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The Business Value of BIM for Owners

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The Business Value of BIM for Owners SmartMarket Report

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About McGraw Hill Construction

McGraw Hill Construction's data, analytics, and media businesses—*Dodge, Sweets, Architectural Record, and Engineering News-Record*—create opportunities for owners, architects, engineers, contractors, building product manufacturers, and distributors to strengthen their market position, size their markets, prioritize prospects, and target and build relationships that will win more business. McGraw Hill Construction serves more than one million customers through its trends and forecasts, industry news, and leading platform of construction data, benchmarks, and analytics.

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Introduction

Owners are the greatest beneficiaries of BIM. Even when not actively involved in their project teams' use of it, BIM accrues powerful benefits to them. In fact, the top BIM benefits consistently identified by design and construction firms in McGraw Hill Construction's past BIM research actually generate even greater positives for their owners.

- **Design firms always cite visualization to better engage clients and align expectations, and BIM analyses and simulations to improve design solutions, both of which provide outstanding benefits to the owner.**
- **Contractors' top two BIM benefits are usually spatial coordination to reduce costly rework and digital fabrication to increase speed and assure quality; again each of these ultimately helps owners to deliver excellent projects on time and within budget.**

Now that owners everywhere are increasingly becoming more directly involved with BIM, their power is even greater to align BIM use with their specific goals, engage more effectively with all stakeholders and extend the value of BIM beyond construction into facility management.

This new SmartMarket Report focuses exclusively on the business value of BIM from the perspective of owners on whose projects it is being deployed. Research with these "BIM owners" in the US and the UK yields several key trends:

- **Current BIM owners plan to actively increase the share of their projects that involve it, with almost half (38% in UK and 40% in US) saying BIM will be used on more than three quarters of their work within two years.**
- **Top BIM benefits perceived by owners include:**
 - BIM visualization to enable better understanding of design
 - Fewer problems during construction from deficient documents or coordination
 - More well-reasoned design due to BIM analysis and simulation
 - Beneficial impact on the project schedule
- **The impending implementation of the UK BIM mandate is driving a much higher general level of owner BIM involvement there than in the US, including a growing focus on the use of BIM for facility management.**

Greater owner involvement with BIM will accelerate the already exciting pace at which it is growing around the globe. This research establishes owners' current views on BIM use and value in several economies where it has gained important traction, and it will serve as an effective baseline against which to measure their growing BIM involvement over the coming years.

McGraw Hill Construction thanks all its partners for their support, in particular our premier partners Autodesk and Skanska, and the owners who willingly shared their experience for this research.



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Stephen A. Jones leads MHC's initiatives in BIM and how emerging economic and technology trends are transforming the construction industry. Active in numerous industry associations (including the buildingSMART Alliance, the BIMForum, Construction Users Roundtable, Alliance for Construction Excellence and Charles Pankow Foundation), Jones frequently speaks at events around the world on the business impact of emerging technology and trends. He also hosts MHC's ENR FutureTech and

High Performance Construction events. Before joining MHC, Jones was a vice president with Primavera Systems (now part of Oracle), a global leader in project management software. Prior to that, he spent 19 years in creative and management roles with top design firms, most recently as a principal and Board of Directors member with Burt Hill (now merged with Stantec), one of the largest A/E firms in the US. Jones holds an M.B.A from Wharton and a B.A. from the Johns Hopkins University.

Harvey M. Bernstein, F.ASCE, LEED AP, has been a leader in the engineering and construction industry for over 30 years. Currently, he has lead responsibilities for MHC's market research group, including MHC's thought leadership initiatives in areas such as commercial and residential green building, BIM, information mobility, innovation and global construction markets. Prior to joining MHC, Bernstein served as President and CEO of the Civil Engineering Research Foundation. He has written hundreds of papers covering

innovation and sustainability and currently serves as a member of the Princeton University Civil and Environmental Engineering Advisory Council and the National Building Museum Board of Trustees. He is a visiting professor with the University of Reading's School of Construction Management and Engineering in England. Bernstein has an M.B.A. from Loyola College, an M.S. in engineering from Princeton University and a B.S. in civil engineering from the New Jersey Institute of Technology.

TABLE OF CONTENTS

04 Executive Summary

- 04 Executive Summary
- 06 Observations and Recommendations

07 Data

07 Introduction

08 Owners' Engagement With BIM

- 08 Owners' Past, Current and Future BIM Activity
- 09 Owners' Initial Interaction With BIM
- 10 Owners' Use of BIM Software
- 11 Owners' Use of BIM Consultants
- 11 **SIDEBAR How to Select and Derive Value From Consultants**
- 12 Owners' Greatest Challenge to Expanding Their Use of BIM

15 BIM Policies

- 15 Role of Public and Private BIM Policy Initiatives
- 15 **SIDEBAR Influence of the Private Sector on BIM Use**
- 16 Owners' BIM Requirements and Guidelines
- 17 Government Policy Impact on Owners' Interest in BIM
- 18 **DATA SIDEBAR BIM for Public Owners: Global Policy Trends, Including Full Discussion of Influential Policies in Singapore, the UK, the US and Scandinavia**

26 Owners' Perceptions About BIM Use by Project Teams

- 26 Perceived Frequency of BIM Use by Project Teams
- 29 Perceived Frequency of BIM Activities by Project Teams
- 30 **DATA SIDEBAR Insights From Owners on Use of BIM in Singapore**

33 Owners' Perspectives on the Impact and Value of BIM

- 33 Overall Impact of BIM on Owners' Projects
- 34 Owners' Views on the Single Greatest Benefit of BIM
- 35 Owners' Ratings of BIM Benefit Statements
- 36 Owners' Measurements of the Impact of BIM
- 40 **SIDEBAR Building Information Modeling for Sustainability**

41 Owners' BIM Needs

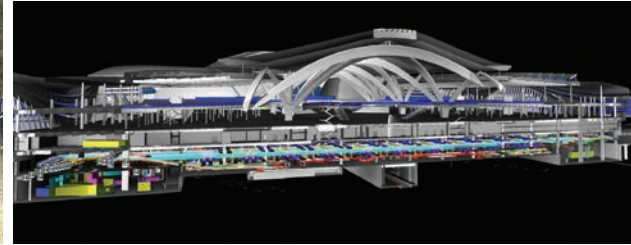
- 41 Owners' Perspectives on Support for BIM
- 43 What Owners Need to Expand BIM Use
- 45 Owners' Messages to the Industry
- 46 **DATA SIDEBAR Insights From Owners on Use of BIM in Scandinavia**



Front Cover:
The model for the New Royal Adelaide Hospital in Adelaide, Australia will be used to support operations and maintenance.

This page:
Left: The Abu Dhabi Airport Midfield Terminal's grand 17-story departure hall will make it the tallest airport terminal in the world.

Below: An integrated 3D model of the Midfield Terminal was created by all disciplines in the design stage, including scheduling and clash detection.



- 49 **Owners' Perspectives on BIM for Facilities Management**
- 49 Value of BIM for Facilities Management and Operations
- 50 Capability to Leverage BIM for Operations After Construction
- 51 Owners Currently Receiving Models for Operations After Construction
- 52 **DATA SIDEBAR** Owner Insights on Using BIM for Facilities Management

56 **Owner Perspectives**

- 56 **Desiree Gandrup-Dupre**, Vice President and Business Information Officer, Kaiser-Permanente Hospital System
- 57 **Richard Draper**, BIM Process Manager, Birmingham City University and
Derek Hughes, Technical Director, Connect Plus M25 Limited
- 58 **SIDEBAR** AEC Perspectives on Owners and BIM

Case Studies

- 13 **An Owner's Path to BIM Accelerated by Government Mandate**
Ministry of Justice, United Kingdom
- 38 **Switching to an Integrated Process on the Fly**
Midfield Terminal, Abu Dhabi Airport, Abu Dhabi, United Arab Emirates

60 **Methodology**

61 **Resources**

Executive Summary

BIM, which began primarily as a design tool then evolved to a must-have for leading contractors, is now rapidly gaining traction with owners around the world.

Owners see BIM's benefits on their projects and also want to use BIM in their facility operating environments. A central government mandate, which takes effect in 2016, is proving highly effective at driving owner BIM involvement in the UK.

Owners' BIM Involvement Steadily Expanding

Owners have been steadily increasing their BIM involvement over the last two years, and most plan more expansion in the near future.

- While only 11% of US owners surveyed for this study report that they were at a very high BIM involvement level (over 75% of their projects involve BIM) two years ago, almost four times as many (40%) forecast they will be at that level two years from now.
- BIM use in the UK is being driven rapidly by the government mandate requiring BIM use by 2016.
 - Most (98%) UK owners are currently at least moderately involved with BIM (25% or more of their projects involve BIM).
 - 38% of UK owners predict being very highly involved (more than 75% of their projects involve BIM) in the next two years, up from 28% currently.

Central Government BIM Mandate is Highly Impactful

UK owners are extremely active in driving BIM use on projects, a direct reflection of the pervasive effect of the upcoming 2016 BIM mandate.

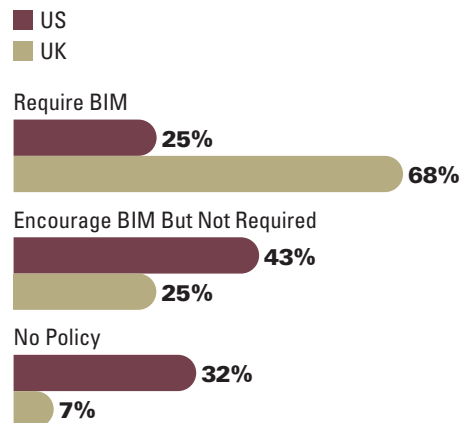
- Over two thirds (67%) of UK owners report a high or very high impact from the pending mandate. Among those:
 - 76% were inspired to initiate a specific BIM project.
 - 66% were encouraged to add BIM resources to their organization.
- Two thirds of both public sector (65%) and private sector (70%) UK owners say they will require BIM on new projects they will be starting.

By contrast, US government BIM policies only exist at a few agencies and have not had the same effect.

- Only 12% of US owners (almost all from the public sector) say that government policies have had a major impact on their interest in BIM, while nearly two thirds (62%) report little or no impact.

Owners' BIM Requirements

Source: McGraw Hill Construction, 2014



- Less than a third (30%) of the US public owners and just 11% of private sector ones say they will require BIM on new projects they will be starting.

Owners Are Aware of Core Team BIM Usage, But Less so for Other Team Members

Because of more day-to-day exposure, owners report higher awareness of BIM use by architects and general contractors (core team) than by engineers or trade contractors, regardless of what those firms' actual levels of use may be.

Because of the recently heightened overall awareness of BIM in the UK, those owners generally report greater awareness of BIM usage by project teams and specific BIM activities than US owners, especially design-related activities. For example, **all UK owners (100%) report awareness of BIM being used to generate preliminary schematic design**, compared with only 28% of US owners, highlighting the greater focus on BIM design activities in the UK.

US owners are typically more aware of construction-related uses than their UK peers, reflecting the relative maturity of BIM in the US and its adoption by contractors, which recently surpassed architects there. In fact, **over half (55%) of US owners, and even more (80%) of those at very high levels of BIM involvement are aware of model-driven spatial coordination being conducted among the trades, versus only 39% in the UK.** The UK percentage is likely to rise as construction-related BIM activity grows and becomes more visible to owners.

UK Owners Highly Engaged in Measuring and Experiencing Benefits of BIM

Most (88%) UK owners report they are formally measuring the impact of BIM on their projects, compared with only 16% of US owners, many of whom say it is too difficult or not necessary.

A far higher percentage of UK owners express agreement with key benefit statements related to BIM than their US counterparts. This enthusiasm may be a combination of more awareness through metrics and an overall excitement about the benefits of BIM being generated by the upcoming mandate deadline.

What Owners Need to Expand BIM

Once owners have initiated BIM, they need both reliable internal support and adequate external resources to successfully expand the volume and value of their BIM involvement. In general, UK owners feel much more comfortable that those elements are currently in place than owners in the US.

- **On average, 87% of UK owners feel positively about their level of internal support and external resources needed to expand BIM.**
- **By contrast, no more than half of US owners showed a similar level of enthusiasm for any aspect of support in their organization or their market.**

UK and US owners' wish lists for improvements that would better enable their BIM expansion include:

- **More BIM Skills at Design Firms:** This reflects owners' reliance on good model development by the design team as a fundamental cornerstone of BIM.
- **More Ability for Operations/Maintenance to Utilize the Model:** Owners see the potential to expand the value of BIM beyond design and construction to operations and maintenance but realize the current limitations of both staff and technology to implement it.

Owners' Ratings of BIM Benefit Statements (Those With a High or Very High Level of Agreement)

Source: McGraw Hill Construction, 2014

	US Owners	UK Owners
BIM Visualization Enables a Better Understanding of the Proposed Design	66%	98%
There Are Fewer Problems During Construction Related to Design Errors, Coordination Issues or Construction Errors	53%	85%
BIM Analysis and Simulation Capabilities Produce a More Well-Reasoned Design	50%	92%
The Use of BIM Generates a Beneficial Impact on Project Schedule	49%	85%
The Use of BIM Generates a Beneficial Impact on Control of Construction Costs	44%	72%

- **Standards of Model Development and Exchange:** This need is felt especially strongly in the UK where the vision for BIM is comprehensive, involving all parties throughout the lifecycle and therefore relying heavily on proper standards to exchange data between parties.
- **More BIM Skills Among Contractors/Trades/Fabricators:** This stated need leads with US owners, probably reflecting their relatively greater experience with the value of contractor-driven BIM activities.

Use of BIM for Owners' Facilities Management and Operations Still Emerging

Lifecycle value of BIM is a core feature of the UK government BIM program, which is reflected in the findings about owners' capabilities to leverage BIM for operations after construction in the UK versus the US.

- **Over half (54%) of UK owners say they already have high capabilities, with about a quarter of those claiming very high skills.**
- **Five years from now almost all (92%) of the UK owners believe they will have high capabilities, with more than half of those forecasting very high level skills.**
- **By contrast, only 14% of US owners believe they currently have high capabilities, and less than half (49%) think they will be at that level in five years.**

Observations and Recommendations

The following observations and recommendations are intended to help owners implement and derive more value from BIM on their projects and in their managed facilities.

Owners Should Actively Embrace BIM

The time has come. Compelling evidence from this and many other research studies around the world demonstrate BIM's significant benefits for building projects. Owners need to actively get familiar with resources—both online and in their local markets—that can help them to either initiate a BIM program or expand their existing activities to enjoy greater benefits.

Identify Your Organization's BIM Goals

One of the great benefits of BIM is that each owner organization can apply BIM uniquely to address its specific challenges in the markets where it operates, and tailor its processes and expectations to those goals. Owners should talk with their peers, BIM consultants, or design and construction teams to help identify achievable goals based on their BIM maturity and the specific project at hand.

BIM Planning Is Key, Regardless of Project Delivery Method

Once an owner's BIM goals are established, it is critical to invest time in early-stage BIM planning to make tactical decisions about processes and deliverables that will optimize BIM. Owners can include BIM Execution Plan development in the design firm's scope, even on design-bid-build projects. On more collaborative project delivery methods, more members of the construction team can also contribute, making it even more comprehensive.

Measure Progress, Insist on Accountability and Remain Open to Process Innovation

Owners should track progress against their goals, share the results and make course corrections as needed. Experienced BIM owners know that not every aspect of the plan will work and not every firm will perform to expectations.

Incorporating BIM is more about changing process than technology.

Owners need to be open, for instance, to adjusting the timing, quantity and responsibility for deliverables to integrate construction expertise into the design process, or driving design to maximize offsite prefabrication, both of which are greatly facilitated with BIM.

Stay Committed Because BIM Experience Increases BIM Benefits

Results in this and all other McGraw Hill Construction BIM research studies clearly show that BIM benefits increase directly for firms with the percentage of their projects that involve BIM. Owners getting started need to recognize that early challenges will give way to increasingly greater benefits as they persevere. Experienced BIM owners, who have absorbed many of the initial costs, process changes and cultural shifts, are well positioned to enjoy dramatically improved project outcomes and ever-advancing capabilities to use modeled data for post-occupancy management.

Explore Extending BIM to Facilities Management

The UK government BIM initiative includes BIM for FM as one of its core tenets. US owners need to identify opportunities to leverage BIM data after construction and put the requirements into their initial BIM plan with design and construction firms to ensure proper and timely data transfer.

Governments Should Study the UK BIM Mandate

The dramatic differences between UK and US owners in many of the study results are a striking testimony to the potential power of a well-conceived and executed central government BIM mandate, such as the one in the UK, that focuses on the full lifecycle and provides appropriate standards, processes and materials to support the demand. Governments everywhere that want to improve productivity in their construction industries should study the UK model mandating BIM and adapt it for their economies. ■

Data: Introduction

Owners are critical to the continued advancement of BIM. McGraw Hill Construction has been studying the accelerating growth and evolving business value of building information modeling (BIM) since 2007 but has been primarily focusing on designers and contractors. This is natural because, in most cases, BIM use was initially driven by architects who were drawn to its powerful visualization and the ability to optimize design solutions through digital iteration, analysis and simulation. Contractors quickly followed, enjoying immediate, tangible and repeatable benefits through spatial coordination, model-driven prefabrication, and cost and schedule integrations, in addition to the improved understanding of design intent that BIM visualization enables.

Although owners were regularly included in the research over the years, they typically showed relatively low awareness of how often BIM was being used on their projects, which parties were using it or for what specific purposes. And they generally had only a scant sense of the value it provided. However, as BIM consistently advances around the world, many more owners are becoming involved in understanding and measuring its value, actively engaging in model-centric processes and in some cases even prescribing its use. To capture the dynamics of this emerging trend, *The Business Value of BIM for Owners SmartMarket Report* focuses specifically on the owners' perspectives on BIM.

In addition to detailed survey data (described on the right), this report features:

- Interviews with key owners in Singapore and Scandinavia, two areas where BIM has been actively mandated
- Profiles of owners whose paths to BIM and current high commitment may serve as inspirations to other owners interested in starting or accelerating their process
- A description of many of the current central government BIM policies and programs around the world
- A feature focusing on how innovative owners are using models after construction to enhance facility management and operations activity

Our goals in conducting this research and publishing this report are to:

- Establish a baseline for current owner perceptions about BIM that can serve as a benchmark for future research
- Determine a forecast for increased engagement by owners with BIM in the future and the factors that they believe would impede or accelerate their increased use of BIM
- Inspire owners around the world to become involved or to increase their engagement with BIM so that the global construction industry can enjoy the productivity benefits of digital technologies, and owners everywhere can have better buildings

Note About the Data

Structured telephone interviews were conducted with 101 US owners and 40 UK owners to collect the data for this research.

Owners for this study were required to be “involved with BIM”, meaning that they are aware that BIM is being used by at least one party on a current project. Each owner who met that requirement was asked how much of their work involves BIM, and the owners were categorized into four levels of BIM involvement (low, medium, high, very high) based on the percentage of their projects that involve BIM. Due to the smaller sample size (40), UK owners are generally referred to as a whole with regard to BIM involvement.

Other owner characteristics used to analyze differences include:

- Tiers of annual construction budget
- Percentage of renovation versus new work
- Public sector versus private sector

Data: Owners' Engagement With BIM

Owners' Past, Current and Future BIM Activity

For the purposes of this research, the metric for the degree of owners' BIM involvement is determined by the percentage of their projects for which they are aware that at least one team member is using BIM, in four levels of intensity:

- **Low BIM Involvement:** Less than 25% of their projects involve BIM
- **Moderate BIM Involvement:** 25%-50% of their projects involve BIM
- **High BIM Involvement:** 51%-75% of their projects involve BIM
- **Very High BIM Involvement:** More than 75% of their projects involve BIM

To gauge the dynamics of their BIM involvement, the owners were asked to identify the level that represents their activity two years ago, their current activity and their forecasted activity two years from now.

The US owners show extraordinary growth over that four-year period.

- **Although BIM is relatively mature in the US, 17% report they had no BIM projects two years ago**, so a number of US owners are still getting involved.
- **The low involvement tier, which dominated just two years ago (58%), is projected to shrink to just 16% two years from now.**
- **While only 11% were very high involvement users two years ago, almost four times as many (40%) plan to be at that level two years from now**, which will make it the most populated level.

The UK owners are generally more enthusiastic about their BIM involvement, almost certainly spurred by the impending government mandate for 2016.

- **The very high involvement level shows consistent growth from 22% in 2012 to a forecast of 38% in 2016.**
- **Almost all (92%) report being at least moderate users two years ago.**

Several factors may be driving this response. At least one contractor heavily involved with BIM has found that large private sector owners and many of their public sector clients "are now increasingly demanding BIM." He also believes that there is a shared goal among leaders in the UK construction industry to strive "to lead the world in BIM."

Proportion of BIM Usage

(Moderate, High and Very High Involvement)

Source: McGraw Hill Construction, 2014

■ 25%–50% ■ 51%–75% ■ More Than 75%

US

2 Years From Now



Currently



2 Years Ago



UK

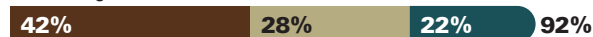
2 Years From Now



Currently



2 Years Ago



That enthusiasm for UK BIM leadership is also expressed by Richard Waterhouse, chief executive, RIBA Enterprises, who says in the introduction to the NBS 2014 BIM survey of design and construction firms, "The UK is in an enviable position of being among the world leaders in BIM adoption and implementation. [BIM] has the potential to bring improved efficiencies and profitability to the construction sector and better buildings to clients."

Owners' Initial Interaction With BIM

Owners have many paths to BIM. While some are introduced to it by design or construction firms, others take the initiative themselves to learn about it and drive its use through a top-down program.

For this study, the owners were asked to think back to the first project where they were aware that BIM was being used and to indicate if one or more of the following four statements applied to that project, acknowledging that multiple forces may have been at play.

■ **The design team (architects and/or engineers) were using BIM without our request:** Design team initiation is the most common method in the US (58%) and even more so in the UK (90%). This makes sense because design professionals consistently have been the earliest BIM adopters in all previous McGraw Hill Construction BIM research.

■ **The construction manager or general contractor (CM/GC) was using BIM without our request.** The most recent US research shows that contractors have surpassed architects in BIM adoption. This dynamic is reflected in these findings, drawn from the *Business Value of BIM for Construction in Major Global Markets SmartMarket Report* and the *Business Value of BIM in North America SmartMarket Report*:

- Over three quarters (76%) of the US owners at a very high BIM involvement level say that both the design team and the CM/GC were already using BIM without owner request on their first BIM project.
- Among the large US owners (greater than \$400M annually spent on construction), the CM/GC was more often already using BIM (61%) than the design team (44%), reflecting its rapid adoption among the large CM/GC firms that serve those mega-clients.

