaining repeat business (42%), recruiting/retaining staff (36%) and fewer claims/litigation (27%).
- **Germany:** The ability to offer new services (44%) is the highest here among all regions, indicating an innovative spirit. Marketing new business (37%) is also above average, although profitability (20%) and fewer claims/litigation (14%) are both the lowest reported in any region.
- **UK/Ireland:** Although somewhat low on improved productivity (44%), this region scores next-highest overall in the ability to offer new services (42%) and is also well above the norm for sustainability (32%).
- **Japan:** This region is an exercise in extremes, with recruiting and retaining staff (39%), sustainability (36%), marketing new business (43%) and maintaining repeat business (39%) all well above average, while productivity (39%), profitability (31%) and offering new services (30%) are below.

Data: Project Team Engagement
With BIM

Project Team Engagement With BIM

The study findings clearly demonstrate that one of the most important areas needed to gain value out of BIM is its use across the project team (see page 35). To do so requires a project team with sufficient BIM skills to work effectively with the model.

To better understand BIM users' perspective on the skills of other companies they work with they were asked two questions :

- The degree of BIM skills that they expect from other project team members, including owners and facility managers.
- Their degree of satisfaction with the BIM skills of each, based on their experiences.

For each company-type in the chart below, the left column shows the percentage of all BIM users surveyed who expect that group to have full BIM usage capability, and the center column shows the number expecting them to just have the ability to read BIM. (No BIM skills are expected by the remaining percentage that would total 100%.) The right column shows the share who are satisfied with the BIM skills they encounter in that group.

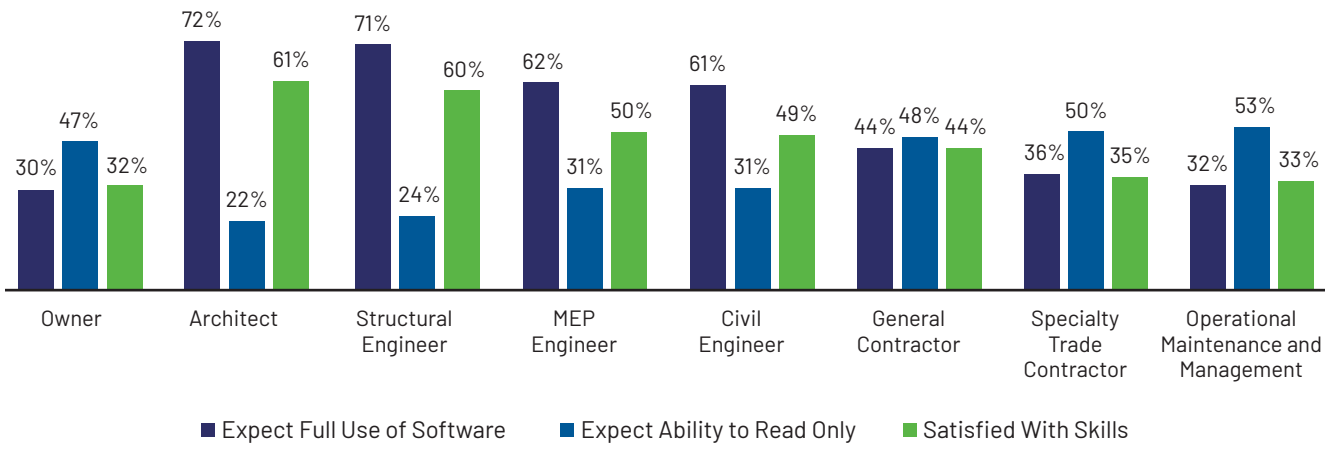
- **Architects and structural engineers:** Over 70% of all the BIM users expect architects and structural engineers to have good BIM skills, and around 60% report that they are satisfied with their skills, the highest for any of the players.
- **MEP and civil engineers:** 60% or more of all the BIM users expect MEP and civil engineers to have full use of BIM software. Only about half, though, report being satisfied with the skills they find for these engineers.
- **Contractors:** BIM users surveyed are nearly evenly split between those who expect general contractors to have full use of BIM software and those who only expect these companies to be able to read BIM. In contrast, far fewer expect specialty trade contractors to have BIM skills than those who anticipate that they can only read the models. They are also far less satisfied with the skills of the trades they have encountered than they are with the skills of the GCs, which no doubt influences their expectations.
- **Owners:** Fewer than one third expect owners or facility managers to be able to use BIM, but about half do expect that they can read a model. Only about one third also are satisfied with the BIM skills among owners.
- **Peers:** Consistently, architects, engineers and contractors are more satisfied with the skill level of their own company-type than others. However, it is notable that,other than building engineers and architects, most have a large share (one third or more) who are not even satisfied with the skills of their peers.

Improving BIM Skills

As shown in the chart, satisfaction is generally under 50%. In order to improve, the design and construction industry needs to have greater confidence in the BIM skills across the project team, and may need owners or government mandates to help drive higher skill levels across the project team. Increased use of outsourced modeling expertise can more quickly address this skills gap.

Expectation of and Satisfaction With BIM Skills of Each Company-Type

Dodge Data & Analytics, 2021



Case Study

Anglian Water Digital Twin

UNITED KINGDOM

Use of BIM is just one element of the larger digitization of design, construction and operations in the built environment. Digital twins, which are often model-based, are another critical element of digital transformation in this industry. A digital twin is the creation a digital version of an existing asset powered by real-time data. Pioneering asset owners are leading the way in helping to explore their potential to transform construction and operations.

In conjunction with construction of a massive greenfield pipeline project, Anglian Water is taking the initial steps toward creating a groundbreaking digital twin in the water sector. Although building a digital twin in the water sector is still a nascent concept, Anglian Water's Guy Gregory says the company sees an opportunity to create "an integrated digital representation of its physical assets, systems and treatment processes." If successful, the digital twin will "unlock value by enabling improved insight to support better decisions, leading to better outcomes in the physical world."

Opportunity for Digital Twin

In terms of geographic reach, Anglian Water is the largest water and water recycling company in England and Wales. It also covers the driest regions of the country, which could face a water deficit of 30 million liters per day by 2025, according to the company. Under Anglian Water's Strategic Pipeline Alliance, up to 500 km of interconnected pipes will be installed within five years—along with associated pumping stations and tanks—to deliver water from the north of the region to the drier southern areas.

With so much new infrastructure being installed, Gregory says the company saw an opportunity to advance its digital twin strategy, including installation of sensors along the new network. Prior to deploying its new technology, Gregory says the company's internal Innovation hub conducted extensive tests as part of a proof-of-concept effort.

"That was essential for us to get a basic understanding of what could go wrong, so that when we scale up, we've got some firsthand knowledge of what we don't want to do or repeat," he says.

One of the more complex aspects of the project is the control and automation that will be required to run the pipeline. "We'll need lots of sensors just to control the flow of water, so we're almost halfway there toward that digital twin piece," he says. "Why not take it one step further and start to deliver this digital twin piece alongside the physical asset?"

Data-Enabled Processes

A key goal of the SPA pipeline project is to improve both delivery and operation of its assets. "Some digital twins are all about operating the asset, but we've got to improve the way we put that asset in the ground and commission that asset," Gregory explains. In the future, he sees the potential to leverage data from the digital twin to help automate pipeline design by creating digital assets that are standardized and repeatable.

Anglian Water and its partners are already banking on the success of these enhanced capabilities. With the availability of real-time data about the performance of its assets, Gregory says the company was able to design the network with smaller diameter pipe than would be typically used.