In the UK, more private sector owners (85%) say that the CM/GC was using BIM on their first BIM project than public sector ones (55%). This may indicate that the firms primarily working for private clients are more active users of BIM than those concentrating more on the public sector.

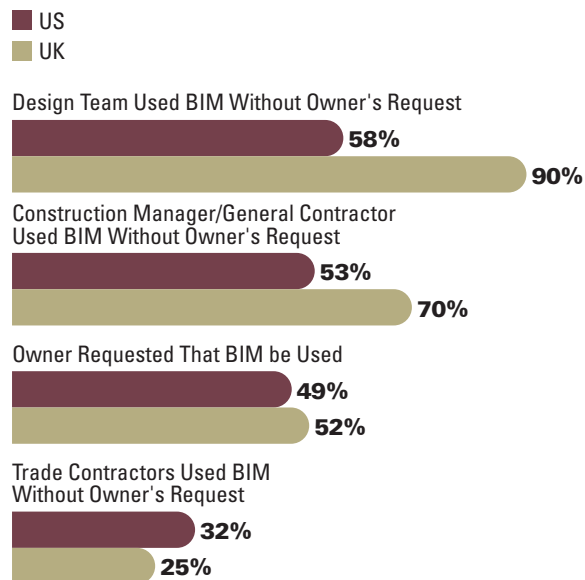
■ **My organization requested that BIM be used on the project.**

This is a growing trend on both sides of the Atlantic.

- Half of the lesser-involved BIM owners (those at low, moderate and high involvement levels) cite that they requested BIM on their first BIM project. Since they likely started BIM more recently, this may indicate an accelerating trend.

Initial Interaction With BIM

Source: McGraw Hill Construction, 2014



- Two thirds (67%) of the large US owners say they requested BIM, indicating an expanding trend toward top-down BIM programs at those larger organizations.
- In the UK more public owners (65%) say they requested BIM on their first project than private sector owners (40%). This likely derives directly from the UK government BIM mandate.

■ **The trade or specialty contractors were using BIM without our request.** This is least frequent both in the US (32%) and UK (25%), although half (48%) of the US owners now at the very high BIM involvement level and 39% of the large US owners each say that a trade contractor was using BIM on their first BIM project. This probably points to the industry-leading specialty contractors (steel, mechanical, etc.) who adopted BIM early and who work regularly with the top CM/GC firms that serve the large and BIM-savvy owners.

Owners' Use of BIM Software

THE BUSINESS VALUE OF BIM FOR OWNERS DATA

While design teams and contractors frequently own BIM software to author and analyze models, owners generally have less of a direct hands-on need for it.

To assess the status of this, owners were asked if they own software to develop/author building information models, and among those who say they do, how frequently are they using it to develop/author models.

- **Twice as many US owners (43%) report owning BIM authoring software than UK owners (20%).**
- **Among those who do own the authoring software, all the UK owners report high activity developing/authoring models, whereas only a few of the US owners show that level of engagement.**

Even higher numbers of owners in both regions report using BIM software to review models.

- **Slightly more of the UK owners (68%) report having software to review than their US counterparts (59%).**
- **Similar to the pattern with authoring software, the**

majority (60%) of the UK owners who have model review technology use it heavily, versus just 15% of the US group.

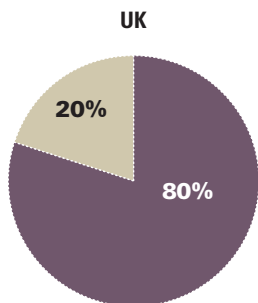
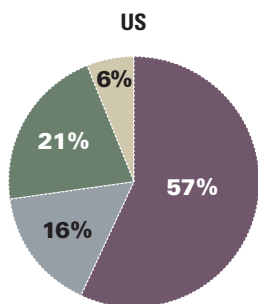
The sharp difference between UK and US owners' engagement with BIM software can perhaps be partially explained by the recent and intense focus on BIM throughout the UK construction industry, or what one contractor actively deploying BIM in the UK refers to as the "novelty factor plus technical innovation factor." He says, "Most clients who commission BIM want to see what it is offering, and they expect to engage more."

This is supported by the firsthand account of a head teacher with a primary school who used BIM software to access the model for a significant project. "I certainly feel more confident because we can actually see what it's going to look like. We have been able to order the furniture now in advance, which we would never have been able to [do] with the use of flat plans."

Owners' Use of Software to Develop and/or Author Models

Source: McGraw Hill Construction, 2014

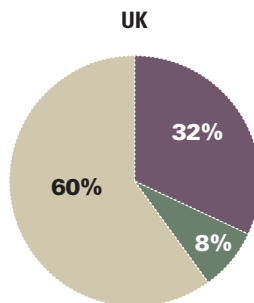
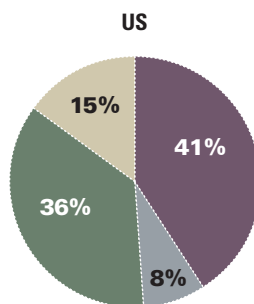
- Do Not Own
- Own but Do Not Use to Author Models
- Own and Sometimes Use to Author Models
- Own and Frequently/Always Use to Author Models



Owners' Use of Software to Review Models

Source: McGraw Hill Construction, 2014

- Do Not Own
- Own but Do Not Use to Review Models
- Own and Sometimes Use to Review Models
- Own and Frequently/Always Use to Review Models



Owners' Use of BIM Consultants

BIM consultants (separate from the design team or contractors) can provide important expertise to owners, especially related to developing their BIM procedures and guidelines or helping them comply with government ones.

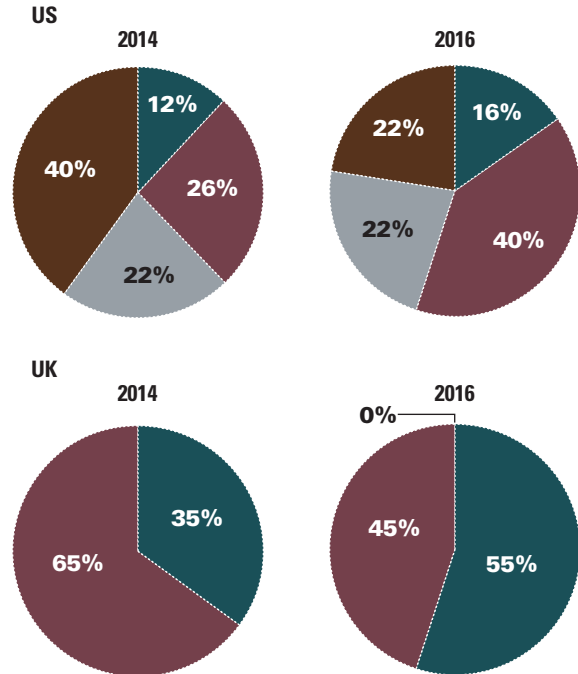
US and UK owners were asked about their current use of BIM consultants and what they forecast their use will be in two years. The results clearly show that the UK owners' use of BIM consultants is far more extensive than in the US, and use will grow dramatically in the UK over the next two years.

One contractor with a high level of BIM involvement believes this can be attributed primarily to government BIM requirements: "The UK government guidelines appear quite complex, and the need for clear briefing information [in the contractual form of Employers Information Requirements] is critical to explain what clients want." His experience is that "most clients do not have the detailed knowledge to articulate exactly what they need in that format, hence the growth of BIM consultants."

Owners' Use of BIM Consultants

Source: McGraw Hill Construction, 2014

Always Use Frequently Use Low Use Never Use



How to Select and Derive Value From Consultants

According to Kristine Fallon, from KFA, BIM consultants can provide three main values to owners:

1. BIM Strategy: Consultants provide internal and designer/contractor requirements, with goals and metrics, and a plan to achieve them.

Owners should seek consultants who know all BIM perspectives—designer, contractor, CM and owner—and understand project delivery, contracts, licensing, liability, business processes and culture. They should ask for a

BIM implementation plan with milestones and budgetary pricing.

2. Implementation Guidance: For example, getting COBie output from BIM software may be an opaque process. A BIM consultant can provide training, videos, documentation, templates, object libraries, etc., for owners' internal use and with project teams.

Owners should seek consultants with the prerequisite software skills, discuss the intended results, agree on deliverables

and have end-user review of deliverables to ensure quality.

3. Doing BIM: Consultants can outsource modeling, checking of BIMs and COBie data from project teams, transfer of COBie data to owner systems or maintenance of BIMs.

Owners should seek consultants who understand industry workflows and who automate processes rather than billing a lot of hours.

Owners' Greatest Challenge to Expanding Their Use of BIM

Owners were asked to describe what they believe is the single greatest obstacle to expanding the use of BIM on their projects. Their responses are grouped into three major themes, and the top five are rank ordered in the table. (Note that only four obstacles received enough acknowledgement by UK owners to be included.)

Training Investment/Lack of Skilled Users

- In the US, this challenge is most deeply felt by the owners with a very high level of BIM involvement (32%) and those with large annual construction programs (28%).
- This issue was not identified by any US healthcare owners (0%), perhaps because that is such a popular project type for BIM.

Cost/Funding/Initial Investment

Far more of the US owners currently at a low BIM involvement level (26%) and those with small construction budgets (28%) named this as an issue than those at a very high involvement level (8%) or with large budgets (0%).

The same pattern holds true in the UK, where only 11% of the large budget owners cite this as an obstacle versus 27% of the smaller ones. This may reflect the investments that the larger and more BIM-active organizations have already made, and, therefore, they no longer see investment as an obstacle to growth.

In fact, Terry Stocks, the director of project delivery for the UK Ministry of Justice states, "Our experience has been that [BIM] hasn't cost more BIM kept us on [our intended] trajectory of savings so we didn't see any spike in increased procurement cost." (See page 13 for more information on the UK Ministry of Justice's adoption of BIM.)

Industry and Upper-Level Buy-In

- Industrywide buy-in is noted as an obstacle by more renovation-oriented US owners (24%) versus those doing mostly new construction (13%). This likely reflects the slower penetration of BIM in that segment of construction activity.
- More large US owners (28%) cite industrywide buy-in as an obstacle than small ones (7%). This is probably because larger owners do projects in more geographic regions and require extensive resources, so they encounter a greater diversity of BIM buy-in by AEC firms and pockets of lingering resistance to BIM adoption.

Owners' Perspectives on the Single Greatest Obstacle to Expanding BIM Use

Source: McGraw Hill Construction, 2014

Ranking	US	UK
1	Training Investment/ Lack of Skilled Users	Cost/Funding/ Initial Investment
2	Cost/Funding/ Initial Investment (tie)	Training Investment/ Lack of Skilled Users
3	Buy-In Among Industry/ Adoption on Wider Scale (tie)	Buy-In Among Industry/ Adoption on Wider Scale
4	Upper-Level Buy-In	Lack of Standards for BIM Across Industry
5	Not as Adaptable for Small Jobs (tie) Lack of Standards for BIM Across the Industry (tie)	N/A

- Buy-in by top management is not identified by any US healthcare owners (0%), perhaps because healthcare is such a popular project type for BIM in the US, and the value proposition is well established. Neither is this issue identified by any UK owners (0%), probably due to the widespread communications underway about the government mandate.

An Owner's Path to BIM Accelerated by Government Mandate

Ministry of Justice

UNITED KINGDOM

Terry Stocks is a chartered structural engineer by profession with 20 years' experience in construction and project management. At the Ministry of Justice (MoJ), he is responsible for design and construction for the prison system, judicial courts and all related administrative buildings in the whole of the UK, delivering over 100 projects a year.

Lean Was First Step on the Path to BIM

Among the stated goals of the MoJ is to "Build a prison system that delivers maximum value for money." To improve MoJ efficiency, Stocks launched a lean construction program in January 2009. His team began collecting and analyzing project data to "benchmark where we were, [so we could] demonstrably put value into the way we procure our buildings."

CHANGE IN PROCUREMENT POLICY FOSTERED A MORE COLLABORATIVE APPROACH

In order to engage the supply chain in the lean initiative, Stocks made significant changes to MoJ's procurement policy. "It's really important that your procurement culture is aligned with the outcomes you want. So instead of having to depend on a whole bunch of contractors and professional service providers, we started working in alliances with a smaller number."

By concentrating on a group of about two dozen design firms and contractors, Stocks could "get a bit of cultural alliance and trust between us. We always had them inside the tent [to create] the practice and process that we wanted to use to deliver a

project." It was a critical transition from being "adversarial into more collaboration and cooperation."

BIM SEEN AS KEY TOOL TO SUPPORT COLLABORATION

When the UK construction strategy mandating BIM was announced, "We were the first on the phone to the BIM Task Group. I said, 'We'll be the first trial project to run through,' and fortunately they agreed."

Stocks saw that BIM "sits in the middle of what we're trying to do to enhance the level of collaboration." He told his group of firms, "We expect you to become BIM proficient over a couple [of] years."

Building Toward BIM Acceptance

Stocks recalls that initially, everyone expressed eager acceptance. "It's not until you really engage with them that [you see] tepid acceptance, no acceptance and willful belligerence."

To ease firms into BIM on the first project, Stocks told them, "We'll make it a job with BIM, rather than a BIM project." He believes that approach "took the fear out of them a bit because they realized that BIM was not the be-all or end-all." After that he says, "They went at it wholeheartedly. They really took the challenge up."

To encourage adoption he set up a special interest BIM group for suppliers, led by a member of the supply chain. "We didn't want to lead the whole thing. We wanted a real relationship. We had the road map that we took to [the special interest BIM group] and said, 'This is where we need to be in terms of milestones; now you guys need to work with us to put the detail in it.' That helped accelerate engagement."

Now there are a series of what Stocks calls BIM4 hubs (e.g., BIM4 manufacturing, BIM4 clients, BIM4 offsite) that are tied into central government, but run by organizations or private sector individuals who are interested.

Strategies for Transitioning to BIM

Stocks' approach was successful. Two thirds of MoJ work is now BIM Level 2, and the 2016 goal is 95%. "For us, BIM is business as usual. You've got to opt out of using BIM rather than opt in, which is a total mind shift." He finds that "the small projects are really good training grounds for your supply chain."

Reflecting on the transition he says, "It's not all been smooth riding for sure. We had enough [large] contractors that were really up for it to give us that critical mass. But we've had to support them in building relationships with their tier twos and threes. The big mechanical electrical subcontractors are not a problem. But we made it clear that the onus was on the tier ones to support the smaller suppliers [with BIM]."

To facilitate this, Stocks continued to modify MoJ procurement policy. "We were working in alliances, but we were asking our tier ones to competitively tender three or four quotes for their sub packages. That was just driving poor behaviors lower down, because we'd have to go with the lowest supplier and that would just create problems later on. We had to step back and say, 'Hang on, no, no, no. Yes, we want value, but we'll measure that overall. We'll let you build up your relationships with your sub suppliers so you can build up innovation.'"

CONTINUED

Ministry of Justice UNITED KINGDOM

Engaging Facility Managers

Incorporating the Government Soft Landings initiative, Stocks engages facility managers to help the design team “think in terms of operations or cost right at the beginning of the job.”

In early meetings he asks them about existing facilities. “What are your top 10 issues? What don’t you like? What can we design better?”

Adding BIM to this process has been a great success. “With 2D drawings, nobody wants to say they don’t understand, and you end up making late-stage changes that cost you money. What you really can’t underestimate is the power of that 3D [BIM] image to walk them through their facility.” On a £20-million project “we took £800,000 out of the initial phase designs” with virtual walkthroughs to refine the design. And having studied the model so closely, the operations manager said, “When I went into the building, I felt as though I had already been in it.”

Stocks is now using BIM on maintenance and repair projects to expand the database of existing facilities.

Benefits of BIM

CURRENT BENEFITS

Stocks says measuring cost/benefit is core to the MoJ BIM initiative. “Our experience has been that [BIM] hasn’t cost more.” And in terms of “pounds in the ground” (the percentage of a project budget that ends up in the actual facility), he says, “We’re about 25% more efficient than we were in 2009.”

BIM helped Stocks re-engineer MoJ’s approach to deliverables and their schedule. “You can be

really efficient at asking for the wrong things,” he jokes. Instead of the traditional approach of “overburdening our supply chain with ‘Give us this, and we want it all now, but actually we might not look at it for six months,’” he is taking more of a just-in-time approach, “so we can work in a calm way rather than a whirling dervish environment that is quite easy to whip everyone up into.”

EXPECTED BENEFITS

Although efficiency is up and risk is down, Stocks hasn’t seen supply chain fees and pricing reductions yet. “That’s our expectation,” he says. “We’ve been using BIM about two years, and everybody is starting to realize [BIM] reduces risk at the front end of projects. I think we’ll start to see that manifest itself in their pricing. At the moment, they’re just at that cusp where they’ve done a couple of projects, they’ve been able to de-risk the construction, but they haven’t been brave enough to put it in their price. That’s something, as an intelligent client, you’ve just got to live with; otherwise, you’re not going to get them on the journey.”

By leveraging model-driven prefabrication and laser scanning, Stocks foresees more “design for manufacture, so the working time onsite can be installation rather than fabrication.” His team recently built a full-scale mock-up of an improved service duct that saves 15 minutes in servicing. They then scanned it into a model for prefabrication. “Leveraging 15 minutes for one duct times 180 in one facility, then using that design across 10, 15, 20 projects, it’s a huge time savings.” He finds laser scanning existing facilities for

renovation projects also shortens their out-of-service time.

Growing BIM in the UK

Stocks says the UK government BIM initiative is now spreading in several ways:

- **Government:** “We are really lucky to have that massive focus from our central government system. Most of the departments are on board with this now, and the ones that are not are running to catch up.”
- **Private Sector:** “By up-skilling the government, we’re also up-skilling the private sector supply chain. Now commercial development companies are using BIM for their signature projects in London.”
- **Europe:** “France, Spain and Italy are all starting to use BIM Level 2 processes wider.”

As to the future, Stocks is confident that “BIM Level 3 is going to take it even further.” ■

Project Facts and Figures

Owner

Ministry of Justice

Annual Construction Budget

£350 million per annum

Current BIM Engagement

Approximately two-thirds of projects currently using BIM

BIM Engagement Goal

95% of projects using BIM by 2016

stats

Role of Public and Private BIM Policy Initiatives

BIM initially gained traction in the global construction industry from the bottom up, as a practitioner-driven initiative. It has grown through a constant process of trial and error by architects, engineers, contractors and owners on thousands of projects all over the world.

As BIM matured, the more experienced users documented and institutionalized proven practices within their own organizations to more consistently and reliably achieve the benefits of BIM, and several industry groups initiated guideline and standards programs for broad dissemination. Examples include the National BIM Standard from the buildingSMART alliance at the National Institute of Building Sciences, Level of Development standards from the BIMForum, Owner's BIM Guide developed by Penn State University, and various types of BIM agreements, amendments and execution plans.

It is now becoming increasingly important for public and private owners to engage with these initiatives and provide more comprehensive direction and guidance to their project teams about the use of BIM. The practice of just putting the word "BIM" into an RFP and sitting back to see what happens must evolve to a more conscious, reasoned and intentional deployment of BIM for specific purposes, by proven and repeatable processes, and with metrics appropriate to the initial objectives.

This section of the report addresses the current state of and attitudes about owners' BIM policies, including a matrix of national-level government policies from a number of construction markets around the world.

Influence of the Private Sector on BIM Use

The data in this report clearly reveal the influence of government mandates for BIM, and an overview of government efforts in several major construction markets globally begins on page 18. However, the research on these markets also demonstrates efforts by the private sector, either on their own or in partnership with government, to encourage more widespread use of BIM.

- **Brazil:** Despite the fact that Brazil has no official government standard, the use of BIM is quickly rising for Brazilian building and infrastructure projects. In fact, the *Business Value of BIM for Construction in Major Global Markets SmartMarket Report* reveals that BIM use is increasing among contractors in Brazil

at a higher rate than in any of the other markets examined. AEC firms have been leading the way in developing internal BIM workflows and processes to keep pace with foreign competitors. buildingSMART has also announced its intention to form a chapter in Brazil to promote open data standards.

- **Canada:** The Institute for BIM in Canada is working with the buildingSMART alliance to adapt the UK National BIM standard as a basis for a Canadian standard.
- **Sweden:** The BIM Alliance—created in 2014 by merging a few separate BIM-related organizations—is promoting open standards and processes, methods, tools and best practices for BIM. The Alliance

consists of more than 140 companies from the AEC industry, as well as owners and building operators.

- **Japan:** In 2012, the Japan Institute of Architects created BIM guidelines. In addition, currently, private owners such as Samsung have taken the lead in requiring BIM on projects in Japan.
- **Hungary:** A BIM trade group is, as of publication date, still developing their website (<http://www.mabin.hu/>). In addition, a local technology company hosts software-related events in which BIM case studies are presented. However, at this point, the private sector is still implementing BIM on a case-by-case basis only.

Owners' BIM Requirements and Guidelines

Requiring or Encouraging BIM

While all the owners in this research study are currently involved with BIM on their projects, they vary greatly in the degree to which they require it, merely encourage it or, in some cases, take no official position on it whatsoever.

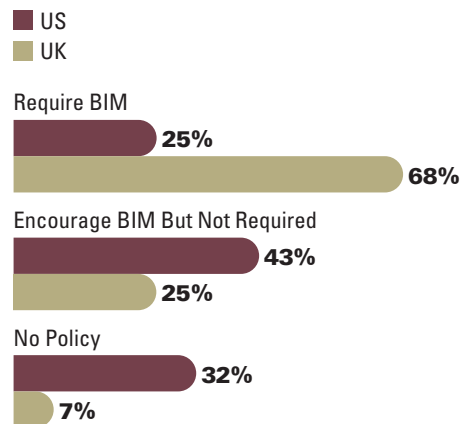
- **Around two thirds of both public sector (65%) and private sector (70%) UK owners say they will require BIM on new projects they will be starting, compared with less than a third (30%) of US public owners and just a handful (11%) of US private sector ones.**
- **Among US owners, their current level of BIM use and annual construction spend relate directly to their propensity to require BIM.** This reflects the growing commitment to BIM programs among owners who use BIM frequently and among those with large annual construction budgets:
 - Over half (52%) of the subgroup of US owners who are currently at a very high level of BIM involvement (more than 75% of their projects) say they will require BIM, compared with only 10% of those at a low involvement level (less than 25% of projects).
 - Similarly, more than half (56%) of US owners with largest annual construction budgets (greater than \$400 million) plan to require BIM, compared with just 10% of owners with relatively small construction spend (less than \$50 million).
 - BIM is required by far fewer renovation-oriented US owners (13%) than those doing mostly new construction (32%), reflecting its much lower use for that type of work in the US.
- **While nearly a third of US owners (32%) say they will neither require nor encourage BIM use on their upcoming projects, only a few (7%) UK owners plan to take that passive stance.** This US group largely consists of those with small annual budgets, low current levels of BIM involvement and a higher proportion of renovation projects than new construction.

BIM Guidelines

To make the most effective use of BIM, owners who mandate or encourage it ought to have BIM guidelines for their teams to deploy. In this study, the owners who say they will require or encourage BIM on upcoming projects were asked to characterize the status of their BIM guidelines.

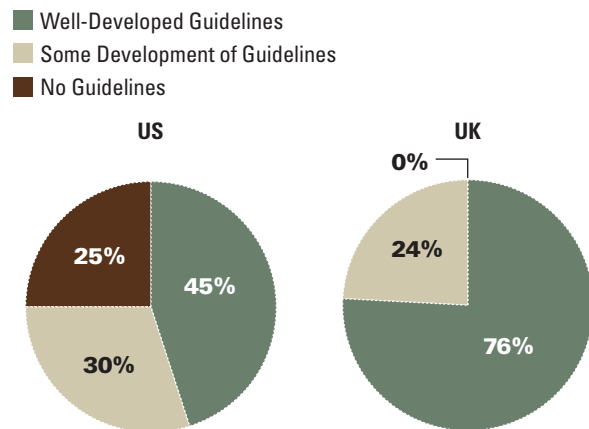
Owners' BIM Requirements

Source: McGraw Hill Construction, 2014



Owners' BIM Guidelines

Source: McGraw Hill Construction, 2014



- **Among this subgroup of US owners, almost half (45%) have what they consider to be well-developed guidelines, although a quarter (25%) still have no guidelines at all.**
- **By contrast, over three quarters (76%) of the UK subgroup believe that they have well-developed BIM guidelines, and none of them report being completely without guidelines.**

Government Policy Impact on Owners' Interest in BIM

It is clear that BIM use in the UK is enormously accelerated by the Government Construction Strategy published in May 2011, which mandates a minimum requirement for fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on centrally procured public projects by 2016. In the US, while several federal agencies have developed BIM programs as well as various other state and municipal initiatives, there is no such cohesive national BIM agenda.

Overall Impact of Government Agency BIM Requirements

This BIM policy differential explains the dramatic variance in results between the US and UK owners when they were asked how much impact government agency BIM requirements have had on their organization's interest in BIM.

- **Over two thirds (67%) of all UK owners, and 80% of the ones in the public sector, report a high or very high impact, versus only 12% of all US owners (almost all of whom are in the public sector).**
- **Only 5% of all UK owners (all of them from the private sector) report that government policies have had little or no impact, versus almost two thirds (61%) of all US owners.**

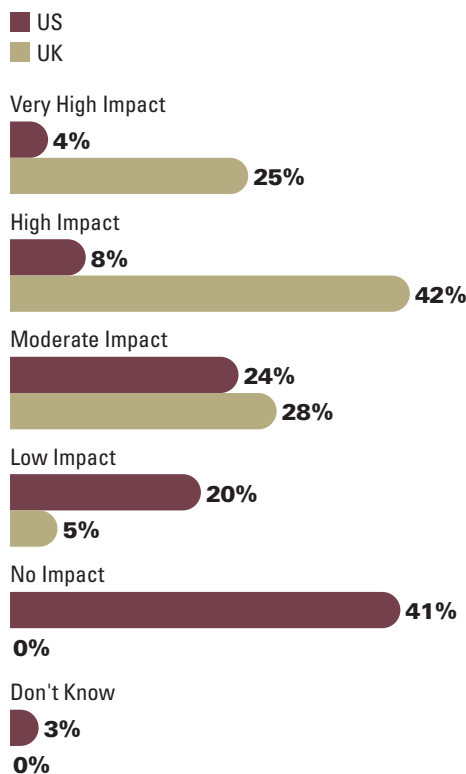
How Government Policies Impacted Owners

Owners who reported at least a moderate amount of impact from government BIM policies (95% in UK and 36% in US) were asked to select one or more of three statements that describe the impact on their organization.

- **In the UK, over three quarters (76%) of that subgroup cite that government policies spurred them to initiate a specific BIM project, and two thirds (66%) say it encouraged them to add BIM resources.** In each case these figures were slightly higher among public sector owners than private.
- **In the US, however, the impact of government agency BIM policies on expanding owners' BIM programs is more muted. Most (80%) of the private sector owners indicate that the impact, small as it may be, does not include any of the options offered to them in the survey.**

Impact of Government Policies on Owners' Interest in BIM

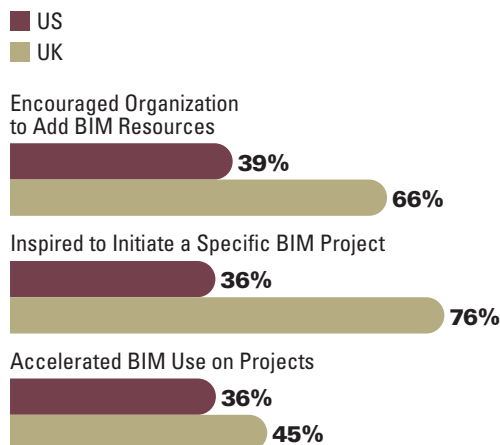
Source: McGraw Hill Construction, 2014



How Government BIM Policies Impacted Owners' Interest in BIM

(According to Owners Who Report Being at Least Moderately Impacted by Government Policies)

Source: McGraw Hill Construction, 2014



Data: Government Policies

BIM for Public Owners:

Global Policy Trends, Including Full Discussion of Influential Policies in Singapore, the UK, the US and Scandinavia

Many major economies today are considering a national BIM mandate or already have one in place because they believe that BIM adoption is a necessary step toward minimizing lifecycle building costs.

Lowering long-term costs is a top goal for all public owners. "BIM has become essential to the realization of recent aggressive energy reduction mandates [enacted in the US and around the world]," says Charles Matta, deputy chief information officer for the Public Buildings Service of the US Government Services Administration (GSA). "Only through using BIM and smart building technologies can public real estate owners design and deliver innovative buildings, maximize energy efficiency and achieve effective building operations throughout the building lifecycle."

In addition, broad regional directives will likely drive the adoption of BIM mandates or incentives in some parts of the world. For example, in January 2014, the European Parliament passed a set of reforms to the European Union (EU) Public Procurement Directive to help reduce costs and project overruns. Included in these reforms were clauses designed to encourage BIM adoption and other electronic tools on public works contracts. It is widely believed that the directive will encourage some EU nations to adopt BIM mandates or incentives.

About the Policy Research

McGraw Hill Construction researched the BIM policies, mandates and resources of 21 countries in Asia, Europe, North America and South America. The research was primarily

conducted through interviews with government officials and policy experts and through extensive secondary research on published policies. In addition to reviewing the key trends, the analysis includes a more extensive look at how and why mandates and policies were established in the UK, Singapore, the US and Scandinavia (Denmark, Finland, Norway).

Factors Driving Adoption of BIM Policies

SHIFT IN FOCUS FROM INITIAL TO LIFECYCLE COSTS

BIM gained traction during the economic and building boom of the early 2000s, when prices for labor and materials were increasing worldwide. So the earliest adopters of BIM for public buildings, most notably the US's GSA, did so primarily with an eye toward keeping design and construction costs in check. At this time there were also fewer BIM-authoring tools on the market, and the most mature tools were geared toward architects and designers. So it stands to reason that the early focus on BIM was achieving efficiencies early in a building's life.

This goal is still important, but public owners have shifted their attention to lowering total lifecycle costs and recognize that implementing BIM is a necessary step toward this goal. The shift is the outgrowth of several factors:

- **Rising energy prices worldwide**
- **Passage of aggressive reduction targets for energy use and/or**

carbon emissions in the US, the EU and other regions

- **Global economic downturn of the late 2000s, which has kept material and labor costs in check relative to the boom years**
- **Technological advances that have improved the value proposition for BIM, such as:**
 - Cloud-based data storage and services, including software-as-a-service (SAAS)
 - Better and more BIM-authoring tools for a broader range of building disciplines
 - Software, applications and interfaces that allow for complex "big data" analyses of and uses for information contained in digital building models

Countries that adopted BIM mandates later, particularly the UK, have been crafting mandates that align explicitly with the goal to lower lifecycle costs; future adopters will likely do the same; and countries with existing mandates are moving their policies in this direction.

COMPETITIVE EDGE IN THE GLOBAL CONSTRUCTION MARKET

All countries mandating BIM, along with those considering a mandate, want to ensure that their building industries are keeping pace with innovative technologies and practices, believing them crucial to future success. In countries where BIM is not yet required for public buildings, there is a general fear of falling behind rival economies and a

Countries With National Mandates

Source: McGraw Hill Construction, 2014

Country	Name of Mandate	BIM Data Required	Building Sizes or Budgets Requiring BIM	Submittal File Formats	Reasons for Establishing Policy	Supporting Materials (e.g., Training, Guidelines)	Date of Original/ Current Mandate(s)	Future Phase-In Plans
Denmark: Building & Property Agency under the Ministry of Climate, Energy and Building	Executive Order No. 118	Project lifecycle (architecture through O&M)	5M kroner and higher for national projects 20M kroner and higher for regional and municipal projects	IFC, Native	<ul style="list-style-type: none"> • Reduce energy consumption in buildings • Improve productivity • Shorten project delivery timeframe • Improve coordination and communication among team members 		2007/2013	
Finland: Senate Properties	Common BIM Requirement 2012	Project lifecycle (architecture through O&M)	All national public projects	IFC, Native	<ul style="list-style-type: none"> • Support making design and construction lifecycle process safe • Support making design and construction lifecycle process compliant with sustainable development • Utilize models for facility management 	Guidelines (updated in 2012)	2007/2012	
Norway: Statsbygg	Statsbygg BIM Manual 1.2.1	Architecture and handover data	All national public projects	IFC, Native	<ul style="list-style-type: none"> • Reduce errors and omissions • Improve communications and coordination • Gain efficiencies • Increase energy efficiency • Use cutting edge research, technologies and processes to improve the built environment 	BIM Manual 1.2.1	2005/2013	Additional BIM data requirements expected by 2016
Singapore: Building and Construction Authority**	BIM Road map and e-submission requirements	Architecture and engineering data	All new buildings over 20,000 sq.m.	IFC, Native, 3D PDF or 3D DWF	<ul style="list-style-type: none"> • Increase construction industry productivity by 20% to 30% over the next decade • Achieve BIM use by 80% of Singapore's construction industry by 2015 • Realize a highly skilled and technologically advanced construction sector led by progressive firms and supported by a skilled and competent workforce in 2020 	<ul style="list-style-type: none"> • Training • Financial Incentives • Guidelines • Sample Contract Language • E-submission Templates • Award Programs for Innovators 	2012	All new buildings over 5,000 sq.m. in 2015.
South Korea: Public Procurement Service (PPS)	BIM Guide Version 1.2	Architecture and property data	All public buildings costing over \$27.6M	IFC, Native	<ul style="list-style-type: none"> • Increase energy efficiency • Reduce design errors • Reduce construction costs • Support efficient facility management 		2010	BIM required for all projects by 2016
United Kingdom: The Cabinet Office of Government Construction Board	Government Construction Strategy	Project lifecycle (architecture through O&M, defined in the U.K. as Level 2)	All national public projects	COBie, Native, PDF	<ul style="list-style-type: none"> • Reduce construction costs • Reduce project delivery time • Make UK's design and construction industry more competitive globally • Help UK meet carbon reduction targets for buildings 	BIM Task Group provides support for both the UK government and supply chain	2011	BIM requirements will apply in 2016.

** Singapore is the only government to require that performance metrics are reported on projects

Definitions of file formats

IFC (Industry Foundation Classes): open standard for exchanging BIM data between different proprietary software applications

COBie (Construction Operations Building Information Exchange): open standard for the capture and delivery of information needed for facility management (FM)

Native: proprietary software standard from the authoring tool of a BIM model

PDF (portable document format): typically extracted automatically from a 3D model authored in BIM software

DWF (design web format): proprietary to Autodesk, used to transmit 3D model information in compressed form to reduce file size

desire to take advantage of business opportunities offered by BIM in robust building markets, whether in-country or abroad.

The desire to advance innovation and become an industry leader is most explicit in the BIM policies of the UK and Singapore. Part of the UK's overall construction strategy is "to drive a more competitive construction sector that's effective, efficient, productive, and can export design and engineering services to other parts of the world. BIM fluency is part of the needed skill set," says Adam Matthews, an Autodesk executive who participates in the UK's BIM Task Force that supports the government's BIM goals.

Singapore has often imported design and construction services to keep up with building demand and to take advantage of the most effective methods and tools. Its BIM mandate and road map aim to turn the tide so that Singapore-based companies can compete with international firms for work in-country, thus supporting the industry's employment figures and revenue.

Success Metrics Not Widely Tracked

Whether they already have BIM mandates or are just considering them, public owners report benefits from documenting and sharing case studies to champion BIM, educating the industry on best practices and processes, and helping owners and their contractors learn from past successes (and mistakes). The UK and Singapore are undertaking significant efforts in this regard due to their mandates.

However, of all the major governments investigated for

this article, only Singapore makes collecting BIM-related metrics a requirement. Policymakers are not convinced that data is needed to capture cost savings due directly to BIM on building projects for two main reasons:

- It is difficult to quantify cost avoidances due solely to BIM with accuracy, due to variables in factors such as project size and location, contractor experience and project complexity. In the words of one public owner, "Every project is vastly different, and many of the assumptions needed to calculate the savings can be called into question. We don't think it's worth the effort."
- Many public owners in major economies are already convinced of BIM's value. Therefore, public owners are no longer making adoption decision based on proof of cost savings.

Quantifying cost savings due to using BIM on public buildings will likely continue on an ad hoc basis: for example, for papers presented at professional conferences and symposia; for awards submissions; and as part of studies done by AEC firms or BIM software vendors as a way to attract clients.

In terms of broader measures of BIM's success and effectiveness, a metric called bimSCORE, developed by Calvin Kam at Stanford University, assesses a BIM project's efficacy in four areas: maturity of the BIM planning process; levels of adoption; sophistication of technology and data standards; and measures of performance.

Overall, public owners are aware of bimSCORE and some, such

as Hong Kong and other Asian economies, use it as a means of fine-tuning and prioritizing resources for implementing BIM.

Data Standards Matter More Than Authoring Platforms

Public owners have embraced open data standards for submittals of BIM information and, at present, have largely settled on Industry Foundation Classes (IFC) as the preferred standard. IFC is an open, international and standardized specification that makes it possible to hold and exchange data between different proprietary software applications. They comprise data from all the disciplines that contribute to a building throughout its lifecycle, from conception through design, construction and operation to refurbishment or demolition.

By and large, public owners are also considering, or in some cases like the UK and the GSA in the US, planning to adopt, the Construction Operations Building Information Exchange (COBie) data standard. COBie is an information exchange specification developed by the US Army Corps of Engineers (USACE) for the capture and delivery of information needed for facility management (FM). COBie data can be accessed and viewed in design, construction and maintenance software, as well as in simple spreadsheets. This versatility allow the data to be used in projects of varying size and technological sophistication.

Though some owners, practitioners and BIM experts express reservations about COBie because the relevant data are

Countries With BIM Policies by Agency or Municipality

Source: McGraw Hill Construction, 2014

Country	Agency or Municipality	Name of Policy	BIM Data Required	Building Sizes or Budgets Requiring BIM	Submittal File Formats	Reasons for Establishing Policy	Supporting Materials (e.g., Training, Guidelines)	Date of Policy	Future Phase-In Plans
USA	General Services Administration (GSA)	National 3D-4D-BIM Program	Architecture and design	All national public projects	IFC, Native, PDF	<ul style="list-style-type: none"> GSA was the first national public owner to adopt BIM and to develop criteria and guidance for delivering BIM work Original intent was to control costs Focus has shifted to achieving energy efficiency and lowering long-term operational costs Broad goals include using BIM to increase project quality, productivity and efficiency throughout project lifecycles. 	<ul style="list-style-type: none"> In collaboration with the National Institute of Building Sciences, academia and other industry partners, championed the IFC standard 	2003	A plan for phasing in COBie compliance and additional BIM data requirements will be announced by the end of 2014.
USA	U.S. Army Corps of Engineers (USACE)	ECB 2013-18: Building Information Modeling (BIM) Requirements on USACE Projects	Architecture and as-built data	All projects	IFC, Native	<ul style="list-style-type: none"> Initially adopted to streamline and lower the cost of designing prototypes of "standard facilities" Currently plans to transform its BIM implementation to focus on business process transformation 	<ul style="list-style-type: none"> Minimum data requirements Templates for BIM execution plans Sample contract language 	2006	Developing checklists for BIM submittals and reviews to streamline workflow. Plans to require additional BIM data to support downstream uses in the project lifecycle and is in discussions about adding COBie as a submittal requirement.
USA	Naval Facilities Engineering Command (NAVFAC)	ECB 2014-01: NAVFAC's Building Information Management and Modeling (BIM) Phased Implementation Plan	Architecture and engineering data	<p>New buildings costing \$750,000 or more</p> <p>Major renovations costing \$2.5M or more and greater than or equal to 50% of plant replacement value</p>	Native	<ul style="list-style-type: none"> Standardize data processes and data format for facility lifecycle sustainment (enter facility data once, use it repeatedly, use it consistently and keep it up to date.) 	<ul style="list-style-type: none"> Currently requires electronic delivery of data for use in its facility management system Eventual goal is that the BIM model will capture data needed across the project lifecycle 	2014	<p>October 1, 2014: FM data required as e-submittal for use in MAXIMO; BIM training will begin internally.</p> <p>October 1, 2015: BIM architectural and engineering data and FM data required as e-submittals.</p>
United Arab Emirates	Dubai Municipality	BIM Mandate	Architecture and MEP data	<p>Buildings over 40 stories high</p> <p>Buildings that are 300,000 sq. ft. or larger</p> <p>All hospitals, universities and other specialized buildings on campuses</p> <p>Buildings delivered by and/or through an international party</p>	Still being determined			2014	

“frozen” in large spreadsheet files, they recognize that it is better to have an imperfect but evolving delivery standard for FM data than no standard at all. Some countries, such as Sweden, have developed their own delivery standards for FM data, but public owners believe that country-specific standards will be folded into international ones.

In general, public owners have become less concerned in recent years about the tools used to create 3D models and capture a building’s design information, as long as the BIM data handed over at critical stages in the project’s lifecycle are useful, accurate, accessible and relevant. This trend is indicative of the broader shift in the conversation about BIM from concerns regarding accurate modeling of a building’s geometry to thorough capture of relevant building information.

Looking to the Future: Merging BIM With GIS and Infrastructure Data

In the longer term, public owners are talking about merging BIM data with infrastructure and GIS data to enable smart grids, cities and infrastructure. These systems would enable public owners to manage built assets in a safe and efficient manner.

There are many barriers to overcome—managing the huge amount of data; cybersecurity; data exchange standards among different systems—but some sample efforts underway include the following:

- Based on requests from its client owners, USACE is undertaking an initiative to marry geospatial information with its BIM data and civil information modeling (CIM) data, which comprises

infrastructure information such as parking lots, location of street lights, utility conduits and water supply mains.

- The UK’s Digital Built Britain initiative, formed in 2013 as an outgrowth of their government construction strategy, is working hand-in-hand with the BIM Task Group to deliver what they define as “Level 3” BIM capability, comprising building, infrastructure and geospatial information.

How to Create a BIM Mandate: Examples

The methods for mandating BIM and for supporting those mandates have differed among public owners, even those seeking the same goals. Broadly speaking, the earliest adopters—the GSA, Norway and Finland—have opted for prescriptive data and authoring requirements that center on a workflow based on delivering IFC data during a project.

Other mandates, such as those in the UK and Denmark, take more of a performance-based approach, setting performance objectives and guidelines for BIM projects and allowing the supply chain to figure out how to best deliver the data. Still others, such as those adopted by Singapore and South Korea, offer elements of both approaches.

In addition, the UK provides an example of a top-down government approach, whereas the US provides a look at a bottom-up approach, with individual agencies working in collaboration with industry.

UK

GOALS

The UK’s BIM mandate is widely acknowledged as the most ambitious and forward-thinking policy in the industry today, requiring that all centrally funded public projects (buildings and infrastructure) deliver BIM data for the entire project lifecycle by 2016, which they have defined as BIM Level 2. BIM fluency is viewed as a must-have skill set for the future health of the industry. The mandate is one action to support the UK’s broader goals for its construction industry: to cut lifecycle costs and carbon consumption by 20%, and to transform itself into an efficient, integrated and collaborative industry and supply chain whose services are in demand worldwide.

ADDITIONAL RESOURCES TO ACHIEVE GOALS

Along with the BIM mandate and broader construction strategy of 2011 came resources to support meeting these targets by 2016. The government established a multidisciplinary organization called the BIM Task Group (bimtaskgroup.org) to ready both the government and the supply chain for delivery of Level 2 BIM data. The group is comprised of experts from industry, government, the public sector, institutes and academia, and members are grouped into various disciplinary and functional committees. They have established multiple avenues that provide resources, training and education to government and industry:

- Establishing of appropriate processes and guidelines for BIM

Countries With Current BIM Guidelines, Standards or Handbooks or Future Plans for BIM Support Materials

Source: McGraw Hill Construction, 2014

Country	Organization	Current Guidelines, Standards or Handbook	Date (if known)	Future Plans for Guidelines, Standards, Road Maps or Handbooks	Background/Purpose (Where Available)
Australia	Australasian Procurement and Construction Council	National BIM Guide	2011		<ul style="list-style-type: none"> Developed by NATSPEC, a nonprofit group composed of industry and government members BIM fluency for the construction industry believed to be crucial to maintain competitive advantage
China	Ministry of Science and Technology	N/A	N/A	National BIM Standard by 2016	<ul style="list-style-type: none"> National adoption may be driven by infrastructure rather than buildings, through "smart city" management and mass transit projects in China's near-term development plans Carbon reductions are a near-term priority that may help drive BIM for buildings
France	Ministry of Ecology, Sustainable Development and Energy, and Ministry for Territories and Housing	N/A	N/A	BIM Road map in draft form expected by end of 2014	N/A
Germany	Federal Office for Building and Regional Planning (BBR)	BIM—Guide for Germany	N/A	Guide intended to provide structure for future national BIM mandate	N/A
Hong Kong	Committee on Environment and Technology of the Construction Industry Council	N/A	N/A	Working group currently determining industry-wide BIM road map and implementation strategy	N/A
Hong Kong	Hong Kong Housing Authority	BIM standards, user guides and library components for contractors	2014	Experimenting with merging GIS and BIM data into facilities management for streamlining operations and maintenance	<ul style="list-style-type: none"> Goal is to use BIM for at least the design stage by 2014-2015
Japan	Ministry of Land, Infrastructure, Transport and Tourism	Guidelines for architectural BIM models	2013		<ul style="list-style-type: none"> In addition to guidelines set by the ministry, the Japan Institute of Architects put forth its own BIM guidelines in 2012
Malaysia	Public Works Department	N/A	N/A	Announced intention to develop guidelines and standards by 2016	<ul style="list-style-type: none"> To address the concern of the readiness of the industry to adopt BIM, industry groups have recommended that the government provide seminars, training workshops and incentives such as tax breaks
New Zealand	Ministry of Business, Innovation and Employment	New Zealand BIM Handbook	2014		<ul style="list-style-type: none"> Handbook developed by the Building and Construction Productivity partnership, a government/ministry collaboration Handbook establishes consistent approach, efficient process and common language for BIM Increasing BIM use is seen as one means to help meet their goal to improve their construction industry's productivity by 2020

- Defining open standards used for BIM data exchange (COBieUK, a version of COBie adapted for their use)

- Hosting competitions for the development of free digital tools that lower the cost of storing, sharing and analyzing BIM data, to help make the information more accessible and usable

- Establishing awards programs for BIM projects across every building category to give successful case studies a high profile and to raise the bar on BIM practice

- Setting up regional hubs for BIM, a network of centers where members of industry can meet with BIM experts to share information and experience
- Forming BIM community groups that target different clients and supply chain organizations (e.g., BIM4Regs [regulators], BIM4SMEs) and give them a forum to communicate about their needs with BIM
- Disseminating information about BIM through the regional hubs and community groups, via regular conferences, seminars, workshops and other modes of bidirectional communication

David Philp, head of BIM Implementation for the task group, says that the task group's ultimate goal is not to implement BIM on behalf of the government, but to help the government build up its capacity and knowledge so that they can become self-sufficient. "Already we are regularly realizing savings of 20% and more due to our government construction strategy, and a lot of those savings can be traced back to using BIM," says Philp.