"That saves us £5 million, but that also increases our risk," he says. "So we've got to get the digital twin piece right to enable us to move that [water] over 24 hours, when typically it would be 22 hours and we'd have some float. We can take away the float and better manage the risk, but we have to make sure we have the right data to make decisions with confidence."

Once the new network is completed, Anglian Water can further explore the next steps on its roadmap, including field use of these digitally enabled physical assets to aid in real-time as well as predictive operations and maintenance. Gregory says the company is particularly interested in capturing data on water pressure, water quality and flow.

Over a five-year period, the team will explore how operators can make best use of data captured by the new technology, including making informed decisions without an operator needing to physically be onsite. The team also aims to create an integrated view of its asset base data so that it can make decisions on an even larger scale, including at an enterprise level.

GIS and AI

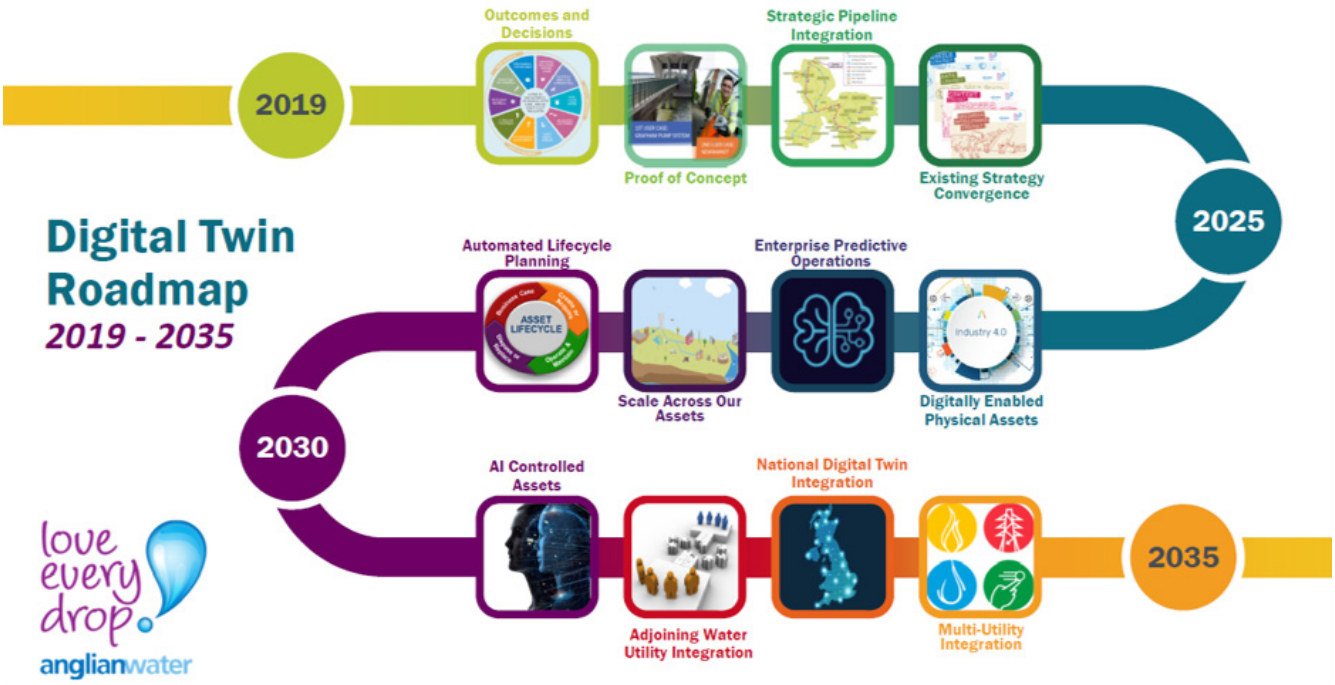
A big part of this step will also focus on where Anglian Water sees that the digital twin and related technology, such as sensors, can provide value. By analyzing what works and what doesn't work, Gregory says they will determine the scale at which it should be deployed across the company's entire asset base. Ultimately, Gregory sees the digital twin will include extensive GIS data, as well as BIM models of built structures. "GIS and BIM will have to work in harmony for us to maximize the opportunities that we hope to gain," he adds.

Anglian Water is also exploring the potential for AI–controlled assets. As part of the current pipeline project, the company will install physical controls such as valves that can be enabled manually from a remote location. Eventually, however, the company

Image Courtesy of Anglian Water

Anglian Water Digital Twin

UNITED KINGDOM



Roadmap for the digital twin development

hopes that some of these decisions and manual processes could be controlled via machine learning.

"Ultimately, the analytics will either drive a manual decision or let the digital twin make the decision for us and undertake the physical piece [such as turning a valve]," he says. "We hope that over time the digital twin will give us the confidence that we can almost take away the manual intervention piece. Small changes will be undertaken by the twin itself. It will turn the valve, it will look at the consequences and it will make minute adjustments."

Challenges

Gregory says the biggest challenge so far to its digital twin implementation plan is stakeholder management. To successfully integrate all of its assets within a digital twin, he says the entire enterprise and its partners need to work in coordination.

"Our business is so big here, someone in isolation could be developing something over in another part of the organization and we don't know about it," he says. "So you start to develop great stuff, but it's not linked together."

Change management is also a significant challenge, navigating the cultural changes within the organization that will be needed. "We have to consider what the operator of the future looks like and how we make sure they are ready to take this on," he says. "They have to be an integral part of the change. They are part of our journey. It's important to get that right. It's a bit of an investment, but it's almost as important as the digital twin itself."

Future Goals

Although Anglian Water is weighing the value of a digital twin for its own organization, it also recognizes its importance within the water sector as a whole. Although it is the first company in the U.K. to explore a full digital twin, Gregory says the company engaged with others in the water industry to see what they would want a digital twin to achieve.

"We will have our digital twin as a water company, but ideally a national digital twin is equally as important," he says. "We need to be able to collaborate with other water companies as well as other industries, so we all have the same baseline. That enables us all to collaborate and share data in the future." ■

Image Courtesy of Anglian Water

Convergence: Digitized Workflows and Prefabrication Are Becoming a Single Powerful Process

Two of construction's most rapidly evolving processes—digitization of work flows and prefabrication—are converging.

While it's common to think of BIM as one factor shaping the way projects are designed, built and managed, and prefabrication as a separate factor addressing productivity and carbon through a shift to manufacturing, there's a growing recognition that these are two interdependent aspects of the same industry-transforming initiative. "You can't really do prefab without doing the collaborative and coordinated design that a digital workflow makes possible," says Jaimie Johnston, London-based head of global systems at Bryden Wood. "And doing collaborative design just to turn it into normal construction throws away major benefit," he adds.

Transformation Through Productization

For industrialized construction—an umbrella term for the application of manufacturing techniques to built environment planning, design, construction and operation— the convergence of digital workflows and prefabrication generates a powerful new driver: the ability to work with assemblies and their associated data, rather than the millions of individual bits and pieces that have been construction's traditional building blocks. Productization offers to speed up design with a palette of standardized, interrelated components; to reduce reliance on a dwindling pool of skilled labor; and to streamline delivery with improved safety, predictability and productivity.

"Productization of building components allows you to define a product and then a workflow that makes sense for it," says Amy Marks, head of industrialized construction strategy at Autodesk. "It's also easier to use analytics like machine learning and AI when you're talking about something that's consistently a productized piece."