Singapore

FACTORS THAT SUPPORT SINGAPORE'S ABILITY TO CREATE THE MANDATE

Singapore's small population, top-down form of government and tradition of embracing technology have enabled it to set forth progressive requirements regarding the use of BIM.

To date these efforts have largely focused on simplifying and streamlining the permitting process.

GOALS

In 2010, Singapore set forth a broad goal for its own industry: to realize "a highly skilled and technologically advanced construction sector that will be led by progressive firms and supported by a skilled and competent workforce in 2020." The government aimed to increase the industry's productivity by 20% to 30% in this time frame. Realizing these goals would mean that their industry could remain competitive in local and regional markets.

ROAD MAP TO ACHIEVE GOALS

A 2010 BIM road map set forth Singapore's five-year plan to provide the industry with the resources, tools, incentives and information needed to adopt BIM, with a goal of having 80% of its industry using BIM in 2015. These activities would take place in parallel with the country's BIM requirements for regulatory approvals, rolled out as follows:

- **2013:** Mandatory BIM e-submissions for architectural approvals for all new building projects over 20,000 square meters
- **2014:** Mandatory BIM e-submissions for engineering approvals for all new building projects over 20,000 square meters
- **2015:** Mandatory BIM e-submissions for architectural and engineering approvals for all new building projects of more than 5,000 square meters

ADDITIONAL RESOURCES TO ACHIEVE GOALS

Singapore's actions that support industry adoption of BIM include:

- Introducing a \$20M BIM Fund, under the auspices of the Construction Productivity & Capability Fund (CPCF), to help

firms defray part of the cost of training, consultancy, software or hardware related to BIM adoption— To date hundreds of firms have used monies from the BIM Fund, and they have been required to document project metrics as a way to quantify and demonstrate BIM's value

- Hosting conferences, symposia and seminars to educate and train practitioners, largely overseen by the Centre for Construction IT (CCIT), established under the BCA Academy to provide technical support for the industry
- Establishing BIM competitions to raise awareness and advocate best practices
- Working with key Government Procurement Entities (GPEs) to stipulate BIM as a requirement in their projects
- Establishing BIM Manager Forum, which gathers more than 40 BIM managers from the industry to study the process issues in BIM implementation—The forum's work led to the publication of the BIM Essential Guide Series, which provides references on good BIM practices in an illustrated, easy-to-read format
- Partnering with professional bodies to set up project collaboration guidelines and object library standards
- Establishing Singapore's BIM Steering Committee to provide strategic direction on the development of local BIM Standards and supporting resources
- Setting up Centres of Excellence in BIM at local universities to develop BIM solutions for industry

United States

Unlike the UK and Singapore, the US does not have one mandate that applies nationally for BIM. However, two agencies—the GSA and the USACE—have created policies requiring BIM for their projects.

GSA

As a champion and the first national public adopter of BIM in 2003, the GSA has worked top down and bottom up with national and international collaborators, including government agencies, professional and standard-setting organizations, academic institutions, BIM vendors and private AEC firms to implement its mandate.

One of the agency's key accomplishments has been its collaboration with the National Institute of Building Sciences, academia and other industry partners, foreign and domestic, to champion the IFC open data standard that is now internationally specified as a delivery requirement in BIM mandates and policies.

Public owners agree that GSA's multiple outreach, research and collaboration efforts have been critical to spurring increased adoption of BIM in-country and elsewhere.

Highlights include:

- An eight BIM Guide series containing case study and pilot project data
- A toolkit of case studies
- Fostering a team of BIM champions around the US
- Sharing best practices and other information with the industry

USACE

The US Army Corps of Engineers (USACE) differs from the GSA in that it doesn't own the buildings it designs and constructs, but instead

serves as the contracting agency for public owners at the national level (e.g., National Air and Space Agency, Federal Aviation Administration and many others) as well as state and local governments. As such, its mandate supports and reflects the wishes of a broad range of owners with varying requirements.

In order to shape their BIM requirements to the needs of their clients, USACE founded the USACE/ Industry BIM Consortium, a group consisting of personnel from USACE and private firms who participate voluntarily and at their own expense. Their overall mission is "to push for innovation within a BIM application-neutral context and to ensure that requirements are practical, fair and reasonable within the current state of technology and standards."

Specific tools and requirements created include:

- A template for a BIM project execution plan (PxP)
- Template "work spaces" using popular BIM-authoring tools
- USACE's minimum modeling requirements for BIM projects in a matrix/spreadsheet (M3)
- Sample BIM contract language

Going forward, USACE continues to identify downstream technologies and processes to leverage its investment in BIM, to look at merging BIM data with GIS and infrastructure information, and to continue "moving from graphic-centric BIM to info-centric BIM."

Scandinavia (Finland, Norway, Denmark)

These three small to medium-size nations first made BIM as a public mandate in 2005 (Norway) and 2007

(Finland and Denmark), not long after the GSA established its mandate in 2003. Like the GSA, they were also focused on controlling initial costs, but other factors were important for their adoption as well, including:

- Significant investment at the national government level in innovative technologies, including advanced technologies, tools and services for buildings
- The potential of BIM to lead to better-performing buildings and lower energy costs
- Interest at the national level in becoming innovation leaders and global leaders in the building industry and exporting those skills to other nations

The Finnish and Norwegian policies are generally more prescriptive in nature and centered around delivery of IFC data at various points in the building lifecycle. Denmark has left its standard looser, in that it defines goals for the use of BIM data, but leaves it to the industry to determine how to best deliver it, similar to the approach the UK would take later.

Like other countries with public BIM mandates, Scandinavia has supported its long-term BIM goals with outreach beyond the mandate, including:

- Providing resources for training, education and dissemination of case studies
- Authoring guidelines, manuals and process recommendations relevant to BIM implementation
- Working to improve BIM education at the university level

The national governments continue to provide support for research of building technologies and for innovative uses of BIM data throughout the building lifecycle. ■

Data: Owners' Perceptions

About BIM Use by Project Teams

Perceived Frequency of BIM Use by Project Teams

While every owner participating in this research is currently involved with BIM on their building projects, they are not always aware of precisely who is using BIM for what on a given project because they are often removed from the day-to-day activities related to authoring and use of models. Understanding owners' perceptions about BIM use by project team members sheds light on their engagement with BIM.

Owners were asked to rate their perception of the level of BIM use by nine different team members on their projects. The charts show the combined percentage of owners who perceive BIM to be used either very frequently or always by each team member.

Owners' perception of BIM use by these various team members shows a correlation to their probable level of day-to-day contact with, and visibility to the activities of, those parties. This aligns with the survey results, where an increasing percentage of respondents selected "Don't Know" regarding various team members' BIM use in proportion to an owner's typical firsthand exposure to that firm's activities on a project. Therefore, for the purpose of reporting these findings, the nine project team members are divided into three groups reflecting differing levels of typical exposure to/ interaction with an owner.

- **Core Project Team:** Architect, Construction Manager/ General Contractor (CM/GC)
- **Engineering Consultants:** Mechanical/Electrical/ Plumbing (MEP), Structural, Civil
- **Specialty Trade Contractors:** MEP, Structural, Building Envelope, Interior Construction

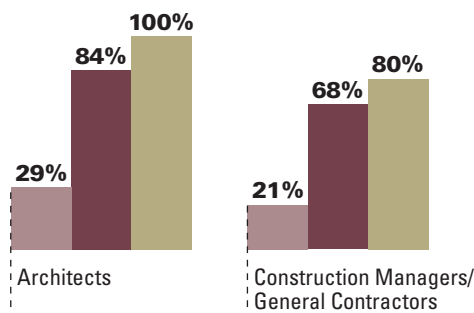
Another trend throughout the results is a frequently higher perception of BIM use in the UK than by US owners. This likely relates to the high level of recent focus put on BIM throughout that region, driven by the impending 2016 government mandate.

Also, a US owner's relative level of BIM involvement has a major impact on their perceived awareness of BIM use by the various team members. To demonstrate the impact of owners' BIM experience on their awareness of project team member BIM use, the charts show US owners at low and very high involvement levels. (For more information on BIM involvement levels, see page 8.)

Owners' Perception That BIM Is Used Very Frequently/Always by Core Team

Source: McGraw Hill Construction, 2014

■ US: Low BIM Involvement ■ US: Very High BIM Involvement
■ UK: All BIM Owners



Core Project Team

Awareness of the core project team's use of BIM is generally high, which makes sense because of the direct level of involvement by owners with one or both throughout the project.

- **Every UK owner, and almost all (84%) of the most BIM-active US owners, report perceiving a high level of architectural BIM use on their projects,** compared with less than a third (29%) of the least BIM-active US owners.
- **CM/GC use is not quite as commonly perceived in the UK (80%), and much lower in the US (36% among all owners), although over two thirds of the most BIM-active US owners (68%) and those with large budgets (67%) perceive it.** This is likely due to their tendency to work with the more sophisticated US CM/ GC firms that have aggressively adopted BIM.
- **No UK owners, and only a few US owners select "Don't Know" for architects (11%) or CM/GC (9%),** reinforcing the effect of their visibility to owners throughout the process.

Owners' Perceptions About BIM Use by Project Teams

Perceived Frequency of BIM Use by Project Teams CONTINUED

Engineering Consultants

Owner perceptions about BIM usage by engineering consultants shows even more variation.

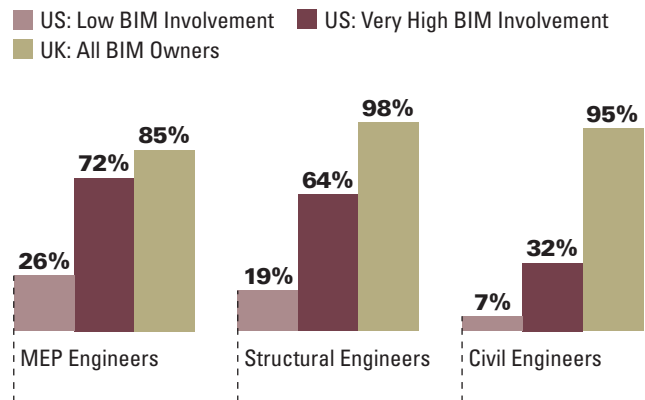
- **MEP engineers lead in the US (45% among all US owners), and especially among academic (54%) and healthcare (58%) owners,** likely reflecting the relative MEP complexity of their projects that lends itself to BIM use.
- **A higher percentage (85%) of UK owners cites frequent BIM use by MEP engineers,** although, interestingly, it is the lowest among the three engineering types.
- **Structural engineers show a similar pattern of perception in the US (40% among all owners)** with a higher recognition by those with large construction budgets (67%), and an almost unanimous rating (98%) in the UK.
- **Civil engineers show the greatest variance between US (15% of all owners) and UK (95% of all owners) perceptions of their BIM use,** with only a third (32%) of even the most BIM-active US owners reporting seeing it frequently. This visibility differential may be the most striking example of the intensity of focus on all players using BIM that is growing in the UK. Typically to date, the emphasis in the US has been on design and construction team members most closely involved with the building itself, with less attention paid to model-driven processes for site/civil activities on building projects.
- **About twice as many owners select "Don't Know" for these three engineer types (18%, 18% and 19%, respectively) than either of the core team members.**

Specialty Trade Contractors

Specialty trade contractors are often active in BIM because of its spatial coordination, digital fabrication and model-driven site installation benefits. But typically, they are the furthest removed from owners on a day-to-day basis, so it is not surprising that owner perceptions of their BIM use rate somewhat lower, with the proportion selecting "Don't Know" relatively high (19%, 21%, 27% and 19%, respectively for the order in the chart). Interestingly, as the chart shows, perceptions by US owners across the four trade contractor types in the survey run exactly opposite to UK owners.

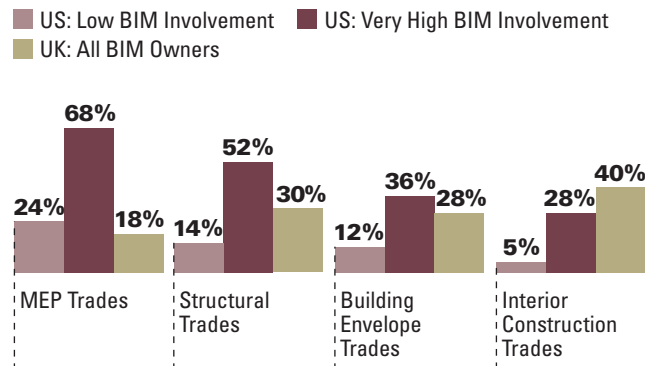
Owners' Perception That BIM Is Used Very Frequently/Always by Engineers

Source: McGraw Hill Construction, 2014



Owners' Perception That BIM Is Used Very Frequently/Always by Trade Contractors

Source: McGraw Hill Construction, 2014



MEP TRADES

- **MEP trades score well with US owners at a very high level of BIM involvement (68%) and among those with the largest construction budgets (57%).** Because of virtual coordination and prefabrication, MEP trades are increasingly using BIM on large and complex US projects.
- **Unfortunately, far fewer US owners at a low involvement level (24%) and those with small annual budgets (21%) perceive MEP trade BIM use,** likely indicating that the relatively smaller MEP trades who tend to work on those projects are either not using BIM or not making owners aware of it.

Owners' Perceptions About BIM Use by Project Teams

Perceived Frequency of BIM Use by Project Teams CONTINUED

- The same reasoning may be behind the low (18%) rating on MEP trades from UK owners, where these firms either need to get more involved or need to alert owners to the multiple benefits of their BIM usage.

STRUCTURAL TRADES

- About a third of all UK owners (30%) and US owners (32%) claim to see very frequent BIM use by structural trades.
- Among US owners, over half of the most BIM-active (52%), and almost half with the largest annual construction budgets (44%) perceive BIM use by structural trades, again reflecting the sophistication of these owners and of the structural trade companies that tend to work on their projects.
- In the UK, private owners (40%) outnumber the public owners (20%) in their perception of structural trades using BIM, perhaps because a higher proportion of private projects involve more complex structural design solutions, lending themselves to more owner awareness of fabrication modeling to achieve the design intent.

BUILDING ENVELOPE TRADES

- Over a quarter (28%) of UK owners see a lot of envelope modeling by the trades, as do over a third (36%) of the US owners most actively involved with BIM.
- A similar percentage of the large-budget US owners (33%) perceive frequent use by envelope trades, compared with far fewer small-budget owners (15%).
- BIM use by building envelope trades is still an emerging activity in the US, which probably accounts for it receiving the highest percentage of "Don't Know" responses (27%) from US owners.

INTERIOR CONSTRUCTION TRADES

- Among all the trades in this survey, interior construction receives the highest rating for perceived BIM use by UK owners (40%). This is likely due to the relatively higher proportion of renovation work involving interior reconfiguration in the UK versus greenfield projects in the US. And it also may be another example of the focus on whole-team BIM usage in the UK, rather than in the US, where BIM activity focuses more on core and shell and the major systems. In fact, there is an active BIM4Fit-out interest group in the UK.

Perceived Frequency of BIM Use on Renovation Versus New Projects (According to Owners by Type of Work They Predominately Construct)

Source: McGraw Hill Construction, 2014

	US More Than 50% New Construction	US More Than 50% Renovation	UK More Than 50% New Construction	UK More Than 50% Renovation
Core Project Team (average)	55%	27%	93%	89%
Engineering Consultants (average)	41%	20%	95%	91%
Specialty Trade Contractors (average)	31%	17%	16%	35%
Overall Project Team (average)	39%	20%	59%	66%

- By contrast, perceived use of BIM by interior construction trades receives the lowest average rating from US owners (20%). Findings from another recent study by McGraw Hill Construction (*The Business Value of BIM for Construction in Major Global Markets SmartMarket Report*) reinforce this. When contractors from 10 major construction markets around the world were asked to rate the BIM capabilities of specialty contractors, interior construction ranked last with only 19% giving a high or very high rating.

Variation by Level of New Construction Versus Renovation

Awareness of BIM use by project team members is twice as high on average among US owners doing mostly new projects (39%) than those doing primarily renovations (20%). In the UK, however, a greater percentage of work involves renovation, so awareness is much more equal, and in some cases is greater among renovation-oriented owners, such as with trade contractors.

Perceived Frequency of BIM Activities by Project Teams

Owners were asked to indicate how frequently they perceive that each of four key BIM-related activities is being conducted on their projects. The chart shows the combined percentage of owners who perceive that BIM activity is occurring either very frequently or always on their projects. The chart also shows the differential between US owners at low and very high BIM involvement levels, to reinforce how awareness of BIM activities increases dramatically with greater owner involvement.

SPATIAL COORDINATION AMONG MODELS OF THE MAJOR TRADES TO REDUCE CONFLICTS IN THE FIELD

This activity consistently ranks first or second for both frequency of use and for value in every McGraw Hill Construction BIM research study all over the world.

- On average, more UK owners (55%) perceive this taking place at a high frequency on their projects than US owners (39%).
- Importantly, 61% of the large-budget US owners and 80% of those most active with BIM perceive it, likely reflecting its high necessity and value on their relatively complex projects.

VISUALIZATION FOR STAKEHOLDER ENGAGEMENT

This activity typically pairs with spatial coordination as the first or second place ranking for frequency and value in McGraw Hill Construction BIM research.

- Although on average only 41% of US owners are frequently aware of model-driven visualization on their projects, about three quarters of those at a very high BIM involvement level (76%) and those with large budgets (72%) do perceive frequent use. This supports one of the key value propositions of visualization, which is to help engage multiple stakeholders efficiently in large organizations and on complex projects.
- The high awareness among UK owners is probably another example of the keen focus on the use of BIM on projects, and the creation of high-quality visualization is one of the most immediate and tangible BIM activities.

USING A BIM-AUTHORING TOOL TO PREPARE THE PRELIMINARY SCHEMATIC DESIGN

This activity has been slow to develop in the US and only rates as highly frequent among an average of 12% of US owners, and only about half (52%) of the ones most active with BIM. The unanimous rating from all UK

Owners' Perception of Frequency of BIM Activities (Those Who Perceived High/Very High Frequency for Each Activity)

Source: McGraw Hill Construction, 2014

- US: Very High BIM Involvement
- US: Low BIM Involvement
- UK: All BIM Owners

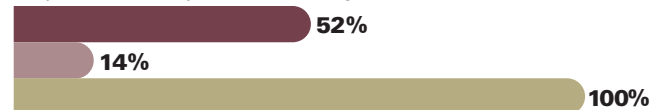
Spatial Coordination Among Models of Work of Major Trades to Reduce Conflicts in the Field



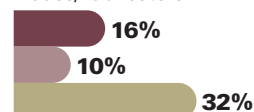
Visualization for Stakeholder Engagement



Using BIM-Authoring Tool to Prepare Preliminary Schematic Design



Model-Driven Prefabrication by Trades/Fabricators



owners likely reflects the high level of focus on using BIM as much as possible to comply with the government guidelines.

MODEL-DRIVEN PREFABRICATION BY TRADES AND/OR FABRICATORS

McGraw Hill Construction's BIM research consistently shows that specialty trade contractors are increasingly active users of BIM for prefabrication, so the relatively low awareness by owners in the study is likely more because of their distance from these team members' day-to-day methods than an accurate assessment of the frequency of these activities. This is an important opportunity for construction teams everywhere to raise owner awareness of the benefits of model-driven prefabrication.

Insights From Owners on Use of BIM in Singapore

Owners in Singapore see potential in BIM, but they are cautious about the short-term impacts of adopting it on their projects. However, the drive toward wider adoption in Singapore, fostered by a national government mandate, will help demonstrate the benefits that can encourage wider owner engagement.

Government policy in Singapore is helping to drive the use of BIM in that country among construction professionals, but interviews with five owners, two in the public sector and three in the private sector who are recognized experts on BIM, demonstrates that owners in Singapore are interested in BIM but prudent regarding adoption.

Adoption of BIM in Singapore

A 2013 survey conducted by Singapore's Building Construction Authority (BCA) reveals dramatic growth in the use of BIM in the construction industry in Singapore, growing from 25% in 2009 to 76% in 2013. In addition, nearly all of the respondents who were not currently using BIM at that point expected to do so within the next 24 months.

In addition, the intensity of BIM use is also growing, with the firms using BIM on more than 50% of their projects increasing from only 4% in 2012 to 15% in 2013. McGraw Hill Construction's research on BIM adoption in North America suggests that this steep growth is likely to continue, with a consistent pattern of firms steadily increasing the intensity of their involvement with BIM.

The findings of the owner in-depth interviews demonstrate that the top few tiers of Singapore's AEC industry are now BIM-ready. However, the state of BIM adoption in the overall market is uneven today. Although

most firms use BIM, not all use it to the same level. BIM is gaining traction among contractors; in fact, some of the largest contractors are already quite advanced in their use of BIM and, therefore, reaping its benefits more fully. On the other hand, other contractors are just beginning to use BIM. There are also growing BIM skills among architects and structural designers.

Interestingly, though, the owner interviews suggest that owners are slower to adopt BIM. However, as the rest of the industry embraces BIM, and the owners see the benefits achieved by project teams using BIM, owner engagement with BIM is likely to increase.