When Bryden Wood designed a cladding system for the passenger tunnels of Crossrail, a major new rail system in London, the project's complex geometry meant that the lining panels could only be described in 3D. From there, the team adopted an entirely digitally driven process—with fabrication-quality models governing the setting out of interface points onsite, automatic checking of as-built against as-designed base tunnel dimensions to identify and preempt tolerance issues, CNC milling and 3D printing of panel molds directly from the model and preplanning logistics. This convergence of digitization and prefabrication enabled a productivity increase Johnston describes as massive, with zero health and safety instances, and zero instances of defects onsite. "We typically get at least double productivity," says Johnston, "and we've certainly delivered projects that were 30% lower cost." Across the industry, such savings are worth trillions.

Fixed Assets vs Current Configurations

As technologies and processes converge, the silos that separate construction's sectors and disciplines inevitably start to collapse. Even different building types turn out to have significant opportunities in common. For example, about 70% of public buildings in the U.K., whether healthcare, education or office, could be built using the same structural system, says Johnston. That's because, as a function of daylight penetration with ceiling heights designed to a human scale, they all use about the same eight-meter (26-foot) floor span. "That's a massive market," Johnston points out. Designing and building with assemblies based on this and other fundamental commonalities makes it possible to stop thinking of buildings as fixed assets, and instead to think of them as a current configuration of manufactured components. "The potential to transform productivity—in terms of design, delivery, manufacturing, assembly and reuse—is absolutely vast," says Johnston, "with the opportunity to solve for enormous global problems."

So who's leading the productization charge? A few years ago it might have seemed that outsiders from the tech or manufacturing sectors were poised to swoop in and disrupt construction. Nowadays, though—especially with the demise of Katerra—that seems less likely. "There's a load of deep-seated things about buildings and construction that you have to have a handle on to be able to develop some of the solutions and apply them," says Johnston. "So it's on us. No one's coming to save us. It has to come from construction." ■

Digital Transformation of the Design and Construction Industry

The construction industry has been undergoing a digital transformation for many years now, and BIM and its tools have been a central part of that evolution. Recently, many other applications have also gained traction in the design and construction industry. In order to benchmark the current status of digital transformation and to be able to understand where it is heading, design and construction industry professionals were asked three questions.

- First, they were asked where they believe their company is in the process of digital transformation from the five-point scale indicated in the chart below.
- Then they were asked two questions about specific emerging technologies: which ones they use currently and which they expect to use in two to three years. Those findings are discussed on pages 49 to 51, but the chart at right shows a summary of the responses to the first question based on the degree of BIM use, including responses from those who do not currently use BIM.

BIM Use and Digital Transformation

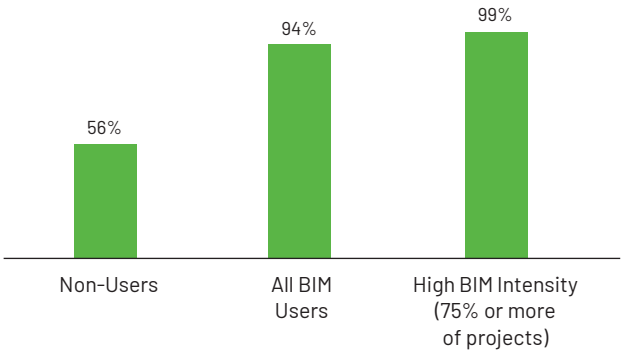
The findings shown in both charts on this page clearly reveal that a more intensive level of BIM engagement is directly correlated with a higher degree of use of digital tools in general.

- Companies not using BIM not only typically rate themselves as not starting their digital transformation process yet or still being in the early stages, but they are also far less likely to use any other digital technologies than BIM Users.
- Nearly all BIM users employ at least one other emerging technology.
- Those using BIM on 75% or more of their projects far more frequently report that they are approaching their digital transformation goals.

Clearly BIM is an important part of an overall digital transformation strategy. As BIM and the many other digital tools and applications become increasingly important to improving productivity and project performance, companies need to make sure they can stay competitive by having a clear digital transformation strategy.

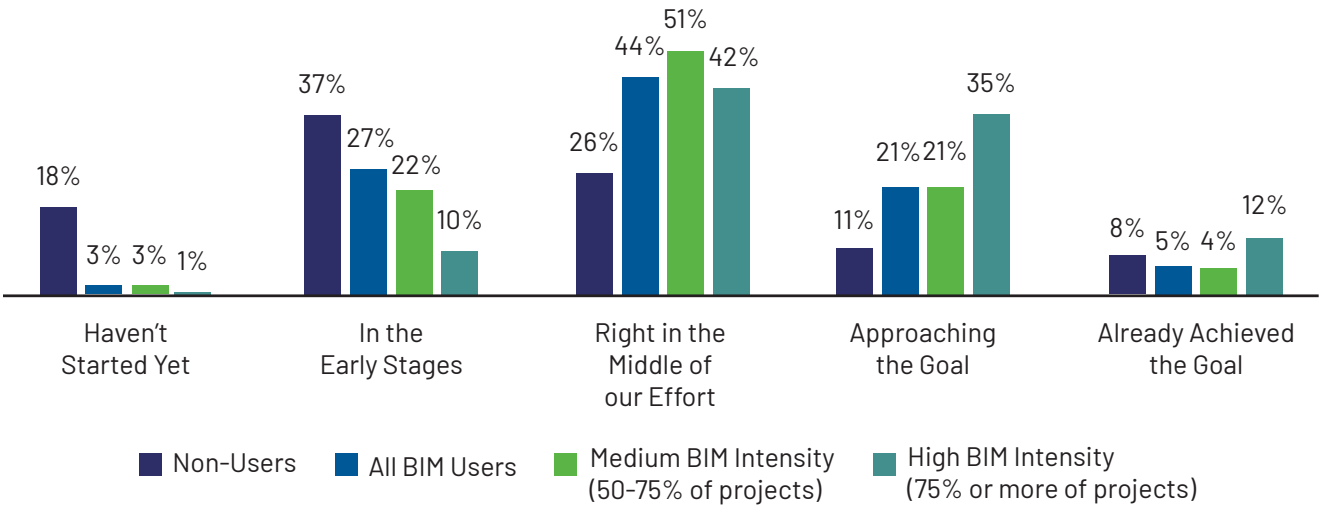
Using at Least One Emerging Technology

Dodge Data & Analytics, 2021



Stage of Digital Transformation

Dodge Data & Analytics, 2021



Digital Transformation
and the Use of Emerging Technologies

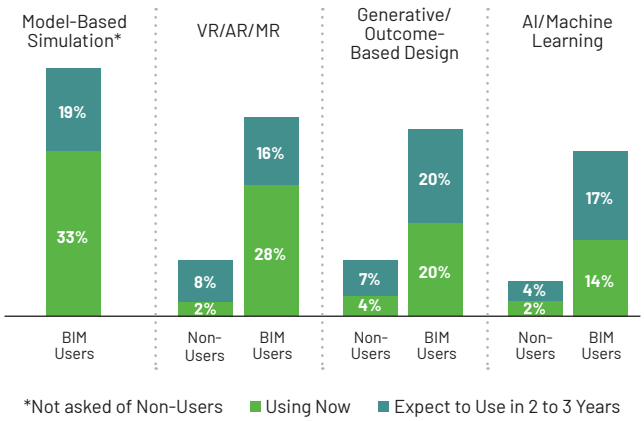
Use of Emerging Design Intelligence Tools

Design and construction industry professionals were asked whether they use or plan to use four tools that help designers and builders gain intelligence about their projects, either through better visualization or the ability to optimize performance options. These have been categorized for the purpose of this analysis under the label design intelligence tools. The findings at right show the difference in current and expected use between those who use BIM and those who do not. (Non-users were not asked about model-based simulation.)

- The most widely used of these four is model-based simulation. One third of BIM users report using this. 19% expect to adopt these tools in the future, suggesting that use will be relatively widespread within the next two to three years.
- The biggest growth among BIM users is expected in the use of generative/outcome-based design. The percentage of users expecting to utilize these tools in two to three years is as high as the percentage using them now.
- The findings further suggest that the already substantial gap in use between BIM users and non-users for VR/AR/MR, generative/outcome-based design and AI/machine learning will continue to widen.

Design Intelligence Tools

Dodge Data & Analytics, 2021



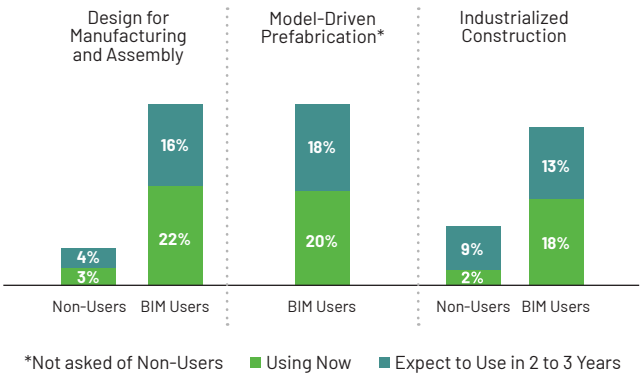
Use of Innovative Construction Methods

The questions about emerging trends also included three innovative construction methods, which the use of digital technologies can often support. Again, BIM users and non-users were asked whether they are using these currently and, if not, if they intend to use them in the next two to three years. (Non-users were not asked about model-driven prefabrication.)

- Among BIM users, use of all three methods is moderate, with the highest share (22%) reporting use of design for manufacturing and assembly, and a similar percentage reporting use of model-driven prefabrication (20%) and industrialized construction (18%).
- Model-driven prefabrication has the largest share of BIM users who expect to adopt it in the next three years, but nearly as many expect to adopt design for manufacturing and assembly.
- Those not using BIM consistently lag behind BIM users, so again, the already substantial gaps in use are likely to expand in the near future.

Innovative Construction Methods

Dodge Data & Analytics, 2021



Digital Transformation
and the Use of Emerging Technologies

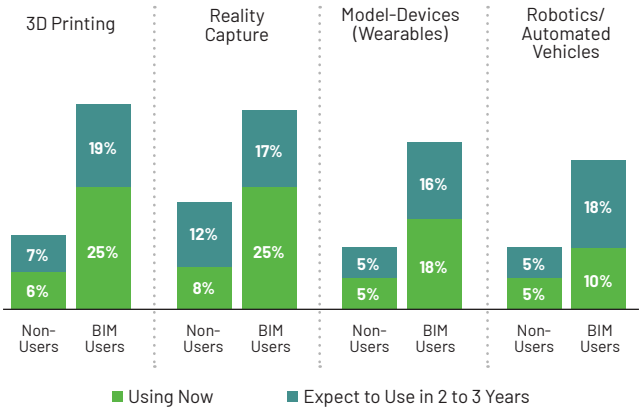
Use of Emerging Jobsite Technology

Respondents were also asked about their use and future expected use of four different emerging technologies for jobsites.

- The most widely adopted technologies for the jobsite are reality capture and 3D printing, each used by one quarter of BIM users, but only by a small fraction (8% and 6%, respectively) of companies not using BIM.
- Even though model-devices (wearables) and robotics/automated vehicles are used by a smaller share of BIM users now, a similar percentage expect to use all four of these jobsite technologies in the next two to three years, suggesting that the potential of each is well recognized.
- Reality capture is of the greatest interest to those not using BIM, with the highest share using it now, and the highest percentage expecting to use it in the next two to three years.
- Again, though, the share of those not using BIM who currently use these technologies lags far behind the BIM users, and the share expecting to use them in future also falls far short, suggesting a widening gap in use.

Jobsite Technology

Dodge Data & Analytics, 2021



Use of Smart Building Technology

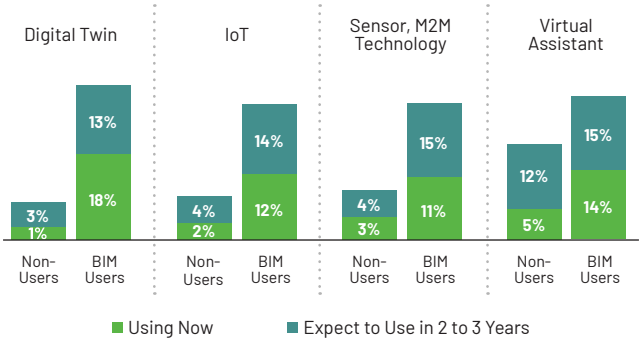
The questions on the use of emerging technologies also included technologies that are often employed in the operational phase of buildings (as well as during the design and construction process) to help understand and improve building performance. These include digital twins, internet of things (IoT) technologies and sensors/M2M (machine-to-machine) technology. These can lead to great intelligence about and automation of building operations processes.

These technologies are less established than some of the previous ones discussed, with fewer than 25% of BIM users reporting their current use. Fewer also expect to use these in the future. However, among BIM users, these technologies have clearly gained a foothold, and use is likely to expand enough for them to become more common in the industry.

Only a tiny share (5% or less) of those who do not use BIM report use of these technologies, and 4% or fewer expect to use digital twin, IoT or sensor/M2M technologies in the next few years. This may lead to a disadvantage when dealing with owners seeking to increase their own level of digital transformation. However, there is greater interest among non-users in the use of virtual assistants, with 12% who believe that they may use this in the next two to three years. Wider adoption of smart speakers and other tools outside of construction may lead to greater interest in these tools for buildings.

Smart Building Technology

Dodge Data & Analytics, 2021



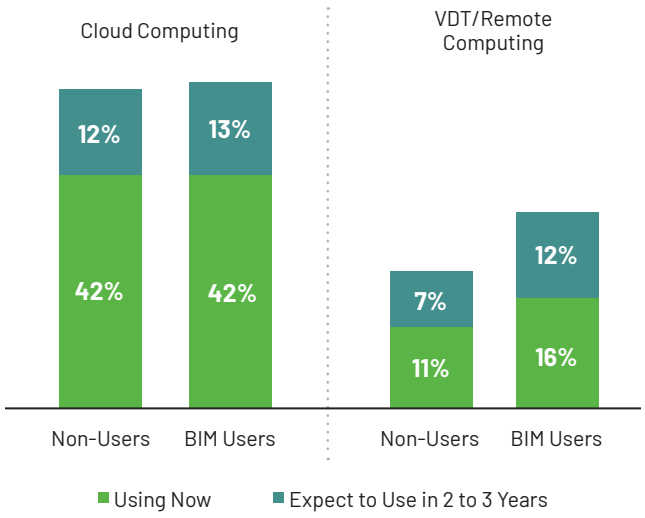
Means of Data-Sharing

Two of the 16 innovations and technologies included in the study involve the ability to share data across teams located in disparate locations. With many Dodge Data & Analytics studies demonstrating the potential of collaboration to improve project performance, these data-sharing technologies are critical to help support collaborative efforts.