Drivers for Adoption by Owners in Singapore

GOVERNMENT MANDATE FOR BIM USE IN SINGAPORE AND EFFORTS TO ENCOURAGE INDUSTRY ADOPTION

The most critical driver of BIM use in Singapore across the construction industry is the government mandate in place for all projects over 20,000 square meters to use BIM for their electronic submission of plans. In 2015, the minimum size for using BIM will go down to 5,000 square meters.

The mandate is just one aspect of the BCA's deep commitment to BIM as a method to raise building industry productivity on a national scale. They see BIM as an empowering tool informing design and management decisions that will

help Singapore reach a variety of productivity and life-quality goals covering sustainability, accessibility, durability and the overall experience of dwelling in the built environment.

The BCA also recognizes that BIM is a tool that can support better, more collaborative processes, in addition to the efficiencies it offers. Cheng Tai Fatt, deputy managing director of the BCA Academy, states, "We believe that when teams are managed collectively, they will achieve better outcomes, and we are encouraging process transformation to raise productivity throughout the entire value chain, including design, construction, and asset and facility management."

While the BCA's efforts are described in greater detail on page 24 in the review of BIM policies from major countries around the globe, it is worth noting here that the transition to BIM is part of a larger effort to improve the industry, which began back in 2001, with the switch from a paper-based submission system for project approvals to an electronic submittals submission, the CORENET e-Plan Check. The government's initiative had a difficult transition, marked initially by the mistrust of construction professionals for electronic documents or e-signatures, but eventually the industry recognized the efficiency and reliability of this approach, which led to CAD skills now being common throughout the Singapore AEC community.

In order to encourage BIM use, the new BIM-based e-submission program was implemented in 2013. However, the transition from CAD to BIM is also challenging for firms. Therefore, the BCA's experience with the challenges from that early transition has led them to encourage industry adoption of BIM beyond the mandate through broad programs to stimulate, advance and reward BIM adoption. This has helped create a supportive environment for BIM adoption that is widely recognized as unique.

To lay out their goals and initiatives, the BCA developed a BIM road map. They set up education and incentive programs to assist the AEC community with BIM adoption.

Now that BIM adoption is progressing well among contractors and design firms, the government has turned their attention to adoption of BIM among sub-contractors, fabricators and suppliers. This is seen as a necessary step to promote integrated design and construction processes.

One truly unique aspect of their program is that they also set up metrics to measure change in the industry. The BCA has a checklist in place to assess BIM uses and benefits on a project-by-project basis. The goal of these measures is to gain additional detail on the actual outcomes, not only within individual companies, but also to measure the cumulative benefits BIM brings to collaborative efforts. This is necessary to build stronger, documented support for adoption of advanced BIM use.

BENEFITS DERIVED FROM USE OF BIM ON PROJECTS

Confidence in achieving real benefits through BIM adoption may be the most significant factor for BIM adoption by facility developers and owners in Singapore. However, the interviews demonstrate that confidence is not high at this point. A 2013 BCA study on BIM use revealed that it is still relatively recent in Singapore at any significant scale.

With adoption so recent, many owners may not yet see the benefits of BIM from their teams. In addition, McGraw Hill Construction's research on BIM consistently reveals that greater experience with BIM also yields greater benefits. As their design and construction teams gain in BIM experience, it is likely that the benefits that the owners see will also grow, increasing their confidence in the value of BIM.

In addition, the owners will have the benefit of the metrics being gathered by the BCA. The BCA's metrics requirements may prove to be critical in encouraging owners to adopt BIM. The data on benefits collected by the BCA can demonstrate the value to owners beyond their immediate experience with their own design and build teams' gains. This may encourage owners to begin to require BIM on all their projects, rather than just those covered by the mandate.

COMPETITIVE ADVANTAGE

For BIM adopters in Singapore, competitive advantage is also important. While many firms in the construction industry are motivated by the new government requirements, others believe that adoption will help their business

interests, and they are positioning their firms to take advantage of new frontiers as BIM skills improve within their companies.

Eugene Seah Hsiu-Min, group managing director of Langdon & Seah Singapore, states, "I decided to adopt BIM in my company because I wanted to be on the forefront and have a voice in getting what I needed from BIM to support my business."

Benefits of BIM

REPORTED BY OWNERS INTERVIEWED

All five of the owners interviewed mentioned productivity as the greatest benefit gained from the use of BIM. Other benefits mentioned by the five owners include:

- Increased efficiency
- Smarter ways to accomplish tasks
- Better control of cost and time variance
- Higher value at a similar or decreased overall cost

Some of the owners also believe that use of BIM can improve the design quality of their built assets through tools like design analysis and performance simulation. Interestingly, though, none of the owners reported that they have had sophisticated automated capabilities such as multidisciplinary optimization performed on their projects.

In addition, the interviews with owners revealed the owners believe that contractors are currently the greatest beneficiaries of the use of BIM. They find that BIM increases contractor productivity and provides them with a competitive advantage.

REPORTED IN THE BCA SURVEY

The following are the percentage of firms reporting gains for key BIM benefits in the 2013 survey conducted by the BCA:

- **86% report improved visualization/presentation**
- **85% report that they identified and resolved design conflicts up front**
- **84% report improved productivity in construction documents preparation**
- **82% report reduced rework downstream**
- **81% report reduced errors and omissions in construction documents**
- **69% report reduced overall project duration**

Use of BIM by Owners for Facility Management

The five interviews revealed that very few owners use BIM after construction for facility or asset management. While there is currently interest among owners to learn how BIM can be used post-construction, most owners are at the very early stages of awareness and understanding.

The BCA does intend to address this gap by giving more emphasis to owners and developers. Dr. John Keung, the BCA's chief executive officer, affirms the importance of these efforts: "We need to help bring facility managers and operators on board. We have a great deal of work to do now in helping them see the pathways to increased productivity of their work through BIM."

The BCA is therefore developing a Virtual Design and Construction

(VDC) leadership program for CEOs to help owners, facility managers and operators appreciate the many benefits BIM can have for their companies. Bringing BIM into the full lifecycle of the building will increase its value for owners and help them to see deeper benefits from its use on their projects.

How to Increase BIM Use in Singapore

In the short term, productivity is an ever-present consideration in Singapore. While research on BIM clearly demonstrates that it has an overall impact of improving productivity, owners and project teams still have concerns about the impact on productivity during the initial adoption and implementation of BIM. Many cite tight project timelines and budgets as inhibiting factors, especially since projects in Singapore often have very tight schedules compared with design and construction timelines in other countries. Even brief periods of reduced productivity connected with learning new methods are regarded as potentially catastrophic by some owners. Research to address this particular concern and to demonstrate that the learning curve on BIM does not have a net-negative impact on project productivity would be useful to persuade owners to more widely adopt BIM on their projects.

The more long-term challenges of increasing BIM use in Singapore are in many ways similar to the challenges faced by the BCA when they moved from paper to CAD in 2001. Overcoming skepticism and resistance will be the keys to unlocking the power of BIM adoption in Singapore.

The owners interviewed agreed that owners in Singapore need to be reassured that BIM adoption is worthwhile and not prohibitively costly or expensive. They also need to see that real benefits will be gained. In order for government and groups advocating for BIM adoption to be effective with owners, they must be able to present the intrinsic value propositions of BIM in a way that is contextualized to speak to the owners' business objectives.

Another critical challenge for the Singapore construction market is to help improve the skills of those working with BIM, from the design and build teams on projects to the owners' staff. Many are comfortable with the use of 2D CAD and workflows involving the passage of CAD-based drawings from consultant to consultant for sequential, iterative coordination and refinement of design details. These processes must change to benefit from the full adoption of BIM for a more collaborative workflow. ■

Data: Owners' Perspectives

on the Impact and Value of BIM

Overall Impact of BIM on Owners' Projects

Owners were asked to make an overall judgment of the positive, negative or neutral impact of BIM on their projects. Those who voted either positive or negative (i.e., not neutral) were further asked to assign a 1-5 score for the degree of positive or negative impact.

Owners Who Perceive BIM Has a Positive Impact

Most owners in the US (69%) and UK (80%) are positive in their overall assessment of BIM. The percentages of positive ratings from US owners at very high BIM involvement levels (88%) and those with large construction budgets (78%) likely indicate the benefit of their deeper commitment and the value of BIM on large projects.

Within the positive group, over half of the US owners and more than nine out of 10 UK owners (91%) assigned particularly high positive scores (4/5 out of 5), registering strongly positive feelings.

Owners Who Perceive BIM Has a Negative Impact

While some UK owners report a negative impact (12%), none of those rated it highly negative (4/5 out of 5), so the negative UK ratings are relatively mild.

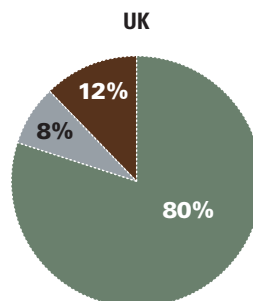
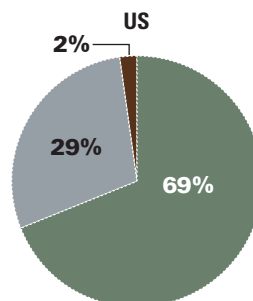
Interestingly, most (80%) of the negative UK owners are from the public sector. This may reflect a sense that the government mandates are forcing them to adopt BIM, regardless of their own interest in doing so.

Compared with the UK (8%), the US market still has a relatively large number of neutral owners (29%) taking a wait-and-see attitude. Not surprisingly, this group is dominated by owners with low BIM involvement and those with smaller annual construction budgets. As these owners gain more BIM experience, it can be expected that their attitudes will turn more positive.

Overall Impact of BIM on Projects

Source: McGraw Hill Construction, 2014

■ Positive
■ Neutral
■ Negative



Owners' Views on the Single Greatest Benefit of BIM

Owners were asked to describe what they believe is the single greatest benefit of BIM to their organization. Their responses are grouped by major themes, and shown in rank order in the matrix.

UK Owners

Although three benefits tie for top rating among UK owners, there is variance between the public and private sectors.

- **Better team coordination/collaboration rates a strong first among private sector UK owners with twice as many of their votes as any other benefit.** This may speak to the critical financial/budget control benefits that can be generated by this type of activity.
- **Conversely, UK public sector owners more strongly favor better accuracy/fewer errors/better quality and more efficient design/ build process/standardized.** This may reflect the specific challenges that those public owners commonly faced on pre-BIM projects.

US Owners

Among US owners, **better team coordination/ collaboration is appreciated by almost twice as many of the large budget owners (44%) than small ones (24%).** This makes sense because improved collaboration generally provides benefits in proportion to the size of the project team, which is a direct function of the size and complexity of the project and is therefore most meaningful to the largest owners.

For similar reasons **better team coordination/ collaboration is also appreciated by a greater percentage of the US owners who do mostly renovations (34%),** where coordination can be particularly troublesome, than the ones doing mostly new projects (19%).

Cost Savings From BIM

In general, BIM has gained traction so far for its cost avoidance benefits rather than actual cost reduction. So the relatively low rating given to cost savings by US and UK owners alike is probably due to the fact that owner-related cost savings directly attributable to BIM have not yet become established as a reliable and scalable benefit across many projects. It should not be interpreted that owners are not interested in cost savings as a potential benefit.

Owners' Perspectives on the Single Greatest Benefit of BIM

Source: McGraw Hill Construction, 2014

Ranking	US	UK
1	Better Team Coordination/ Collaboration	Better Team Coordination/ Collaboration (tie)
2	Use for Facility Maintenance and Operations/ Long-Term Management	Better Accuracy/ Fewer Errors/ Better Quality (tie)
3	Helps With Visualization/ Understanding Concepts & Scope	More Efficient Design/ Build Process/ Standardized (tie)
4	Better Accuracy/ Fewer Errors/ Better Quality	Cost Savings
5	Cost Savings	Helps With Visualization/ Understanding Concepts & Scope

Owners' Ratings of BIM Benefit Statements

Owners were asked to rate how much they agree with each of five key BIM benefit statements, based on the degree they apply to their projects. The chart shows the percentage of owners who were in strong or very strong agreement with each. It also features responses from US owners at both low and very high levels of BIM involvement to demonstrate the impact of owners' BIM experience on their perceptions about its benefits.

BIM VISUALIZATION ENABLES A BETTER UNDERSTANDING OF THE PROPOSED DESIGN

Consistently scoring as a potent benefit in all McGraw Hill Construction BIM research studies, **visualization gets a top rating from essentially all the UK owners (98%) and over three quarters of the most BIM-active US ones (76%)**. Even over two thirds of the least BIM-active US owners (67%) support it strongly.

- **Weighing in most emphatically among US owners are those with large annual budgets (94%)**, probably because of the power of visualization to more efficiently engage the many stakeholders on their large volume of projects.
- **More renovation-oriented US owners (71%) cite the value of BIM visualization than those primarily doing new construction (62%)**. This is counter to most other findings between these subgroups, and it may point to an important value proposition to generate more use of BIM for renovations.

THERE ARE FEWER PROBLEMS DURING CONSTRUCTION RELATED TO DESIGN ERRORS, COORDINATION ISSUES OR CONSTRUCTION ERRORS

Benefits derived from improved documents and coordination also score strongly, though less so among the least BIM-active US owners. This may relate to other findings about those owners' low perception of this activity; therefore, they may not be aware of how much of a benefit they are actually receiving from it.

Coordination/documentation benefits receive above-average support from US healthcare owners (71%) and owners with large construction budgets (83%). This is natural because health projects are often programmatically intense and benefit especially strongly from improved coordination.

Owners' Ratings of BIM Benefit Statements (Those With a High/Very High Level of Agreement)

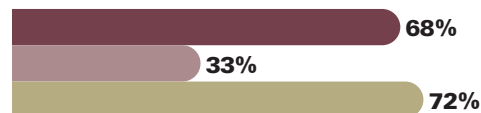
Source: McGraw Hill Construction, 2014

- US: Very High BIM Involvement
- US: Low BIM Involvement
- UK: All BIM Owners

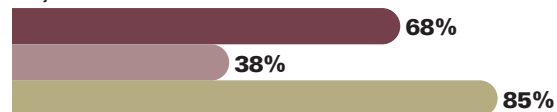
BIM Visualization Enables a Better Understanding of Proposed Design



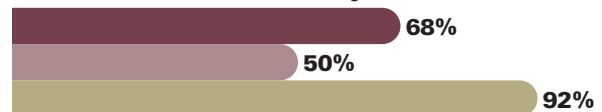
Use of BIM Has a Beneficial Impact on Control of Construction Costs



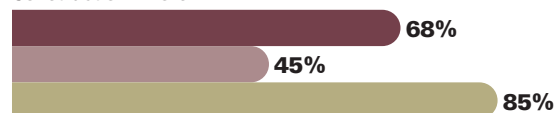
Use of BIM Has a Beneficial Impact on Project Schedule



BIM Analysis and Simulation Capabilities Produce a More Well-Reasoned Design



There Are Fewer Problems During Construction Related to Design Errors, Coordination Issues or Construction Errors



Owners' Perspectives on the Impact and Value of BIM

Owners' Ratings of BIM Benefit Statements CONTINUED

BIM ANALYSIS AND SIMULATION CAPABILITIES PRODUCE A MORE WELL-REASONED DESIGN

This scores well with UK owners overall (92%) and unanimously with the private sector ones (100%). This finding is part of a larger pattern throughout this study, which reveals a focus in the UK on BIM's impact on design, while in the US, there is a stronger focus on construction.

Owners with large annual budgets are the most supportive of this benefit (72%) in the US, perhaps because their higher volume of projects gives them a better basis of comparison to judge a BIM-driven design solution as "more well-reasoned" than traditionally generated work.

THE USE OF BIM GENERATES A BENEFICIAL IMPACT ON PROJECT SCHEDULE

■ It requires a number of completed BIM projects to be able to know that BIM generates a beneficial impact on project schedule, which probably explains the large differential between the US owners at low (38%) and very high (68%) BIM involvement levels, because the latter group has had the opportunity to evaluate more completed projects.

■ Enthusiasm shown by 85% of the surveyed UK owners may be somewhat aspirational, but it is a positive indicator of strong faith in the potential for this benefit.

THE USE OF BIM GENERATES A BENEFICIAL IMPACT ON CONTROL OF CONSTRUCTION COSTS

As shown in other results, cost savings that can be directly attributed to BIM have not been as widely demonstrated as other benefits that reduce or avoid problems on projects. Encouragingly, it is cited as a benefit by over three quarters of large-budget UK owners (76%), and it should improve among others as more BIM projects are completed and owners with similar buildings are able to make meaningful cost comparisons to their non-BIM projects.

Owners' Measurements of the Impact of BIM

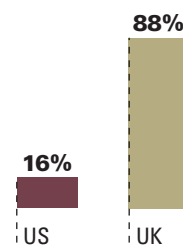
In order to evaluate any new process, it is important to measure its impact. To assess their level of commitment to measurement, owners were asked if they are currently doing anything to formally measure the impact of BIM on their projects. The results show a dramatic difference between UK and US owners.

- A vast majority of UK owners (88%) are formally measuring BIM impact, versus only 16% of all US owners surveyed.
- Above average in the US are the large-budget owners (56%) and healthcare owners (29%).

Among those who are measuring BIM impact, there is general alignment between US and UK owners on the frequency of using particular methods to conduct measurements.

Owners Formally Measuring the Impact of BIM

Source: McGraw Hill Construction, 2014



Owners' Perspectives on the Impact and Value of BIM

Owners' Measurements of the Impact of BIM CONTINUED

However, there is some variation among the UK owners. Private sector UK owners actively use multiple methods:

- **Comparing Specific Results From BIM Projects to Non-BIM Projects (82%)**
- **Using Their Organization's Established Process for Measuring ROI (59%)**
- **Using a Custom Process Developed By Their Organization, as Well as Asking Design and Construction Firms for Their Input on Specific Process Improvements (both 53%)**

Those in the UK public sector report using fewer methods, concentrating mostly on two:

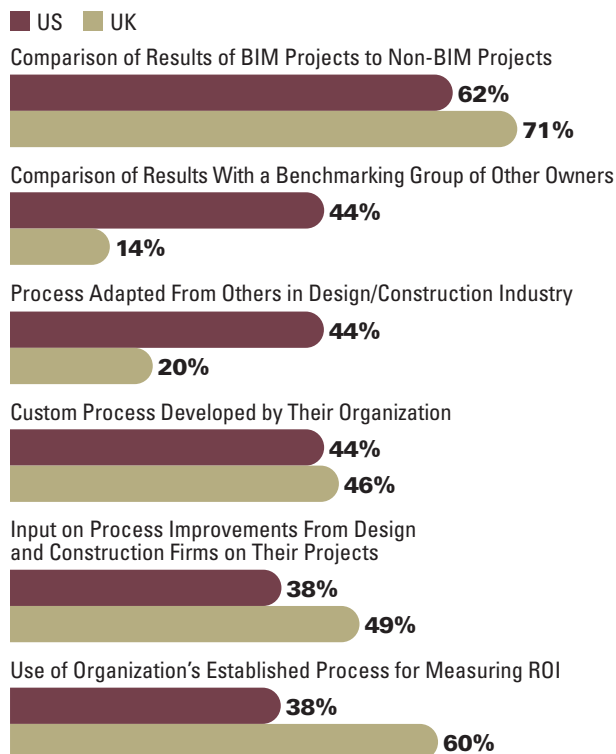
- **Using Their Organization's Established Process for Measuring ROI (61%)**
- **Comparing Specific Results From BIM Projects to Non-BIM Projects (also 61%)**

The owners who do not formally measure the impact of BIM on their projects (84% of US and 12% of UK total respondents) were asked for their reasons.

- **Two thirds (65%) of the US group say they never formally measured it because they informally understood its value.**
- **The largest portion of the UK group (40%) also deems it a non-issue, saying they used to formally measure it but do not feel it necessary to do so anymore, along with 6% from the US.**
- **Many (40%) from the US admit they do not know how to formally measure the impact of BIM.**
- **Some others from the US (28%) say it is too hard to measure it, which 20% of the UK group also agrees with.**

Types of BIM Measurements Conducted (According to Owners Who Conduct Measurements)

Source: McGraw Hill Construction, 2014



Switching to an Integrated Process on the Fly

Midfield Terminal, Abu Dhabi Airport

ABU DHABI, UNITED ARAB EMIRATES

THE BUSINESS VALUE OF BIM FOR OWNERS



Use of BIM was critical to help an integrated team deliver a complex, "once in a lifetime" project.

Back in 2005, Kohn Pedersen Fox Associates (KPF), headquartered in New York, NY, participated in a design competition for the Midfield Terminal of the Abu Dhabi Airport. The scope of the project was ambitious from the outset. At 7.6 million square feet and with a budget of \$3.5 billion, KPF principal Anthony Mosellie knew that this project offered a unique opportunity to design a welcoming transportation hub in a burgeoning part of the world, the tourism-focused United Arab Emirates, the only part of the Middle East that much of the West will ever see in person. The new terminal would be the home of Etihad Airlines, the flagship carrier of the UAE.

Owner-Driven Use of BIM and an Integrated Team

KPF won the project in 2006. At the time, BIM was not standard delivery methodology like it is today. For certain disciplines there wasn't even reliable software at the time, particularly on the mechanical side. BIM software has come a long way since 2006, and toward the end of the design process, ADAC (the Abu Dhabi Airport Corporation) asked KPF to do at least a clash detection model and make sure that the big construction issues were taken care of. This was during the construction documents phase of the project. As the architect and client talked more about the project, a broader vision of how BIM could be used to deliver the

massive airport terminal took shape.

KPF's contract stipulated that after a date of completion, the design team would work with the contractor's model as the governing 3D model for the project, but as they delivered more electronic deliverables and talked with their client, a more robust way of using BIM and 3D modeling emerged. In March of 2013, Tony Douglas, who was chief executive of the £4.3-billion Terminal 5 build program at Heathrow Airport in London, joined ADAC as its new CEO. He brought with him a much higher demand for integrated processes and information sharing.

"Heathrow was an integrated delivery methodology," Mosellie said. "When Tony came on, given

Midfield Terminal, Abu Dhabi Airport

ABU DHABI, UNITED ARAB EMIRATES

the schedule demands of the project, the size and complexity of it, he and his team insisted on a much stronger site presence for all of the design team members, including structural, mechanical, electrical, architectural [and] specialty systems. Over the last two years, we've built a very robust site team. Between the architects and engineers, we have about 65 people there. We sit in the same complex as the contractors. The day-to-day meetings are shoulder to shoulder. Scheduling, logistics, coordination, are all going on. BIM is the primary platform, logistical and coordination-wise, to deliver the project."

BIM and the Construction Team

The joint venture of Consolidated Contractors Company (CCC), Arabtec and TAV won the construction contract for the Midfield Terminal Building in April 2012. The pre-award preparations of the joint venture played an essential role in convincing ADAC of its ability to deliver the BIM-integrated project as they needed it to be done.