- Cloud computing is the only one of the 16 innovations and technologies as widely used by those not using BIM as it is by those using it. However, with both groups at 42%, even this most common technology is still in use currently by less than half of the industry. And it is notable that the share anticipating use in the next two years is only 12% to 13%, suggesting that much of the industry is not planning to tap the potential of this technology.
- VDT/remote computing, while more widely deployed by BIM users than non-users, still sees far more comparable levels of use between these two groups than most of the other technologies included in the study. However, with 12% of BIM users expecting to use it in the future, compared with 7% of non-users, the gap in use will continue to grow.

Data-Sharing Technology

Dodge Data & Analytics, 2021



Designing for the Future With AI

In the next 10 years, artificial intelligence (AI) is expected to transform how design teams work by providing predictive analysis and helping designers generate designs to meet their project goals.

With the construction industry's stagnant productivity rates and the need to provide for a burgeoning global population, tools for streamlining the design process, such as AI, have a vital role to play. Various estimates put the compound annual growth rate for AI development in the construction market between 24% and 38% through the next two to five years, and industry observer Frank Stasiowski, CEO of the AEC-focused management consulting firm PSMJ Resources, predicts that by 2030, half of the architecture profession will be using AI for 50% of its work.[1] But for many AEC professionals, whose work is premised on developing humane solutions to site-specific conditions, it is still difficult to imagine how.

Targeting Schematic

The most promising point of intervention is the schematic design phase, according to Håvard Haukeland, co-founder and head of Spacemaker, an AI-integrated design platform, at Autodesk. "In the early phase, there are hundreds of variables to take into account," he says. "AI supports you in reasoning about them, and making decisions about things that are often left to a later stage, but that actually should impact the concept."

The types of variables that AI can process include daylight and views, traffic noise and wind behavior, in addition to geometrical constraints resulting from floor area, height, setback and other zoning regulations, and economic and spatial requirements pertaining to unit layouts.

"We use the term 'AI on your shoulder,'" says Carl Christensen, co-founder and chief technical officer at Spacemaker. "We don't believe in AI making decisions about design or architecture. We want the designer to be in control." AI can support early, improved, data-informed decision-making in two ways: predictive and generative. In predictive mode, it can anticipate an emerging design's implications for project priorities instantaneously; and in generative mode, it can suggest alternative options based on the project's priorities and constraints. "We've done our best to make the AI feel unobtrusive, to the degree that a lot of people ask, 'Where is it?'" says Christensen. "It's about making it accessible and transparent. We don't want a magic box that comes up with things. You need to be able to reason about what just happened."

Designing Faster, Denser and More Livable

Steen & Strøm, a retail and real estate company partnering with Storebrand (pension fund and real estate) in the development of Økern Sentrum, a more than two million square-foot mixed-use redevelopment of 17 acres of former industrial lands in Oslo, began using AI about two years ago in the conceptual phase of the project's master plan. At one point, the municipality asked that the proposal be adapted to daylight two channelized waterways on the site. AI enabled the team to achieve this in an unprecedented two days, while at the same time actually increasing developable floor area, halving the number of residential units with the lowest exposure to daylight and reducing by 10% the residential facades with the highest exposures to traffic noise. "Our own analysis could take weeks," says Peter Fossum, project administrative manager at Steen & Strom. "Now we have the chance to sit together, the architects and engineers, and run hundreds of alternatives, check the analysis and find the best solutions much, much faster."

To meet the demands of urban population growth, we need to build denser and faster than before. "But often as you densify a neighborhood, you hit a threshold where the quality starts coming down, the compromises start coming in and things don't add up," says Haukeland. "My biggest enthusiasm is the case studies where we can see that AI has contributed to teams making better decisions and coming up with better solutions for the next 50, 100 or 200 years." ■

[1] https://commonedge.org/an-optimists-take-on-ai-and-the-future-of-architecture/?utm_medium=website&utm_source=archdaily.com

Perspectives on the Future of BIM

Introduction

To add to the findings about current practices, Dodge invited four industry leaders from academia, construction, government and architecture/engineering to share their visions for the future of BIM.

Phillip Bernstein, FAIA, RIBA, LEED AP
Associate Dean and Professor Adjunct, Yale University
Phil is a well-known advocate for advancing the entire process of design, fabrication, construction and operations to produce better projects, more satisfied stakeholders and an enlightened use of resources.

Marzia Bolpagni, Eng., Ph.D.
Head of BIM International, Associate Director, Mace Group, Ltd.
Marzia will explain how BIM is key to her strategy for driving digital construction solutions at this large global construction firm.

Adam Matthews, MBA
Head of International, Construction Innovation Hub, and Chair of the Global BIM Network
Closely involved with the UK BIM mandate, Adam will address the positive role government agencies can play in bringing information, structure and clear expectations to the complex process of industry advancement.

Kurt Maldovan, CM-BIM, CM-Lean
Digital Delivery Global Solution Director, Jacobs
Kurt will share how BIM contributes to Jacobs' digital future, including linear, vertical and plant information modeling, robotic process automation, automated design and VR/AR.

Interviews: Thought Leaders

Phillip Bernstein, FAIA, RIBA, LEED AP
Associate Dean and Professor Adjunct, Yale University

Phil Bernstein is an architect, a technologist and an educator who has taught at the Yale Schoolf of Architecture since 1988. He was formerly a vice president at Autodesk where he was responsible for setting the company's future vision and strategy for BIM technology.

What is your perspective on how BIM fits into the overall evolution of design and construction?

BERNSTEIN: BIM, the data phenomenon—as distinct from BIM, the product—is an important juncture in the evolution of building in that it represented the first intensive digitization of AECO information that wasn't in the service of some other artifact, like the production of a drawing. Predecessor tools, particularly geometric modelers, created complex representations of the underlying geometric logic of, say, a building, but nothing close to the complex of inter-related spatial, relationship, parametric or characteristic data that a BIM process should produce in the service of creating a more dynamic, accurate and behaviorally provocative representation of the project prior to construction. The fact that there is so much controversy about what comprises a "buildable" BIM is an indication of that potential, somewhat unrealized, of these tools themselves, and the popularity of what seems to be the successor concept of "digital twin" is derived from the anticipated utility of BIM as it was originally conceived, by the likes of Chuck Eastman ("product models") and others.

The emergence of "accessible BIM"—that could be bought and implemented by AECO players—contrasts with that

> Familiarity with BIM processes, and the ability to manage BIM-related data and collaboration tools, has prepared today's architects, engineers and builders for what appears to be the coming explosion of "BuildTech" capabilities as the industry is finally digitized.

Perspectives on the Future of BIM

Phillip Bernstein Interview CONTINUED

of "theoretical BIM," which was defined long before machines were powerful enough to actually support it. By the late 2010s, BIM tools were capable and mature enough that conversations began about their transformative power: to refactor the structure of project delivery models (IPD), accelerate sustainable design (through energy modeling) and close the gap between design intent and construction execution (the end of the shop drawing). Manifestos like the CURT whitepaper declared the onset of a new digital era in building. The argument for the transition from CAD to BIM was largely predicated on this theoretical foundation. In that sense, BIM foretold a potential future of a digitally enabled, and thereby more effective, AECO industry. But as described by McKinsey's analysis of AEC digitization and low productivity, this potential is largely unrealized.

than the number of employees—at least in US architectural firms—would suggest. BIM-related efficiency was the likely cause.

Second, the accuracy, completeness, and proper coordination of technical drawings, particularly working drawings, is far greater than in the previous CAD era. Automatic generation of coordinated views, schedules, call-outs and other documentation techniques is vastly improved with BIM, as is the management of the resulting drawings sets. Construction is more precise as a result. The era of clash-related change orders, for example, is largely over.

Finally, perhaps BIM is the "gateway drug" that has made the AECO industry ready for a digital future. Familiarity with BIM processes, and the ability to manage BIM-related data and collaboration tools, has prepared today's architects, engineers and builders for what appears to be the coming explosion of "BuildTech" capabilities as the industry is finally digitized. The resulting data may form the basis of a more rational, analytical, fact-based and outcome-driven industry as these tools mature in capability and use. In Europe, for example, BIM tools are used in the service of cost management and energy analysis. But not in the service of design, the core competency of architects and engineers. This is all to say that the early promises for transformation of AECO by BIM are largely unrealized. To see that the most dramatic innovation in the means of representation since the invention of tracing paper has been deployed, once again, in the service of generating construction documents, is an enormous missed opportunity. The reasons for this failure of nerve, on the part of either the vendors or their customers, is the subject of another discussion.

> It's my hope that as the industry faces its next set of existential challenges—climate change, social inequity, labor shortages, broken supply chains—it will deploy tools like BIM, and eventually AI, in the service of optimizing the entire delivery process.

Today, where are you seeing the greatest value, and where are we falling short of its potential?

BERNSTEIN: A realistic, rather than idealistic, view of BIM's greatest value is a function of its actual utility in daily practice. Although this observation deserves further research (which might be a result of this SmartMarket report's analysis), anecdotal evidence suggests that BIM's greatest value to the industry today is threefold. First, it has increased the productivity of the designers and builders who use it by making it possible to create, coordinate and distribute information about a project more effectively. The growth in work volume since 2014, when BIM adoption (at least in the US) reached 60%, was far greater

What do you believe will be the future of BIM in the built environment?

BERNSTEIN: The internet-enabled capabilities of the cloud, where intensive computation can be delivered anywhere from studio to jobsite to building management system, portends a future where, like the rest of human enterprise, building becomes digitized. One would hope that BIM, beginning with a dynamic conceptual model at the outset and culminating with a digital twin during operation, would be the basis of vastly improved capabilities for design, construction and operation. Artificial intelligence-based systems demand enormous datasets to be properly trained, and BIM can play a part in providing this fodder.

It's my hope that as the industry faces its next set of existential challenges—climate change, social inequity, labor shortages, broken supply chains—it will deploy tools like BIM, and eventually AI, in the service of optimizing the entire delivery process, and not simply optimizing less interesting subsets of that process (like making working drawings). That will require vision on the part of technology providers, who can define the potential of information itself in the building enterprise, as well as technology consumers, who must be willing to be as innovative in their use of technology as they purport to be in the conception and construction of the built environment itself. But as the saying goes, "hope is not a strategy." The strategy is a proper collaboration between these two constituencies who, together, can define the future of a digitized, BIM-enabled AECO industry.

Perspectives on the Future of BIM

Interview: Thought Leaders

Marzia Bolpagni, Eng., Ph.D.
Head of BIM International, Associate Director, Mace

Bolpagni develops and implements digital construction solutions for public and private international clients in five international hubs. In 2021, she received the prestigious Young Engineer of the Year award and the Sir George Macfarlane Medal as overall winner by the Royal Academy of Engineering.

How were you introduced to BIM and how are you currently engaged with it?
BOLPAGNI: I discovered BIM during my time at University, thanks to professor Angelo Ciribini who has been the Italian pioneer in piloting and promoting BIM adoption. At that time BIM was mainly used by construction companies and designers and there was still limited use by public clients. Thus I decided to work in Finland where I developed a master's thesis on the use of BIM in public procurement in collaboration with the Technical Research Centre of Finland (VTT). The work has been used as a reference for different governments for their national BIM strategy, including Germany and Russia.

I continued my career in helping construction companies and designers in day-to-day modeling and clash detection activities, and at the same time I started a Ph.D. where I worked in Boston for the Massachusetts Port Authority with the exceptional Dr. Luciana Burdi. At Massport I learnt how BIM can be integrated into Lean Construction.

Currently I develop and implement BIM strategies for construction clients: I focus on what clients can get from using BIM. I specialize in the information management side of BIM and, especially, on how to define information requirements in a more accurate way. I lead the development of a new standard that goes beyond the concept of "LOD". The standard (EN 17412-1 Building Information Modeling —Level of Information Need—Part 1: Concepts and Principles) defines a new framework that can be used by anyone who needs to receive information when using BIM, and it enables automatic checking of deliverables. The standard is now followed by the main European clients to structure their requirements.

Today, where are you seeing the greatest value, and where are we falling short of its potential?
BOLPAGNI: It is a great question, but I do not see a univocal answer. BIM can drive value to different actors at different points of time, depending on the purpose we are applying it for. Instead of speaking of value of BIM in general, I prefer to focus on the value that different BIM uses/model uses can bring to the projects.

Penn State University has been one of the first to speak about "BIM uses" and Massport also developed an extensive list. I personally use the model uses list developed by the BIM Excellence Initiative. What is "valuable" for architects, might not be the same for the main contractor or the client. That is the reason why main contractors usually tend to redo models: We should not be surprised. The reason is that the models created by designers were not developed to fulfill contractors' purposes. It is the reason why the concept of Level of Information Need is key: to measure value, it is essential to define the purposes (BIM uses) first and then define the needs to avoid over- or under-creation of information.

Coming back to your question, among all BIM uses, I see the implementation of BIM for sustainability as an essential driver to deliver value, especially for embodied and operational carbon analyses. It is the reason why Mace is investing on this topic to refine the boundaries of ambition and pursue a sustainable world.

Finally, I see still a big misconception of considering BIM just as a technology instead of a methodology that includes also processes and policies: This is where we are falling short of its potential.

What do you believe will be the future of BIM in the built environment?
BOLPAGNI: I see BIM becoming business as usual to a point that we will not call it BIM anymore, but the journey is still long, and we do not need to jump the steps. Now I see several people speaking about digital twins, forgetting the basics such as structuring data using an appropriate classification.

At the same time, I see the use of virtual design and construction (VDC) principles (such as integration with information management, project management, agile, lean construction, innovative business and procurement models) as key drivers, as well the "golden thread" approach, to create a line of sight of information.

But we do not have to forget about the new challenges that we need to face with the emergence of BIM adoption and integration with artificial intelligence. Ethics aspects are already relevant, and we will need to fight more and more for our data rights, in the built environment as well as in our private lives if we want to use technology for the public good.

Perspectives on the Future of BIM

Interview: Thought Leaders

Adam Matthews, MBA
Head of International, Construction Innovation Hub, and Chair of the Global BIM Network

A former chair of the EU BIM Task Group, Matthews has over 30 years' experience in information technology, strategy, policy and change management across various sectors, including utilities, infrastructure, retail and airports.

What is your perspective on how governmental entities can best support design and construction innovations such as BIM?

MATTHEWS: We have seen that governments can play an important role in encouraging the digitalization of the construction sector. Firstly, they can signal the way ahead with policy (e.g., the *UK Construction Playbook*), which provides confidence to the sector to invest in digital upskilling, process improvements and technology.

As one of the largest buyers of the built environment, public sector owners can set professional standards for project delivery. By specifying requirements for information management (i.e., BIM aligned with ISO 19650), clients and owners can incentivize the sector's modernization.

Finally, governments can influence the system of innovation within a country. They can help diffuse the benefits of innovations, such as BIM, and stimulate further innovations. For example, in the UK the government helped to bring industry and academia together under a national program, called the Construction Innovation Hub.

How effective has the UK BIM initiative been, and what steps are underway to improve and expand it?