"The owners have been forward-thinking in how this can be helpful in scheduling, coordination, logistics and maintaining the design quality. Those demands all came from ADAC," Mosellie said. "The Emirates is going to get the best-in-class facility they asked for, and they came around to a BIM process as the way to ensure that."

CCC immediately dispatched 40 BIM engineers to the site upon winning the project. CCC also brought in a collaborative BIM-sharing platform used by all disciplines for model updates. It is a secure online collaborative BIM platform with

integrated web capabilities. The platform includes software packages for modeling, collecting, managing and synthesizing project data. It also embeds workflows for quality control, review and approval processes.

Standards, procedures and workflows were developed carefully to unify and streamline the BIM production and operations, and guarantee complete and accurate results.

4D and 5D capabilities such as cost, time, quality, material management, progress and others were integrated into the platform. CCC developed in-house, business-oriented 3D applications that can host, integrate, manage and report 3D, 4D and 5D information. Electronic data interchange standards have been set, and all BIM objects can be tagged within their individual BIM-authoring tools and subsequently saved to a BIM project database.

Team Coordination

KPF was a big proponent of using a joint venture contractor for the project because of the sheer size and scope of the job. TAV is a major developer and operator of airports. They brought a multiheaded approach that is cognizant of airline issues. Arabtec is the most local member of the group, although all of the joint venture companies have previously worked in the UAE.

TAV set up a project BIM theater in their site office. Between the Chinese steel fabricator, the curtainwall fabricator, the MEP engineer, ADAC representatives, and personnel from KPF and the joint venture, there are at least 15 to 20 people constantly updating and coordinating the model with input from subcontractors.

While Midfield Terminal's construction will continue through 2017, the integrated process has already yielded some major project wins. CCC was able to provide a plan for accurate temporary works through explicit 3D modeling of works, cranes and installation sequencing, for example. Site preparation was finished on schedule in 2011.

Influence on Participants

The experience has had influence beyond the UAE as well. "It has heavily influenced how we're doing a big project here in New York, the Hudson Yards project, which is one of the largest BIM projects in America right now," Mosellie said. "We learned our lessons from the Abu Dhabi Airport." ■

Project Facts and Figures

Owner

Abu Dhabi Airport Corporation

Architect

Kohn Pedersen Fox

Joint Venture Contractor

CCC/Arabtec/TAV

Type of Project

Airport Terminal

Size

7.6 million square feet

Cost

\$3.5 billion

Expected Completion

2017

Building Information Modeling for Sustainability

BIM offers useful tools to help owners achieve their sustainability goals for their building projects, both during design and construction and into the operational phase of the building.

Ask project owners whether building information modeling (BIM) contributes to productivity and efficiency during design and construction, and they'll likely have lots to say. Ask whether BIM contributes to sustainability, and they'll need to think for a minute.

"When we started this project, we were developing BIM for virtual construction of the building," says J. Stuart Eckblad, AIA, director of design and construction for the University of California at San Francisco's new Medical Center at Mission Bay, a \$1.5 billion, three-hospital facility targeting LEED Gold certification. "If I'm honest, I can't say we did BIM for any purposes of sustainability."

Design for Sustainability Made Easier

Eckblad's experience is common among the building owners contacted for this article. Also common, after a moment's reflection, is his identification of BIM as a facilitator, if not a direct cause, of his project's sustainability achievements. In particular, BIM made designing for UCSF Mission Bay's energy reduction goals easier, more predictable and more accurate, he says, and BIM's analytics enabled the design team to make quick, iterative evaluations of the balance of priorities, including sustainability, represented in design alternatives.

"BIM allowed [us] to do those things faster and much more

accurately, and make better decisions," says Eckblad. "It gave [us] more options and improved our ability to hit our goals."

Two Pennsylvania State University projects under construction in Philadelphia's decommissioned Navy Yard are making use of BIM in their mission to serve as living labs for reducing commercial buildings' energy usage. The main challenge in using the copious information BIM generates, according to Craig Dubler, Ph.D., virtual facilities engineer with Penn State's Office of Physical Plant, is integration.

Each BIM program is set up for a certain use, says Dubler. For example, a facade model generates information about structure, thermal envelope and daylighting, and an MEP model generates information about heat and cooling distribution and electric lighting. It is up to the design team to integrate the information and apply it effectively. "The models definitely assisted in identifying the problems," says Dubler. "They didn't solve them."

Sustainability and BIM for Facility Management

While Dubler values the contribution of BIM to designing for sustainability goals, his primary focus for BIM from an owner's perspective is facility management. "Sustainability is only as good as the function of the facility," he says. "We want to maintain [the projects'] level of energy efficiency throughout the life of the building[s]."

Dubler defines BIM two ways. The first is BIM as a product: the model itself, its geometry and data. This aspect of BIM enabled Penn State's design team to test facility management priorities such as whether service points are well located and whether maintenance workers will have enough room to do their work. The second is BIM as a process: design through building virtually and construction from the virtual model. This aspect of BIM facilitates information gathering, from servicing intervals to part numbers, to support building operations and maintenance. "With BIM," says Dubler, "we're collecting information to make sure whatever efficiencies we set up don't stop once the project is turned over."

At UCSF Mission Bay, Eckblad also perceives BIM's potential as a platform for managing building maintenance and energy usage. He is currently upgrading the Medical Center's BIM to make use of this potential, with the addition of attributes that were not part of the design process, including more O&M-focused detail. The goal is to use BIM as a comprehensive and precise institutional memory, leveraging its information into continuing energy and operational efficiencies. "You'll be able to call in an issue, and spot it in the BIM model," says Eckblad. "That's what we're working toward." ■

Data: Owners' BIM Needs

Owners' Perspectives on Support for BIM

Owners were asked how much they agree with seven positive statements and one negative statement about their perceived level of resources and support for BIM involvement. The chart shows the combined percentage of owners who either agree or strongly agree with each statement.

To demonstrate how owners' experience with BIM positively impacts their perceived level of BIM support, the chart shows responses of owners with low BIM involvement (less than 25% of projects involve BIM) and with very high BIM involvement (more than 75% of projects involve BIM). **On average, 50% of the very high involvement group agree with the seven positive statements, versus only 21% of those at low involvement.**

A consistent and highly evident trend in these findings is that UK owners are more positive about their environment for expanding BIM use than even the US owners with the highest levels of BIM activity. **In fact, 87% of UK owners on average agree with the seven positive statements.** This is likely another example of the enthusiasm that has been generated for BIM over the last three or four years in preparation for the UK government mandate that takes effect in 2016.

THERE IS ADEQUATE TOP MANAGEMENT SUPPORT FOR THE USE OF BIM ON THEIR ORGANIZATIONS' PROJECTS

- **More UK owners in the private sector (90%) agree than those in the public sector (75%), and more in the public sector actually disagree (25%).** This may reflect that, although implementation of the mandate is pending, support has not been established at the leadership level of various public entities.
- **In the US, twice as many owners with large budgets agree (67%) than those with small budgets (38%),** reflecting the growth of established BIM programs at the larger companies.
- **Agreement is also weighted more toward firms doing mostly new work (44%) than renovations (34%),** where BIM use is still emerging.

THE PROJECT DELIVERY METHOD(S) THEIR ORGANIZATIONS USE ARE HELPFUL IN SUPPORTING THE USE OF BIM ON PROJECTS

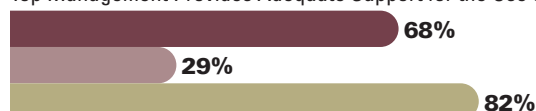
- **Half of US owners with large budgets agree (50%), compared with little more than a third (34%) of those with small budgets and almost a quarter of those smaller owners (24%) actually disagree with this**

Owners Who Agree With Described Level of Resources and Support for BIM (Those With High/Very High Level of Agreement)

Source: McGraw Hill Construction, 2014

■ US: Very High BIM Involvement ■ US: Low BIM Involvement
■ UK: All BIM Users

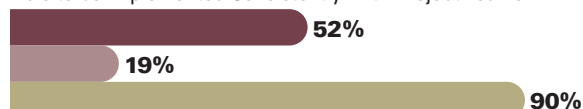
Top Management Provides Adequate Support for the Use of BIM



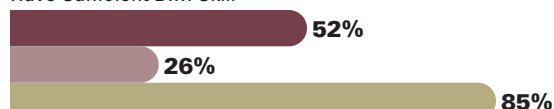
Organization's Project Delivery Method(s) Help Support BIM Use on Projects



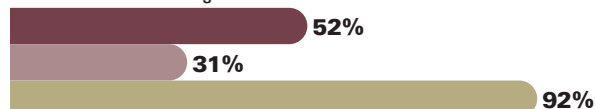
Organization Has Standards/Policies for BIM Execution Able to be Implemented Consistently With Project Teams



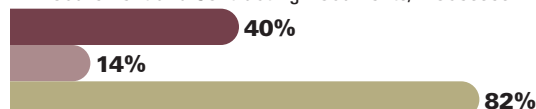
Their Design and Construction Communities Have Sufficient BIM Skill



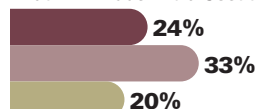
Staff Involved in Design/Construction Have a Good Understanding of BIM Benefits



Organization Uses Appropriate BIM-Related Language in Procurement and Contracting Documents/Processes



There is a Perception at Their Organization That BIM Adds Extra Cost to Projects



Organization Has Established Ways to Measure BIM Benefits



statement. Smaller owners may use the design-bid-build delivery system more, where larger owners tend toward more collaborative methods such as construction management, design build and integrated project delivery.

- **Almost half (44%) of US owners focused on new construction agree, compared with only about a quarter (24%) of renovation-oriented owners,** so work is needed in that market segment to support BIM.

THE PEOPLE DOING DESIGN AND CONSTRUCTION AT THEIR ORGANIZATIONS HAVE A GOOD UNDERSTANDING OF BIM BENEFITS

- **While 92% of all UK owners agree, over half (55%) of private sector UK owners say they strongly agree, compared with only a third (35%) of the public sector ones,** perhaps suggesting that more education about BIM benefits would be helpful in the public agencies that will be implementing BIM because of the mandate.
- **The findings for US owners are similar, with more private sector ones agreeing (55%) than public ones (40%),** so a focus on that market segment will help drive BIM expansion.
- **Also in the US, over a third (38%) of small-budget owners disagree with the statement,** reflecting the need for broader dissemination of data about BIM benefits within the smaller owner organizations that are already involved with it so that they can get support to expand their programs.
- **Less than a third (32%) of the US owners who do mostly renovations agree, versus over half (52%) of those focused on new work, indicating the still-developing status of BIM for renovation in the US.**

THERE IS SUFFICIENT BIM SKILL IN THE DESIGN AND CONSTRUCTION COMMUNITIES WHERE THE OWNERS DO PROJECTS

- **Over half of the US owners with the highest BIM activity (52%) and those with the largest construction budgets (56%) agree,** perhaps because their projects frequently employ larger, more sophisticated AEC firms and are often in or near major urban areas, where BIM skills are more plentiful.
- **Only a quarter (25%) of small-budget US owners agree and a third (34%) actually disagree, with about half (43%) being neutral.** This points to the need for more AEC BIM capabilities among the smaller firms that typically service these owners.

- **Though still very highly rated by UK owners (85%) compared with US results, this falls among the bottom three with both,** reflecting the need to continue spreading BIM capabilities throughout the construction economy.

THERE ARE STANDARDS AND POLICIES AT THEIR ORGANIZATIONS FOR BIM EXECUTION THAT CAN BE IMPLEMENTED CONSISTENTLY WITH PROJECT TEAMS

- **No UK owners disagree with this statement, and a third (35%) of private sector ones strongly agree, although only 15% of the public sector ones do.** This may reflect a sense that these public agencies still have some work to do in preparation for the implementation of the mandate.
- **In the US, over two thirds (67%) of the owners with large construction budgets agree versus only a third (31%) of the relatively small-budget ones.** This underscores the need among smaller owners for more well-developed BIM policies and procedures.

THERE ARE APPROPRIATE BIM-RELATED TERMS AND LANGUAGE IN PROCUREMENT AND CONTRACTING DOCUMENTS AND PROCESSES IN THEIR ORGANIZATIONS

- **While 82% of all UK owners agree, a higher proportion of those with larger annual construction budgets (94%) agree compared with those with smaller budgets (73%). This is also the case in the US, where nearly half those with the larger budgets (44%) agree versus far fewer (17%) of the smaller owners.** So clearly, smaller owners would benefit by incorporating BIM more fully into their procurement and contracting processes.
- **Owners in the education sector (41%) show the highest level of agreement among the various project types in the US.** So other owner types may be able to learn from their work.
- **US renovation-oriented owners are least well aligned, with about a third (32%) expressing strong disagreement compared with only 19% of new construction-focused owners.** Again this reflects the lower penetration of BIM into US renovation projects.

THERE IS A PERCEPTION AT THEIR ORGANIZATIONS THAT BIM ADDS EXTRA COST TO PROJECTS

As the only negative statement among this group, its very low level of agreement from both US and UK owners is not surprising.

Owners' BIM Needs

Owners' Perspective on Support for BIM

CONTINUED

- **Similar to other aspects of BIM, US owners with low BIM involvement (33%) and smaller US owners (38%) are more likely to have this negative perception than their very highly involved (24%) and large-budget (11%) counterparts**, whose BIM experience has reduced this concern. To further emphasize this point, almost two thirds (61%) of the large-budget US owners actually disagree with the statement.
- **There is an interesting variation in US results between private sector (16%) and public sector (33%) owners who think that BIM adds cost to their projects.** This speaks to a need for more data in the public sector about the actual cost of BIM on their projects.

MY ORGANIZATION HAS ESTABLISHED WAYS TO MEASURE THE BENEFITS OF BIM

These results echo the other findings in this report about measuring the impact of BIM, showing clearly that UK

owners are far more engaged in those activities than ones in the US. (See pages 36 to 37 for more information about owners measuring the impact of BIM.)

- **80% of UK public sector owners strongly agree, compared with 65% of the private sector**, suggesting that they are a bit better prepared to measure BIM impact.
- **Owner size (as reflected by annual construction budget) is a factor.** Almost all (94%) large-budget owners in the UK agree, compared with 82% of small-budget owners. Also, nearly three times as many large US owners agree (28%) than small ones (10%).
- **Further reinforcing the lower commitment to measuring BIM impact in the US, three quarters (75%) of all US owners disagree with the statement, with nearly half (45%) strongly disagreeing.** Only 4% strongly agree.

What Owners Need to Expand BIM Use

Owners were asked to rate the potential positive impact of seven different factors on the likelihood that they will increase BIM involvement and value. The chart shows the combined percentages of those who find that each factor would have a high or very high positive impact.

As with other findings in the research, UK owners show more intensity in most of their responses, likely reflecting the growing wave of BIM activity pending from the government mandate.

Factors That Will Increase BIM Skills and Activity Levels

Three of the factors relate directly to this theme:

- **More BIM Skills Among Contractors/Trades/Fabricators**
- **More BIM Skills at Design Firms**
- **More Use by Other Owners in the Areas Where They Work**

US owners are in close alignment about the benefit of increasing design (47%) and construction (50%) BIM skills, and rate them as the top two most impactful factors. Even more of the large-budget US owners stress the importance of increasing design (61%) and contractor

(72%) BIM capabilities. This probably results from their desire to implement BIM on large projects, requiring extensive resources.

By contrast, UK owners show dramatically different attitudes on the importance of increasing design (95%) versus construction (58%) BIM skills. In fact, designers with more BIM skill is their highest rated need and more construction BIM skill the lowest. This probably reflects the timing of focusing on design first on a BIM project. Given the finding that 85% of UK owners say the design team was already using BIM on the first project where they encountered it (see page 9), and the finding that 85% believe that "there is sufficient BIM skill in the design and construction communities where they do projects" (see page 42), it is likely that owners recognize the value derived from having a design team that exceeds merely sufficient BIM skills.

Although architects and contractors in other McGraw Hill Construction BIM research studies always clamor for more owners in their area using BIM, most owners in both the US and the UK ascribe relatively low beneficial value to it. An exception is that more than a quarter (29%) of US owners currently at a low BIM involvement level

say it would help them to expand their BIM programs, probably because it would help them, by reference, to gain top management support and to more reliably access BIM-capable design and construction talent, both identified as challenges for that sector.

Factors That Will Enhance BIM Use for Facilities Management

Two of the factors relate directly to this theme:

- **More Ability for Operations/Maintenance to Utilize the Model**
- **More Demonstrated Benefits of BIM for Post-Construction**

While UK owners generally exceed American owners in their enthusiasm for greater use of BIM for facilities management, some sectors in the US show a much more marked interest in this area.

- **More UK owners express a need for models that are useful to operations/maintenance (88%) than cite a need for post-construction BIM benefits to be demonstrated (68%).**
- **In the US, above-average percentages of healthcare owners (71%) and owners with large construction budgets (61%) cite their need for that as well, reinforcing their eagerness to expand the value proposition of BIM past design and construction.**
- **Renovations-focused owners cite the need for both of these factors at higher rates than greenfield owners, perhaps because many of those owners manage multiple renovations in their buildings and feel they would benefit by having accurate models as a baseline.**

More about owners' perspective on BIM for facilities management is on pages 52–55.

Other Factors

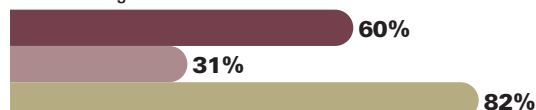
- **Ability to Quantitatively Measure the Positive Impact of BIM:** Aligned with other findings in this report, far fewer US owners (21%) are enthusiastic about measuring BIM benefits than UK owners (80%).
- **Standards of Model Development and Exchange:** This technically oriented factor shows the greatest differential between very high involvement US owners (60%) and low level ones (31%), likely owing to a greater appreciation by BIM-active owners of the critical importance of moving project data efficiently between BIM users. Not surprisingly, it also scores high with UK owners.

Most Impactful Factors to Increase Owners' BIM Implementation and Value (Percentage Who Consider Them to Have a High/Very High Impact)

Source: McGraw Hill Construction, 2014

- US: Very High BIM Involvement
- US: Low BIM Involvement
- UK: All BIM Users

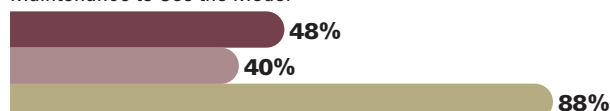
Standards of Model Development and Exchange



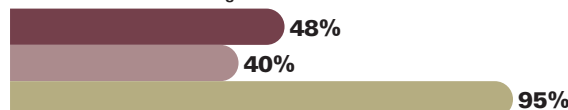
More BIM Skills Among Contractors/Trades/Fabricators



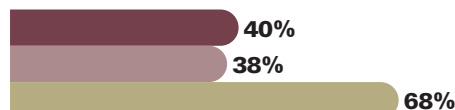
More Ability for Operations/Maintenance to Use the Model



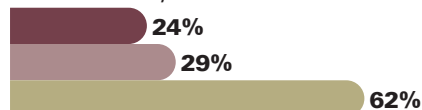
More BIM Skills at Design Firms



More Demonstrated Benefits of BIM for Post-Construction



More Use by Other Owners in the Areas They Work



Ability to Quantitatively Measure the Positive Impact of BIM



Owners' Messages to the Industry

Owners were asked if they have a single message to give to the design and construction industry about their perspectives on the future of BIM.

Most US owners focused on positive messages, with themes such as:

- It is the future/Stop resisting (especially popular with large owners and those in the healthcare sector, who are generally the most highly committed to BIM)
- Learn its value and usefulness (also coming strongly from healthcare owners)
- Should be a standard
- Need to encourage its use
- Useful for finding/preventing errors and maintaining quality

One owner's statement in particular summed up the general responses by saying: "To not adopt BIM and all its capabilities is like continuing to use a flip phone instead of a smartphone."

A few of the smaller owners and those with less BIM activity were more cautionary:

- Needs to be used properly
- Needs standardization
- Should not rely on it exclusively

One owner advised, "It's a good tool, but it's just a tool, so it doesn't solve all your problems. You can't disengage your brain."

While many UK owners also offered positive outlooks and none offered cautionary notes, the largest portion (48%) used the opportunity to make the point that people need to be educated on it. This probably derives directly from their current initiative, preparing an entire construction economy for the government BIM mandate.

Data: Scandinavian Owners

Insights From Owners on Use of BIM in Scandinavia

Countries in Scandinavia, particularly Finland and Norway, have a long history with innovation, which has aided BIM adoption. However, owners in these countries are still seeking to encourage wider use of BIM to support collaboration and facility management.

Two of the most mature BIM markets in the world are Scandinavian countries: Finland (population of 5.5 million) and Norway (population of 5.1 million). Interviews with over 20 individuals representing various public and private organizations, as well as industry associations in Norway and Finland, reveal that both countries are widely adopting and innovating with BIM as an integral part of their construction industries.

While this analysis focuses on Finland and Norway, it should be noted that BIM is widely used in other Scandinavian countries, such as Sweden, which is considering one. (See the policy analysis beginning on page 18.)

Strategic and Public Positioning of BIM: Government Leadership and Owner Demands

FINLAND

Since 2007, **Senate Properties** (Senatti), the national public owner in Finland, has required BIM on every project over €1 million. Its capital assets include 10,500 buildings totalling 6.4 million square meters, and its diverse portfolio includes military facilities, ministries, museums and offices. In 2013, 46 major capital projects met the minimum requirement for the mandated use of BIM.

Senate Properties is in the midst of a transition to a “new norm,” in

which BIM will play an important role. There will be decreasing levels of funding from the public sector, and Senate Properties’ clients cannot predict their modes of operation in the next five years. In addition, public sectors are adjusting to how these changes are altering the ways in which citizens interact with the government. Kaj Hedvall, director of strategy, development and information management at Senate Properties, sees these changes adding up to a more dynamic environment, requiring a realignment of functions that focus on the portfolio and resource optimization in order to improve space utilization.

BIM will help support these changes. It allows faster explorations of design/construction scenarios with more iterations, which will allow Senate Properties to interact more effectively with clients who have rapidly shifting demands.

The example of Senate Properties’ BIM policy also encouraged **Finavia Airports**, owner of more than 20 airports throughout Finland, to require BIM in its Helsinki International Airport Terminal project in 2007. Kari Ristolainen, design manager at Finavia Airports, explains the appeal of BIM for owners: “BIM allows decision-makers to understand their investments with better accuracy.”

In addition to building projects and airport terminals, there has been a growing adoption of BIM by

municipal and local governments, as well as for infrastructure projects.