MATTHEWS: 2021 marks 10 years since the launch of the UK's national BIM program, I'm often asked how well the UK industry is adopting the standards and practices. While the industry adoption of BIM aligned with ISO 19650 is high, it is not 100% across all public projects, but where would we be now if we hadn't launched the BIM program?

The consensus view is that we would not be where we are: BIM and the UK government's BIM program have been a major driver for a broader call for change across the sector. It is hard to imagine that the UK would have a central policy focus to transform construction (transforming construction challenge) were it not for the spectacular success of the UK BIM Program under the Government Construction Strategies of 2011 and 2016-2020.

Taking a global view, the UK's international program has contributed to national BIM policies and programs across Europe, Latin America and Asia, and, most recently, support of the US BIM program led by the National Institute of Building Sciences.

The UK is seen as a world leader in BIM—not just the implementation of it—but its approach to purpose-driven information management. The next phase will see the UK extend its innovation from BIM and information management across the lifecycle of the asset. For example, extending benefits from information management to the procurement and briefing phase of an asset, by using value-based procurement (Value Toolkit) and downstream benefits from whole-life operations with Soft Landings.

Looking ahead, what do you believe will be the role of governmental entities re: BIM going forward, and how will it impact the built environment?

MATTHEWS: With the formation of the Global BIM Network in March 2021, we expect governments to play an increasingly important role in encouraging BIM and information management across the lifecycle of assets. This global network of public sector and multilateral organizations aims to encourage the digitalization of the sector to increase benefits for society and for the built environment. By increasing the capacity and capability of the public sector as a major infrastructure client, the Global BIM Network will encourage the construction sector to achieve shared socioeconomic goals for COVID19 recovery, net-zero and environmental sustainability.

Recent studies. including *Value of Information Management in Construction.* support the view that investment in information management creates value in three areas: 1) direct productivity gains for organizations; 2) increased growth across the wider UK economy as a result of thsoe productivity gains; and 3) social value to customers, wider society and the environment through enabling the delivery of higher quality and more sustainable built assets.

While this is a UK-based study, its message is clear: A global investment in information management by governments and industry has the potential to unlock a triple benefit—for the construction sector, the built environment and for society.

Perspectives on the Future of BIM

Interview: Thought Leaders

Kurt Maldovan, CM-BIM, CM-Lean
Digital Delivery Global Solution Director, Jacobs

Maldovan drives innovation by connecting, leading and growing Jacobs' internal capabilities and external market presence. He cultivates leaders supporting the company's linear, vertical and plant information modeling as well as robotic process automation, automated design and VR/AR initiatives.

How were you introduced to BIM and how are you currently engaged with it?
MALDOVAN: I was introduced to building information modeling (BIM) as an undergraduate at Penn State. I had been doing an independent study and created a 4D model of one of our under-construction campus dormitory projects. The 3D model developed had data attributes associated with it so we could more easily tie it to the construction schedule, thus creating a 4D model.

A few years later I was back as a graduate student and began undertaking research specifically on BIM. I was introduced to a nuclear power plant model that was used for design review visualization and construction scheduling as well as several built environment models used to analyze schedule sequences. As part of this introduction, I had hands on experience with Smart Plant 3D, Bentley Microstation, Navisworks Jetstream, and took a certificate course for Revit.

When I initially joined Jacobs in 2006, we were implementing our first multidisciplinary BIM project and I was fortunate to get closely embedded with the team and became responsible for design phase clash detection and model-based quantity take offs.

Today, I'm more aligned with the broader spectrum of information modeling and digital delivery. My focus is to make sure we are leveraging the suite of modeling applications our staff has access to as well as initiatives to optimize our processes around design automation. The key is that we must continue to leverage the data attributes contained in our models, drive for consistency and deliver content—whether it be models, data or both— to our clients for their benefit in downstream stages of the project.

Today, where are you seeing the greatest value with BIM, and where are we falling short of its potential?
MALDOVAN: I've had intriguing discussions with people who began implementing BIM around the same time as myself. BIM has both a rapid and slow adoption across the industry. It seems that early adopters who embraced the technology have experienced challenges to completely streamline operations and convince internal staff and external partners that BIM software is one of the best ways to deliver a project. The greatest value is the collaboration opportunities, the overall process, discussions, the ability to see modeled elements in three dimensions, to drill down into the data associated with modeled components and to make decisions—all the items I first saw when I was indoctrinated into BIM in the early 2000s. Unfortunately, I have the same discussions today as we often favor the product over the process.

Being a user of BIM software is a gateway to embracing the larger whole, but it is not a prerequisite to understanding the value of both a well-articulated BIM product and process. Still having to educate in both areas has slowed adoption and is not yet allowing the collective industry to embrace the full potential of BIM.

What do you believe will be the future of BIM in the built environment?
MALDOVAN: The future is now, and the industry needs to embrace it. Incorporating both automated design and robotic process automation to initiate, iterate, ideate, coordinate, conform and analyze design products is crucial to providing innovative solutions for clients.

It's my belief that we'll see more data analytics and reporting associated with our built environment BIMs, whether that stems from statistics on modeled elements used across an enterprise as a design library or into operations to better understand real installed equipment performance. In the past several years, as 5G infrastructure becomes more prevalent the opportunity to achieve a smart, connected, and secure facilities is going to be a primary focus.

The opportunity to develop BIM software to harness data is yet to be standardized around the globe, but the opportunities with automated design, RPA [robotic process automation] and BIM must be at the forefront of our conversations today so we can build a better tomorrow.

Methodology

This study was conducted to assess the extent to which BIM has been embraced in major regions of the world, including the experience of those who have used BIM in terms of related activities they employ, the benefits they receive, the ROI they get from BIM, the BIM engagement they expect and experience from other team members on projects. The study also examined digital transformation in general, and the current and future use of emerging technologies and processes in particular.

This research was administered online from October 2020 to March 2021. The survey data was collected from the Dodge Data & Analytics Architect and Contractor Panels, the Dodge Database of construction professionals, and memberships of partnering associations (AMCA, Australian Constructors Association, CIBSE, CICES, CINOV, COMIT, GBC Finland, GBCA, Norwegian GBC, Planen Bauen 4.0, RICS, RIL, USGBC and UNSFA). The Dodge Data & Analytics Architect and Contractor Panels contain representative samples of construction architects and contractors across the US. The panelists are identified by many categories, including size, region, types of projects undertaken and specialty.

Respondent Profile

REQUIREMENTS

Respondents were required to be employed by an architecture firm, site design firm, construction company, engineering firm or consulting company and located in Australia, Canada, France, Germany, Japan, New Zealand, Scandinavia, UK or the US.

BIM USERS

The analysis for most sections in this report focuses on the responses from respondents who report that their company uses BIM. In total, 641 respondents report using BIM in this study.

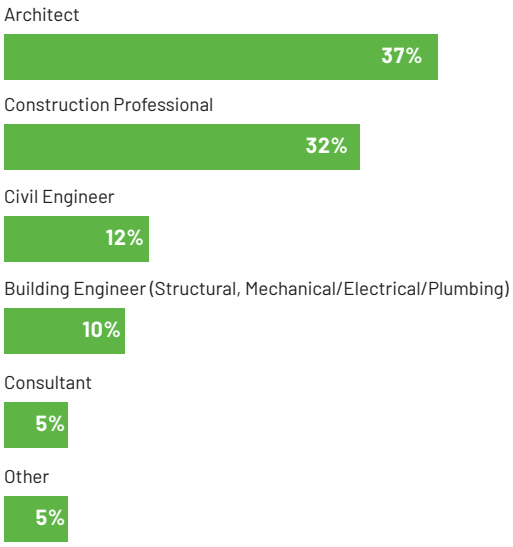
The following definition was provided for BIM to identify those using it: Building Information Modeling (BIM) is a process that begins with the creation of an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance).

The profiles of the BIM users are shown in the two bar charts at the bottom of this page and the following one.

The final section, which analyzes current and future use of technology, also examines the responses of those not using BIM about digital transformation. All respondents to the survey were asked to rate the current status of their companies' digital transformation, with 843 total respondents to this question. Subsequent questions about current

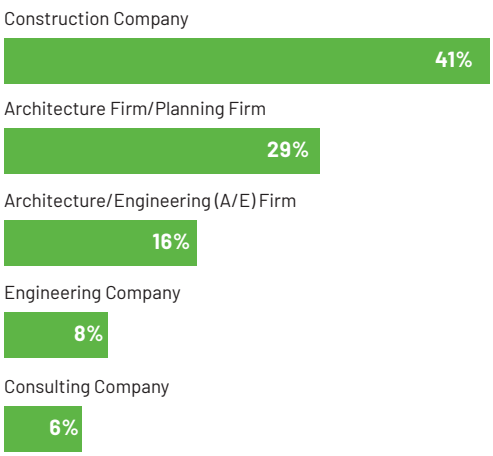
BIM Users: Job Roles

Dodge Data & Analytics, 2021



BIM Users: Types of Companies

Dodge Data & Analytics, 2021



and expected future use of emerging technologies and processes were made optional due to survey length, and 576 total respondents contributed insights to this question, 374 BIM users and 202 non-users.

Finally, the study also explores the differences in responses among BIM users in the seven regions/countries included in the study.

Because of a high number of smaller companies in the responses from North America, weighting was applied to make the proportion of North American respondents in varying size categories (by number of employees) match those of respondents located in regions other than North America.

Analytic Variables

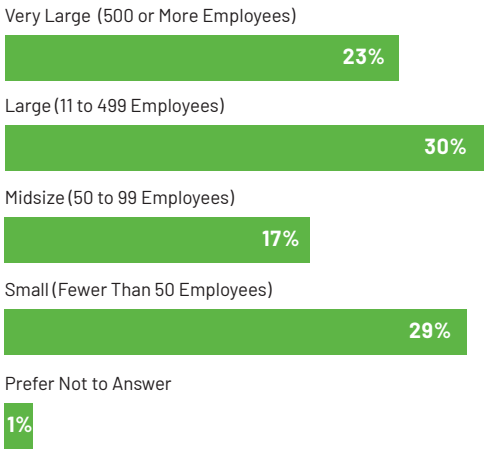
Two analytic variables drawn from the findings of this study are also used throughout the report.

BIM Intensity of Use: More information about the share of contractors that fall into the four categories of BIM intensity—very low, low, medium and high can be found on page 11.

- **Engagement With BIM-Related Activities**: A full analysis of the degree of engagement with BIM-related activities can be found on pages 12 to 16. That data was then used to categorize BIM users into three groups:
  - Low Engagement: 3 or fewer activities
  - Moderate Engagement: 4 to 6 activities
  - High Engagement: 7 or more activities

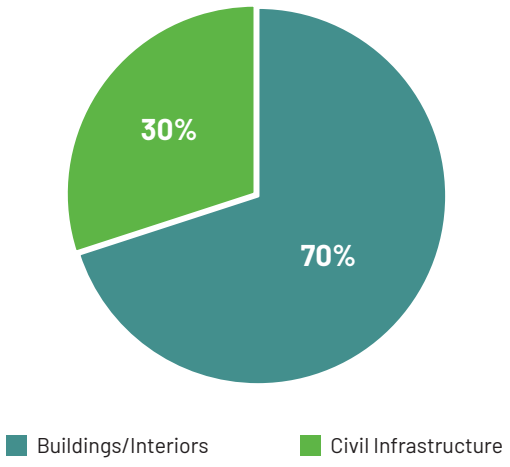
BIM Users (Size of Company by Number of Employees)

Dodge Data & Analytics, 2021



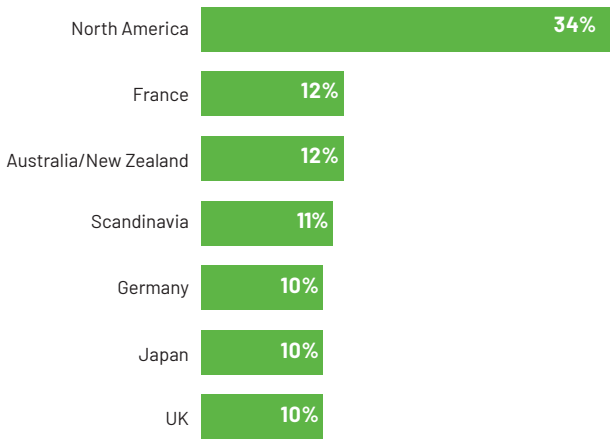
BIM Users: Primary Types of Projects

Dodge Data & Analytics, 2021



BIM Users: Distribution by Location (Weighted)

Dodge Data & Analytics, 2021



Resources

Organizations, websites and publications to help you get smarter about BIM and digital transformation.

Dodge Construction Network

Dodge Construction Network
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

ACKNOWLEDGEMENTS:

We would like to thank Autodesk for their ongoing partnership with Dodge to bring intelligence about BIM and the digital transformation of the design and construction industry.

We thank all of our research partners for their participation in the survey process to help make sure the industry is better informed. These include the Air Conditioning & Mechanical Contractors' Association (AMCA), Australian Constructors Association (ACA), the Chartered Institution of Building Services Engineers (CIBSE), the Chartered Institution of Civil Engineering Surveyors (CICES), la Federation CINOV, COMIT (Construction Operation & Maintenance through Innovative Technology), Finnish Association of Civil Engineers (RIL),Green Building Council of Australia (GBCA), Green Building Council Finland, Norwegian Green Buiding Council, Planen Bauen 4.0, Royal Institution of Chartered Surveyors (RICS), US Green Building Council (USGBC) and UNSFA (L'Union des Architectes).

We thank all those who shared their insights and experiences, including the thought leaders featured in this report and those who provided us with case studies or shared their insights in our feature articles.

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Australian Constructors Association: **www.constructors.com.au**
Chartered Institution of Building Services Engineers: **www.cibse.org**
Chartered Institution of Civil Engineering Surveyors: **www.cices.org**
la Federation CINOV: **www.cinov.fr/la-federation-cinov**
COMIT (Construction Operation & Maintenance through Innovative Technology): **www.comit.org.uk**
Green Building Council of Australia: **https://new.gbca.org.au**
Green Building Council Finland: **https://figbc.fi/en**
Norwegian Green Buiding Council: **https://byggalliansen.no**
Planen Bauen 4.0: **https://planen-bauen40.de**
RIL (Finnish Association of Civil Engineers): **www.ril.fi/en/ril.html**
Royal Institution of Chartered Surveyors: **www.rics.org/uk**
US Green Building Council: **www.usgbc.org**
UNSFA (L'Union des Architectes): **www.unsfa.fr**

Other Resources:

BIMForum: **bimforum.org**
buildingSMART International: **www.buildingsmart.org**
Construction Innovation Hub: **https://constructioninnovationhub.org.uk**
Global BIM Network: **www.globalbim.org**
Lean Construction Institute: **leanconstruction.org**
National Institute of Building Sciences Building Information Management (BIM) Council: **www.nibs.org/bimc**

■ Design and Construction Intelligence

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