NORWAY

An early step toward BIM use in Norway was the collaboration on digital e-submissions between the Norwegian Building Authority and the Map Authority of Norway in 2000. This collaboration led the Norwegian Building Authority to determine that BIM would play an important role in providing drawing information. In particular, they realized that Industry Foundation Classes (IFC) open standards would be crucial in supporting the information exchange. By 2005, an extension of IFC was available to support the interoperability between the map information and building information.

Other agencies have also seen value in BIM.

- **Statsbygg**, an agency in charge of managing a real estate portfolio for the government of Norway, has mandated BIM on all new and renovation projects since 2010.

- **The Norwegian Defense Estates Agency (NDEA)**, the agency responsible for real estate belonging to the military, created a BIM strategy in 2012, in order to improve the efficiency of buildings through their entire lifecycle.

- **Major hospitals** in Norway are using IFC-based BIM. This is a particularly active market with new software applications and mobile apps emerging.

A joint statement has been issued by Statsbygg, the NDEA and healthcare owners in Norway that they will all require BIM deliverables by July 2015, following buildingSMART Norway Standards.

Common BIM Requirements

In 2012, buildingSMART Finland published the “Common BIM Standards” (COBIM2012). Having a national standard has encouraged broader BIM adoption in Finland because public and private owners were now able to rely on this standard to specify BIM requirements.

Recognizing the value of one common standard, owners with preexisting BIM guidelines and standards, including Senate Properties, have now adopted COBIM2012.

Open Standards as Common Practice

Open standards hold particularly strong sway in Finland and Norway, as well as in other Scandinavian countries. In fact, 93% of industry professionals in a survey of more than 400 Finnish firms reported the use of IFC on their projects.

In this region, BIM is widely associated with an open standard, which provides greater potential for interoperability. This opens up the potential to link BIM with other tools like zoning maps, web services and GIS data.

One vivid example is the use of IFC open standard BIM on the €16-million Helsinki Music Center, one of the largest projects to rely on an open standard for model exchanges and analysis.

Tomi Henttinen, chair of buildingSMART Finland, states it quite succinctly: “By BIM, we always mean open BIM.”

Active Private Industry Involvement

The adoption of BIM in Finland and Norway has not been solely based on top-down, government influence. Private industry has also been actively advocating for the use of BIM. In fact, Øivind Rooth, Norwegian Building Authority, states, “The industry has no debate about BIM, and industry will have this up and running by itself.”

FINLAND

The buildingSMART chapter in Finland has over 100 organizations that are members, and that membership has grown dramatically in just the past five years, revealing an ongoing interest in engaging with BIM by Finnish companies.

The long-term involvement with BIM is also not confined to the public sector in Finland. For example, Granlund, the largest building services design consultant in Finland with a staff of 500 people, has been using BIM on 100% of its projects since 2000.

NORWAY

buildingSMART has a particularly strong influence in Norway, with its membership accounting for 75% of the construction market, according to the Norwegian Building Authority.

BIM use is evident across many project types in the private sector in Norway, including retail, museums and residential projects. The use of BIM by design consultants has helped encourage its widespread use across building types.

There is evidence of increasing owner engagement as well, including a recent BIM for Owners event in Norway, attended by 80 representatives from 30 owner organizations.

Technology Innovation

One striking feature of the long-term use of BIM in Finland and Norway is the degree to which it has been fostered by their rich culture and impressive record of research and development in construction information technology.

Lars Christiansen, founder of multi-BIM and former co-CEO of buildingSMART International, sums up the engagement with research and development with a local saying: “The Finns conduct research, the Swedish develop the product, the Danish sell the product, and the Norwegians own the technologies.”

Active government support has helped foster this culture of innovation. In the 1990s, the Finnish government—building upon the success of government-funded research in telecommunications and biotech—set up agencies to support research endeavors and provided a substantial research and development fund for the building industry. This investment helped provide a foundation for BIM by developing technologies that demonstrated the value of product modeling and 4D modeling. Senate Properties engaged in one of the first public-owner pilots of an array of design, construction and operation BIM applications on an actual renovation project using IFC-based open standards.

Norway has also invested in innovation through funds such as

Innovation Norway and Statsbygg Research and Development, which have catalyzed efforts in conceptual energy simulation, data dictionary, information exchange and delivery standards, model services and requirements modeling.

Private industry has reaped the benefits of the culture of innovation with a wide variety of software products and apps that push construction information technology forward. A number of BIM entrepreneurs from Finland and Norway, as well as other Scandinavian countries, have successfully exported their software beyond the European Union to markets in the Americas, Asia, Australia and the Middle East.

Moving forward, companies in these areas are engaging with the issues for which the industry seeks better technology, including how BIM intersects with facility management, GIS integration, information security, infrastructure and interoperability. Rooth indicates further priorities for research and development: "We need open source and dynamic means to refine, maintain, and "plug and play" the updating of the building codes in automated code-checking BIM applications, rather than hard-coding."

Better Processes and Collaboration Needed

Despite the long commitment and high levels of use of BIM technologies in the region, the industry has not fully leveraged the opportunities that come with the collaborative processes of BIM.

Christiansen estimates from his experience that "70% [of the industry is engaged in] model production,

but only 15% or so are *using* BIM." Representatives from Granlund agrees that "collaborative BIM is not [used] frequently enough; BIM in project management or construction management has been lacking."

One area in which industry leaders and experts hope to be able to better use BIM is in support of lean approaches, such as using BIM in the Big Room or bringing a lean production mindset to the BIM process. Lean construction approaches rely on team communication and collaboration, and BIM provides a critical tool to enable firms to engage collaboratively in pursuit of efficiencies.

Another area in which BIM can be employed to encourage collaboration is with the Spearhead Alliance project delivery system in Finland. Adapted from integrated project delivery and the use of public-private partnerships, the Spearhead Alliance keeps a certain percentage of the consultants' profit at risk (up to 6% of project cost), while placing more focus on bonus clauses (which may reach up to 12% of project cost.)

Senate Properties has introduced this approach on three large-scale, complex projects. They will focus on the upside incentives when design consultants and contractors can meet the price, value and performance targets, and they are developing BIM requirements to align with this approach.

Benefits

Many of the owners interviewed expressed difficulties in consistently measuring the benefits of BIM. However, there were some clear benefits reported by owners.

■ Reliability and Value for Owners:

During the tendering phase of a new €30-million parking structure project at the Finland Helsinki Airport, Ristolainen reported that by giving IFC-based models to general contractors, the owner was able to see that the bill of materials and the quantity take-off across the general contractors varied only between .6% and 3.3%, giving the owners much better reliability and value moving forward to construction.

■ BIM's Appeal to a Younger

Generation: In 2013, Granlund was able to attract 95% of its new employees under the age of 25.

■ Quality Assurance:

Ole Kristian Kvarsvik, head of business and technology with Nosyko and former senior engineer at Statsbygg, points out that while 2D CAD requires a lot of resources to ensure a good design (and may only cover about 20% of the design through spot checks), BIM has enabled owners to automatically check the design for space management, accessibility, information take-off, requirements management and conducting design compliance checks early during the design phase.

BIM Use Moving Forward

Clearly, the commitment to BIM in this region will continue. As Henttinen states, "We are very practical people ... We are utilizing open BIM, [and] nobody sees that as a big issue. There may be some technical issues, [but] let's just find a workaround. You don't need to cover everything." ■

Data: Owners' Perspectives on BIM for Facilities Management

Value of BIM for Facilities Management and Operations

Potential of BIM for Facilities Management and Operations

For as long as BIM has been used, practitioners have foreseen the potential value to owners of bringing the data-rich models developed by design and construction teams into owners' facility management and operations environments. In theory, benefits would include:

- Complete and accurate data that is linked directly to graphics
- BIM-FM software integration to eliminate double entry of information into their existing automated systems (the main purpose of the Construction-Operations Building Information Exchange [COBie] standard)
- Ability to capture real-time performance data in a "digital double" of the physical facility
- Reliable as-built model that can be maintained in perpetuity
- Scheduled maintenance integrated into the model and work order systems
- Robust, iterative space management
- More accurate planning, scoping and budgeting for alterations

Although the potential is still strong, the traction has been slow among US owners, who are still primarily focused on BIM for design and construction. This is changing, though, and the results show that many owners, especially in the UK, are getting involved and are planning to become much more actively engaged with BIM for post-construction over the next five years.

Perceived Value of BIM for Facilities Management

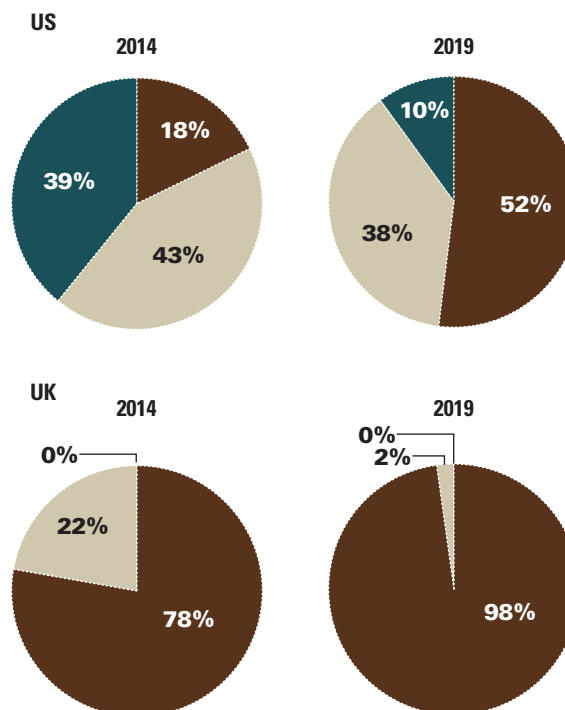
Aligning with a general trend throughout this report, UK owners are more enthusiastic than US ones about the value they perceive of BIM for facilities management and operations in their organizations.

- All UK owners report some degree of value, and over three quarters (78%) say it currently has high value.
- Virtually all UK owners (98%) predict they will perceive high value in five years, with the vast majority of those believing it will have very high value.
- Meanwhile, only 5% of US owners regard it as having very high value. Three quarters of those are in the public sector, perhaps indicating more of a long-term owner/operator mind-set.

Perceived Value by Owners of BIM for Facilities Management and Operations

Source: McGraw Hill Construction, 2014

- High Value
- Moderate Value
- No Value



- Among the relatively few US private sector owners giving a high rating, the largest project-type group is healthcare, again aligning with owner/operator thinking. By contrast, nearly half (48%) of the private commercial owners see no value at all, and none feel it is of high value.
- US owners perceiving value only increase to 27% in five years, but they are led by the healthcare and education sectors (both 75%), again reinforcing the anticipation of value for hands-on owner/operators.

This spread between US and UK results likely reflects a more concentrated focus on the comprehensive lifecycle value of BIM in the UK, whereas the US industry has been heavily focused on design and construction benefits, and traction is slow for post-construction uses.

Capability to Leverage BIM for Operations After Construction

THE BUSINESS VALUE OF BIM FOR OWNERS DATA

A similar pattern to the findings on the value that owners place on BIM for facility management and operations (FM) appears when owners were asked to rate their organization's capability to leverage BIM for operations after construction, both currently and in five years.

- **Over half (55%) of UK owners feel they already have high capabilities, with about a quarter of those claiming very high skills.**
- **Five years from now, almost all (92%) of the UK owners believe they will have high capabilities, with more than half of those forecasting that their skills will be at the very high level.**
- **By contrast, only 14% of US owners believe they currently have high capabilities, and less than half (48%) think they will be at that level in five years. However, two thirds of those do say they will have very high skills, particularly in the healthcare and education market sectors.**

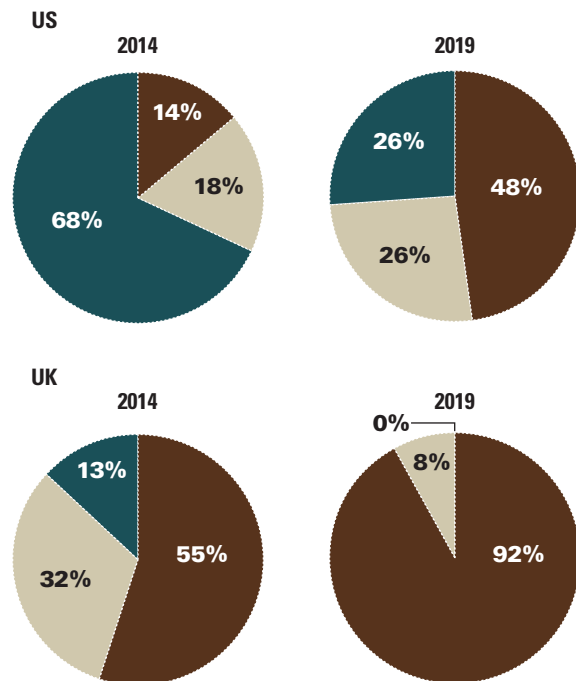
As with the rest of the data, firm size and level of BIM activity matter. Larger US companies and those with higher BIM activity are already more capable at leveraging BIM for operations than the average. And they, as well as public sector owners, all foresee above-average capabilities five years from now.

- **Large owners generally have well-established investments in automated FM systems, so they are better positioned to engage with digital data and models, and several software companies have offerings to enable that.**
- **BIM-active owners are already aware of the depth of data available in models, so moving to the post-construction phase is not a conceptual leap.**
- **Initiatives such as Integrated Facilities Management for Federal Agencies (FED iFM) are driving interest among government agencies, especially the Department of Defense.** The Whole Building Design Guide site for the National Institute of Building Sciences describes FED iFM as "an initiative to create shared and common practices for integrated facility management in federal agencies and the private sector."

Owners' Capability of Leveraging BIM for Operations

Source: McGraw Hill Construction, 2014

- High Capability
- Moderate Capability
- No/Low Capability



US Owners' Perceptions of Their Organization's Current and Future Capability to Leverage BIM for Operations After Construction

Source: McGraw Hill Construction, 2014

	Currently High Capability	High Capability in Five Years
Small Owners (<\$50M annual construction)	10%	38%
Large Owners (>\$400M annual construction)	28%	78%
Low BIM Involvement (<25% of projects)	10%	31%
Very High BIM Involvement (>75% of projects)	24%	72%
Private Sector Owners	16%	35%
Public Sector Owners	13%	53%

Owners Currently Receiving Models for Operations After Construction

Owners may believe BIM for FM is valuable and may be developing their capabilities to work with models, but how often are they currently receiving models from their design and construction teams?

To determine this, the owners reporting moderate, high or very high current capability to leverage BIM for operations after construction (32% in the US and 87% in the UK) were asked how frequently they are receiving models for that purpose and how often they are using the Construction-Operations Building Information Exchange (COBie) standard for the models.

Owners' Frequency of Getting Models

Most UK owners (94%) report they frequently get models, with a third of those saying they always get them. No UK owners (0%) say they rarely or never get models.

US owners are less engaged. Fewer than half (47%) say they frequently get models, and over one quarter of US owners report rarely (12%) or never (16%) receiving them.

- **Not surprisingly, BIM activity is a key factor, with 82% of very high involvement US owners reporting getting models frequently, versus only 12% of low involvement ones.**
- **Size is also a factor, with over half of large US owners (56%) getting models frequently, versus just a third (33%) of small ones.**
- **The renovation-oriented owners who report frequently receiving models (22%) fall significantly behind owners largely doing new construction (57%), reflecting the generally lower level of BIM activity for renovations.**
- **Among project-types, more healthcare owners (67%) report a high frequency than others, which makes sense because of the popularity of automated facility management systems in that owner/operator segment.**

Owners' Frequency of COBie Use

The Construction-Operations Building Information Exchange (COBie) was devised at the United States Army Corps of Engineers in 2007 as a standard data format for delivering building information, as opposed to geometric modeling data. This standard is being widely promoted as a highly effective format for data integrations between building information models and automated facilities management programs.

In alignment with findings about perceived value of BIM for facilities management, UK owners are more actively embracing COBie than their US counterparts. Nearly three quarters in the UK (74%) say they frequently use COBie, with almost one quarter (23%) claiming they always use it, and none saying they never use it. This high degree of commitment is likely a direct result of the UK BIM Task Force's focus on COBie as an element of the impending 2016 BIM mandate.

In the US, only 15% of owners say they frequently use COBie, with a mere handful (3%) always using it. While over a third either rarely (19%) or never (16%) use COBie, almost half (41%) report they are not sure, probably also reflecting unfamiliarity with it.

This is an opportunity for the US BIM community to learn from the leadership being demonstrated in the UK and help owners to embrace the value of structured data exchange that enables BIM for FM, which will allow them to finally realize the potential that so many people have identified for so long.

Data: Facilities Management

Owner Insights

on Using BIM for Facilities Management

Owners who adopt BIM for facilities management are eyeing numerous potential benefits, but they face a range of cultural and technological challenges along the way. In order to achieve integration, owners are pursuing a variety of strategies.

While BIM has proven its value during design and construction, some owners also see the potential benefits of integrating data from BIM models into facilities management systems. Early adopters of BIM for facilities management are eyeing a range of opportunities, from eliminating the need for reentry of equipment-related data into existing FM software to creating more model-based virtual environments for the planning and execution of operations and maintenance activities.

To realize these benefits, owners also face significant challenges. Facilities management and operations departments use a wide range of software and systems that typically do not integrate seamlessly with BIM deliverables. In addition, owners may face cultural challenges when bringing BIM data into facilities management, as use of this data may change—or be perceived as changing—established operations and maintenance practices.

Cultural Challenges

Bill Brodt, chair of the Facilities, Maintenance and Operations Committee with the National Institute of Building Sciences, has pursued the potential benefits of BIM for facilities management since its earliest days and has met considerable challenges along the way. Early on, Brodt saw the potential to eliminate reentry

of equipment data as it passes from designers to contractors and, ultimately, to owners. His work helped lead to the Construction-Operations Building Information Exchange (COBie) standard.

While Brodt has seen considerable technology hurdles during development of COBie, he says the cultural challenges have been considerable.

"I have a heck of a time getting people to wrap their heads around this," he says. "I run into a lot of issues with operations and maintenance people. At first they ask, 'Why do I need this information?' Then they complain later when they don't have the information. They don't see the value in investing resources up front."

In some cases, Brodt says, users are simply resistant to change. "A senior maintenance guy with 30-plus years of experience and near retirement isn't usually interested in doing things differently," he adds.

Birgitta Foster, vice president of operations and facility integration at VDCO Tech, says getting facilities managers to understand the value of that building data is a critical first step. Through working with owners on BIM for facilities management strategies, Foster says she has focused on data first, rather than the 3D aspects of BIM.

"The basic problem I see is that owners are very data-centric, while contractors and designers are more model-centric," she says. "In

general, FM is not really prepared for models yet. They are looking more for data right now. Even if they do recognize the value in models, they don't have the software to maintain it or [the models] don't work with their existing [systems]."

BIM for FM Champion

As is often the case with process changes, getting an owner to recognize the value of BIM for facilities management often requires an in-house champion to drive adoption. At Florida International University in Miami, Brian Perez, associate for information technology in the FIU facilities department, is spearheading the effort. Perez says he saw an opportunity when FIU first began accepting BIM models as deliverables from design and construction teams.

"I jumped into this because I saw the potential to extract information up front, which we were entering ourselves later on," he says.

Perez notes that, traditionally, it can take up to a few months for the FM team to input building data into its existing work order system. "We had an arduous task when we got a new building," he says. "We'd pull together the O&M manuals and equipment information—it was a very labor-intensive effort. I would ask people on the facilities team—when they had a chance—to go out and start gathering information," he says. "Some were mechanics with other jobs, so they got to it when they had time."

Once FIU saw the value, Perez says it became a matter of defining the data that the university needed to receive in its BIM deliverables and determining how that data could be exchanged. FIU is currently developing a BIM standard that leverages COBie to integrate BIM data with FIU's existing systems. Perez says defining FIU's needs in contracts will be a critical component of its strategy. "Often, the models we see are built from the designer's standard and when they deliver it, it doesn't work for the owner," he says.

Once FIU begins to leverage BIM for FM, Perez expects to see greater buy-in from the field. As with many institutions, FIU traditionally kept building documents in planrooms, but the university is moving toward giving mobile devices to field staff.

"There can be a tremendous benefit to the technician, having a set of plans on a tablet," he says. "They can have a portion of the model to navigate through the system and see where things are located. I saw that people were against it before, but I've shown them the potential. It's opened people's eyes, and people really see the benefits. There is a time-savings when you don't have to keep going back to a planroom."

While the 3D benefits of BIM could be leveraged by FIU's facilities staff, Perez recognizes its limits. FIU plans to set a standard of LOD 350 for its deliverables. According to the BIMForum, to meet LOD 350, model elements are graphically represented within the model as specific systems, objects or assemblies in terms of quantity, size, shape, orientation and interfaces with other building systems. Non-graphic information may also be attached to the model

"The basic problem I see is that owners are very data-centric, while contractors and designers are more model-centric."

— Birgitta Foster, VDCO Tech

element." But Perez plans to "layer them out," so that each discipline area gets what it needs.

"Initially, we showed [the FM staff] the BIM models, and a lot of guys thought it went over their heads," he says. "So we want to simplify it and only show them what they need to make it easy for them."

Going forward, Perez says, FIU's next challenge will be how to keep its 3D models updated.

"We don't have an in-house design staff, so we need to decide if we will hire staff or partner with a firm to manage the models," he says.

Crawl, Walk, Run

Carolinas HealthCare System has been on the path to adoption of BIM for FM since it first started receiving models in 2009. Meghan Ruffo, BIM manager with its facilities management group, says she recognized the cultural and technology challenges and instituted a "crawl, walk, run" strategy of gradual adoption. CHS first created standards and tested them for a year and a half, establishing guidelines "to ensure that we get the deliverables we need."

The next big goal was to integrate BIM models with the CHS space management system. As a healthcare provider, Ruffo says CHS needs to record its square footage as part of reporting for Medicare and Medicaid reimbursement. Space management is such a priority that CHS is now modeling the majority of

its current facilities so that they can all exist in a BIM environment. More than 75% of the 17 million square feet of space in its primary system has been modeled to date, she says.

Next, CHS moved on to integrating BIM data into its work order management system. Throughout the process, consistent standards, such as naming conventions, have been critical, she says.

"The key is the consistency and the format," Ruffo says. "We developed add-ins that check the model for accuracy and make sure the correct parameters are populated. We developed tools that help with the input and tracking of that data on the contractor side. We know that not every contractor will be very sophisticated, so it can be done using a spreadsheet."

While Ruffo sees the value in models for facility management to provide crews with drawings, she is less interested in making those available via mobile devices.

"We have a virtual planroom at a few facilities, where they can pull up drawings on monitors and print out portions, if they need to," she says. "If you think about someone doing their work [in the field], it's not always the easiest thing to do while holding an iPad. Sometimes printing out a piece of paper and recycling it is the best option."

Private Sector Opportunities

While some institutional owners, such as hospitals and universities, see the value of BIM for FM, the trend is also making inroads with other private sector markets. Trammell Crow, which develops a wide range of properties through its 15 US offices, has started to evolve its BIM strategy to include facilities management. George Farrish, senior associate at Trammell Crow, says the company offers it as an option for its clients. The key, he says, is early engagement. But in order to do that, Trammell Crow needs to know who the building tenant will be and what needs they will have. As a result, Farrish says he sees great potential of build-to-suit projects for an established client. However, on a speculative project, where a tenant has not been determined, Trammell Crow would be less likely to pursue BIM for FM.

One core issue is cost. "If you can discuss [BIM for FM] early enough with your AE and general contractor, there should be little to no cost," he says. "The later you discuss it, the more likely it will become a premium cost. The one cost we expect to see is third-party services for running validation of the model, testing it to make sure the models deliver what is contracted."

Right now, Farrish says Trammell Crow sees offering BIM for FM as added value for clients, providing them with additional tools to help them operate and maintain their facilities. "People in the facilities management world know how expensive it is to run their facilities, and they know solid data is important," he says. "When we

explain what we can provide, that's not a hard sell for them."

Part of the key is starting with the "low-hanging fruit," extracting data from BIM that can flow into existing FM software for daily use. "At this point, how BIM models can be used for operations and maintenance is still foreign to more facilities manager," he says.

But that could be changing. Although it is an added service now, Farrish sees some owners beginning to inquire about it. "More and more owners know about this or have heard of it," he says. "We're educating them about it now, but it could become an expectation at some point."

Federal Road Map

Among some areas of the federal government, BIM for FM is already seen as an important part of the BIM road map. At the General Services Administration, pressure from Congress has helped advance its BIM adoption. Charles Matta, deputy CIO at the GSA's Public Building Service, says that, prior to the recession, concerns about cost overruns helped push the case for BIM. Now he sees operational issues deepening the need to leverage BIM. Specifically, Matta notes that legislation that has set targets on energy reduction at GSA facilities is a big driver for BIM's use in facilities management.

"What really matters to the leadership about how BIM is used has shifted [over the years from] planning to facilities management," he says. "There has been a lot of legislation about energy efficiency goals that, at the time, looked very daunting and required innovation within the agency to get there. Now

one of the key aspects for leadership has to do with freezing the footprint. Both of those things can't be done without integration of BIM and our CMMS (computerized maintenance management system)."

As part of the effort, GSA awarded a national CMMS contract in early 2014 and is currently adding facilities to its GSALink system, which manages building system data, including integrating information from manufacturers as well as automation systems and energy meters in buildings.

Currently, the GSA is developing a road map for a central facility repository, which will archive BIM models and related building data and documents. According to the GSA BIM Guide Series 08, "through the central facility repository, it is envisioned that buildings' BIMs would be managed and maintained for all types of projects, including new construction, major renovation, [renovations and additions], small projects, and [operations and maintenance]. Furthermore, O&M personnel would be able to view the BIMs. Software tools would 'sit on top' of the central facility repository to provide security, search and view capabilities, version control, notifications on updates, and analysis and reporting."

The central facility repository illustrates a major challenge that all federal agencies face: incorporating all of an agency's building information—ranging from paper documents to BIM models—into a usable system. The GSA oversees more than 1,500 buildings, and Matta says that it receives BIM models of facilities as part of the design and construction processes for both new

construction and renovations or modernizations.

"We don't have models for all facilities because that's how funding works," he says. "There is no fund for that. Instead, buildings get built or modernized and that's what it will take to get there. So, it will be a long process to get them all onboard."

Integrating Existing Data

The Department of Defense (DOD) is exploring how to best leverage the information it has in order to develop a cloud-based inventory of buildings data. "Like a lot of owners, DOD is sitting on a lot of information about their buildings," says John Roach, a consultant with the Defense Health Agency Facilities Division. "DOD recognizes the value of that and is trying to figure out a way to share it between different users and uses."

Roach says the first step is identifying the data they have, defining the standards to hold it together and having tools to make that information widely accessible. This could range from BIM models to basic inventories of rooms, he says.

"The model at the simplest stage can start from an image, which you use to identify the footprint of the building," he says. "It could resemble an evacuation floor plan. More simply, you could just input information about the space inventory and build a stacking diagram."

While the approach often provides only basic information, Roach says that is still valuable. Ultimately, he says the approach is scalable and can evolve to include more complex information as modeling becomes more prevalent in the future.

"[Start] with the data you have, and [do] what you can with it. But you also establish the standards of what you need in the long term and work toward those goals."

**— John Roach, Consultant,
Defense Health Agency Facilities Division**

"I advocate starting with the data that you have and doing what you can with it," he says. "But you also establish the standards of what you need in the long term and work toward those goals. You improved the data stores as you go, so you incrementally improve it."

Decoupling the Data

The DOD approach is in keeping with the new FED iFM initiative. FED iFM aims to tackle interoperability issues that hinder the advancement of BIM for facilities management. Typically, buildings data is locked into information silos or proprietary formats, says Kimon Onuma, president of Onuma, Inc., which is consulting on the FED iFM project. The goal of FED iFM is to "decouple" the facilities data from applications, making it neutral rather than bound to a specific application.

Instead, the system would create a backbone of accessible data that multiple applications can draw from. Onuma suggests that this would allow for greater development of new and better tools for facilities planning and management. By making the data more accessible, applications could be developed to carry out various functions, drawing from the data it needs that is available through the open data service.

Onuma likens it to GPS data. Since GPS data has been made available to the marketplace, numerous uses

have been devised for that data, including maps and location services on smartphones.

Staying Secure

Naturally, security is a major concern, given the numerous sensitive facilities that the DOD and other agencies operate. Onuma says that specific data can be secured, creating rules about who can access specific pieces of data.

However, long-standing cultural concerns remain. GSA's Matta says that several agencies it works with typically keep facilities data within a closed system that cannot be accessed via the Internet. "We had an agency agree to be part of a pilot study on this, but then decided against it because of security concerns."

Roach says DOD and DHA are embracing the approach, trusting that data can be secured properly.

"DHA sees the importance of being able to share information," he says. [DHA] doesn't want a system that lives in isolation from the rest. If [DHA] can get other federal owners to adopt a similar framework or approach, everybody wins. There are economies of scale. Everyone isn't inventing their own system, and there's incentive for everyone to contribute." ■

Interview: Owner Perspectives

Desiree Gandrup-Dupre, Vice President and Business Information Officer, Kaiser-Permanente Hospital System

An integrated managed-care consortium, Kaiser operates in nine states making it the largest managed-care group in the nation. Desiree Gandrup-Dupre discusses Kaiser's experiences implementing BIM practices as an owner.

THE BUSINESS VALUE OF BIM FOR OWNERS

How did Kaiser-Permanente originally get into BIM, and where are you in the process of using it systemwide (plan, standards, projects, etc)?

GANDRUP-DUPRE: Kaiser Permanente first started exploring BIM about four years ago. We worked with UC Davis to understand how BIM can help us plan and execute our projects more efficiently.

Originally, we were focused on room templates and facilities management in planning and design, and on clash detection, scheduling and material management during construction. However, we quickly realized there was tremendous opportunity to leverage the tools of BIM across the total lifecycle of a building—not simply the initial planning and construction phases.

Presently, Kaiser Permanente utilizes BIM on virtually every major project. We even leverage BIM technology on many of our smaller maintenance and remodeling projects. It's truly become a standard tool in our building arsenal where we require its use for clash detection and schedule optimization.

And we're not stopping there. We're now exploring its use in our facility management and operations, while continuing to push the envelope in design and construction with laser-scanned point-clouds as well as cloud-based BIM desktops.

What has worked well in your implementation, and what has been a challenge??

GANDRUP-DUPRE: BIM is, and had been for some time now, an extremely successful planning tool. In addition to using it to manage our clinic room templates, we're currently working [to] create autocode checking functionality, where we will use BIM technology to validate life-safety requirements through ongoing digital design plan checks.

As stated earlier, our challenge going forward with BIM will be to leverage the full power of our models throughout the building lifecycle. It's very clear that BIM offers a tremendous advantage for building operations.

How have you determined what "success" would be, and do you measure it? If so, how?

GANDRUP-DUPRE: The true test will be: Are we taking full advantage of the tremendous amount of information available through BIM for FM to actually operate our buildings more efficiently? We can't do this alone in our own planning and construction silo. We need to help our facility engineers incorporate the model's parametric information technology into their day-to-day work and leverage the available information to operate these buildings at maximum efficiency. That's the challenge we're trying to measure and quantify right now.

Any advice for other owners?

GANDRUP-DUPRE: Our advice for other building owners is to engage everyone on your project teams; beginning with your internal planning staff and moving on to your design and construction professionals, and finally the facilities operations and maintenance staff to ensure that BIM is leveraged from beginning to end and back again.

For example, on our San Diego Central Hospital project, which began construction earlier this year and opens in 2017, we had our planners and facility engineers at the table almost from day one of the project. Thanks to BIM and other supporting technologies, this building will be very smart.

We've realized, since design and construction takes less than 10% of the total building lifecycle, if we want our facility engineers and stakeholders to enjoy the full benefits of BIM across the lifecycle, they need to be involved in the design so that they can leverage BIM in the operations. ■

Interview: Owner Perspectives

Richard Draper, BIM Process Manager, Birmingham City University
and
Derek Hughes, Technical Director, Connect Plus M25 Limited

The UK has seen wide BIM adoption due to the upcoming implementation of the BIM mandate. Two UK owners, one public and one private, share their specific experiences with BIM.

THE BUSINESS VALUE OF BIM FOR OWNERS

Why and how did your organization first get involved with BIM?

DRAPER: Initially BIM was introduced to the organization by a BIM consultant after a scheme we had needed to be redesigned. After the announcement of [the central government BIM mandate], Birmingham City University mandated the use of BIM during the redesign period and provided training for all of the design consultants to get them up to speed. Our use of BIM came before the government mandate to use BIM.

How far along are you in your engagement with BIM?

DRAPER: We have used BIM for design [and] construction and are now embarking on using BIM for maintenance. We also hold our space database within the BIM environment and currently manage the database through BIM.

HUGHES: For the new major construction works that we have undertaken, our “step-down” construction contractor has relied upon BIM extensively. We have used BIM extensively for planning, briefing, training and clash detection purposes on all our major and more complex lifecycle renewal projects.

What has worked well so far?

DRAPER: Most areas are working well. We are constantly developing new ways of using BIM and improving on the process we are using.

HUGHES: BIM has been very effective. The introduction of [laser scanning] as an associated tool has made a significant difference to its effectiveness and usefulness for the type of work that we do. We have also used BIM supported by very high definition [laser scanning] for precision machining of critical construction components. This was pioneering [work] in construction, as far as we know, in the UK.

What have been the key challenges so far?

DRAPER: Culture change/buy-in from users. For example, we have mandated that the contractor uses [a cloud-based BIM server] ... on the projects, and it has taken a little while to get the processes working fully onsite.

HUGHES: Economic and rapid translation of [laser scanning] data into 3D CAD. Also consultants treating 3D CAD/BIM as something special requiring special in-house units attracting higher hourly rates to do the work. It should be part of every CAD technician’s capability suite. We are in a similar position to that of the early days of CAD.

How do you determine what “BIM success” is, and how do you measure it?

DRAPER: The ultimate BIM success for me would be when we have a fully integrated system in the organization that is in daily use by an Estates Management team that doesn’t refer

to it as BIM anymore, and when more Estates Management systems [are] being fed by new/maintained BIM models.

HUGHES: [When these can be achieved] Has the data and tool been used? If so, how effectively? Does a quick calculation indicate that BIM has been at least cost neutral? Most important, has it provided safety risk reduction in some tangible way?

What advice do you have to owners like yourself?

DRAPER: Start at the end of the process: What do you want out of the BIM? What do you really want to do with it for the management of your facilities? What information does your maintenance team need access to quickly, and what information do they need linked to the BIM, such as operations and maintenance (O&M) documentation? BIM structure and O&M structure should match.

HUGHES: BIM is already, and will continue to grow into, an everyday part of construction and maintenance. You can start small, but it is important to start somewhere. It is also good to identify a trustworthy supply chain that can contribute to the overall end-to-end processes. ■

AEC Perspectives on Owners and BIM

As owners expand their BIM involvement, there is a growing need for them to understand how best to enable their project teams to provide them with the greatest BIM value. In other words, what makes a good “BIM owner”? Several experienced AEC firms offer perspectives on that question.

Because AEC firms work with a variety of owners, they have a broad set of BIM experiences from which to draw hard-earned wisdom and guidance that can improve BIM outcomes for everyone.

Navigating, Not Driving BIM

“In simple terms” says Hal Jones, VDC director with Skanska, “good BIM owners understand the intrinsic value that BIM can bring, whether it’s empowering team collaboration, enhancing the project’s quality or improving the continuity of information. They don’t need a deep technical knowledge of BIM to see these values manifest.”

Preparing Their Organization for BIM

Owners will benefit by having the right internal organizational framework for BIM. Greg Gidez, director of design services with Hensel Phelps, recommends several key steps:

- **Establish goals for BIM—cost/benefit, faster completion, less rework, etc.—and assign a champion to implement the BIM program.**
- **Assess internal capabilities that align with the BIM goals, and supplement resources if necessary.**
- **Assess internal technology capabilities, making sure that systems are compatible with the designers/builders where**

necessary and sufficient to support the process.

- **Assign (or train) an educated staff, and define roles and responsibilities consistent with achieving the BIM goals.**
- **Assess the BIM capabilities of service providers (designers, trades, GC) to ensure that they can support the BIM strategy.**

Investing in Pre-Project BIM Planning

Mike Lefevre, vice president of Holder Construction, often sees that “owners—experienced, knowledgeable ones—continue to set up projects without the time to establish the infrastructure, protocols and systems required to realize even modest benefits from BIM. They end up in a rush to execute their projects, and we have to [fall back on] dumb hard work to succeed. The lack of time to set up a BIM process continues to extinguish BIM flames.”

Mark Konchar, chief enterprise development officer of Balfour Beatty, concurs that establishing ground rules for BIM—such as “Will there be a Big Room?” or “How are we going to share the models?”—is a key owner role. He sees owners who “have the capacity in-house, but they’re not focused” on advance BIM planning, and when BIM doesn’t meet their expectations, “they’re unhappy.” Lefevre applauds owners who “set aside enough time for BIM planning so that they can reap

the benefits. After that,” he says, “everything else is easy.”

Jesse Whalen, from Balfour Beatty, recommends that owners too inexperienced to direct BIM planning should “be open to making it a collaborative journey to discover what their BIM needs are and create a joint BIM execution plan [with their AEC team]. Having them say, ‘This is our vision: Show me what BIM can do to help us achieve that’ is how owners can most quickly learn what they should ask for.” Jones adds that by defining the project problems they want to solve, owners empower their teams to apply BIM appropriately and “drive toward a more positive and effective end result.”

Asking for and Getting the Right Things at the Right Time

Gidez says the best BIM owners “define expectations for BIM deliverables and level of development in their procurement documents during the proposal and negotiation phase, not at the end of the project.” Erleen Hatfield, partner with Buro Happold, cites an example: “Telling an architect or engineer for the first time to hand over a model after CDs creates a series of process and legal issues that are not easy to resolve quickly, and the owner may end up paying a contractor to rebuild the BIM.”

Gidez also notes that good BIM owners don’t “ask for BIM deliverables that provide no value

to the designer, the builder or the owner, such as camber in a beam or exactly placed wall outlets, unless there is a specific reason for it." He also encourages owners not to "dictate the software that the teams should use, only the end product that is expected."

Hatfield says BIM owners can get what they ask for by carefully evaluating competing firms' BIM proposals, warning that some "may be lower in price because they take shortcuts on the modeling." Examples are leaving out fire alarms, fixtures or steel connections, not modeling the pitch of pitched pipes or modeling ducts sitting on a floor slab. "The 2D picture looks right, but you can't coordinate with it, which hinders one of the best uses of BIM." She recommends that owners "level proposals by validating the modeling scope, just like they validate design scope."

Encouraging Collaboration

BIM greatly facilitates collaboration and integration. Konchar encourages owners to promote collaboration because "when you drive teams together to collaborate and innovate early, before final design choices are made, you can find real opportunities [for project value]." He also recommends that BIM owners be open to creative collaborative approaches, such as having "the trades can pick up some of the modeling for better benefit."

Staying Involved

BIM planning is critical, but a good BIM owner can't just set-it-and-forget-it. Jones says, "To maximize AEC team collaboration, the owner

"Set aside enough time for BIM planning so [you] can reap the benefits. After that, everything else is easy."

— Mike Lefevre, Holder Construction

should be an active participant in the project [and] be accessible and engaged in the day-to-day decision-making. It promotes both team unity and accountability." Konchar notes that it also keeps team members from resorting to old behaviors. "We use the analogy that when you pull a rubber band, if you ever let go of it, it goes right back to its shape, and if any individual at any point in the project lets go of the rubber band, it reverts back. Other people let go easier when the client lets go."

Measuring What Matters

Metrics are important for any new initiative, but as Jones advises, "It's important for owners to remember that the value [savings] of BIM on a project is often the money or time not wasted rather than a quantifiable reduction in total cost or schedule. Focus on the total value BIM brings to the project, rather than its perceived upfront cost." Daniel Shirkey, from Balfour Beatty, expands on that point, encouraging "a philosophical change from first cost to lifecycle cost on buildings" when evaluating BIM impact.

Thinking With the End in Mind

Jones states that a successful owner practice is to require that contract documents be generated from models and that the design team must maintain and update models through the construction phase. "This assures that the models and documents accurately reflect each other throughout the project

lifecycle, while also allowing the owner to use the model as part of their facilities management program if desired."

Regarding BIM for FM, instead of simply saying, "I want a BIM at the end of the project," Brian Skripac, Astorino Associates, advises interested owners to work backwards from the end result to understand what information is critical to maintain their facilities and then define a process/path for the AEC team to deliver that information at the right time. "If you ask for everything and get everything, you'll have way more than you can really do anything with. Owners need to have a process in place to use the information before they receive it." Konchar encourages owners to "identify the facility management staff who will be the ones who will take over in the end" so that they can get involved early.

Skripac, who is implementing a 36,000,000-square-foot BIM FM program at Ohio State University, also strongly counsels owners to embrace data standards. "The simple task of leveraging COBie to structure and consume data can have a tremendous ROI over traditional methods. Integrating systems and removing the redundancy can be an extremely valuable by-product of implementing BIM [for owners] to define a single source of truth for building information." ■

Methodology:

The Business Value of BIM for Owners Study Research

McGraw Hill Construction conducted the 2014 Business Value of BIM for Owners survey to assess the level of owner involvement with BIM and the value it is generating on their projects and for facility management.

The research in this report was conducted through a computer-assisted telephone interview (CATI) survey of owners between July 7th and August 26th, 2014. The survey was targeted to owners in the United States (US) and the United Kingdom (UK).

Definition of BIM Use Employed in the Research

For the purpose of the survey, BIM use was defined as BIM being used on at least one of the owners' current projects by at least one member of the design and construction team.

Survey Participants

The survey had 141 complete responses, 101 in the US and 40 in the UK.

- More owners were sought in the US because of McGraw Hill Construction's strong connection with construction in the US and the large Dodge database of construction projects to draw from in order to contact potential owners.
- A survey panel was used in the UK to reach owners.

The use of a sample to represent a true population is based on the firm foundation of statistics. The sampling size and technique used in this study conform to accepted industry research standards expected to produce results with a high degree of confidence and a low margin of error.

The total sample size (141) used benchmarks at a 95% confidence interval with a margin of error (MOE) of about 8.25%. For the US alone, the MOE is about 9.8%. For the UK alone, the MOE is 15.5%, but the 40 UK respondents are enough to look for and note significant differences across countries.

Screening Criteria

Size of firm was used as a screening criteria for firms in the US but not in the UK.

- In the US, larger firms, those with project values totaling over \$10 million, were contacted because BIM tends to be used on larger projects in the US.
- Because of the recent proposed guidelines in the UK around BIM use, more owners were expected to be using BIM, and, therefore, no criteria by size was placed on those owners.

Other screening criteria included knowledge of BIM use on their projects and types of construction.

- Owners did not have to be direct users of BIM but did need to be aware of its use on their project.
- Owners were also asked if they do more vertical building projects or infrastructure projects. Those who responded vertical building were included in the survey to ensure consistent types of owners were being interviewed.

Variables Used in the Analysis of US Owners

The larger sample size in the US allows for comparisons across different subgroups, most notably by level of BIM involvement. The following lists the percentage of total US respondents in each category.

■ Level of BIM Involvement (based on current level of BIM use on projects)

- Low BIM Involvement (Less than 25% of projects involve BIM): 41%
- Moderate BIM Involvement (25% to 50% of projects involve BIM): 21%
- High BIM Involvement (51% to 75% of projects involve BIM): 13%
- Very High BIM Involvement (More than 75% of projects involve BIM): 25%

While the majority of the analysis in this report focuses on level of involvement, the following variables are also used on occasion:

■ Size of Firm by Annual Construction Budget

- Small (Budget less than \$50 million): 29%
- Medium (Budget \$50 million to less than \$400 million): 53%
- Large (Budget \$400 million or more): 18%

■ Sector

- Public: 69%
- Private: 31%

■ Type of work

- More Than 50% of Construction Projects Are New Construction: 47%
- More Than 50% of Construction Projects are Renovation Projects: 38% ■

Resources

Organizations and websites that can help you get smarter about the business value of BIM for owners.



McGraw Hill Construction

Main Website: construction.com

Dodge: construction.com/dodge

Research & Analytics:

construction.com/dodge/

dodge-market-research.asp

Architectural Record: archrecord.com

Engineering News-Record: enr.com

Sweets: sweets.com

SmartMarket Reports:

construction.com/market_research

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Autodesk
www.autodesk.com



Skanska
www.skanska.com/group

Contributing Partners

Balfour Beatty Construction Services UK:
www.balfourbeattyus.com

Balfour Beatty Construction Services
US: www.balfourbeattyus.com

Mortenson Construction: www.mortenson.com

Partners

American Institute of Steel Construction: www.aisc.org

buildingSMART alliance: www.buildingsmartalliance.org

Hensel Phelps: www.henselphelps.com

Other Resources

American Institute of Architects—

AIA E202 BIM Protocol Exhibit:
info.aia.org/aia/form_free_bim.cfm

AIA Practice BIM, Standards & Interoperability:
network.aia.org/technologyinarchitecturalpractice/home/bimstandards

AIA Guide to Integrated Project
Delivery: www.aia.org/ipdg

Association of General Contractors ConsensusDOCS, 301
BIM Addendum: www.consensusdocs.org/Resource/FileManager/301_Guidebook_08_12_13.pdf

Australia National Guidelines for Digital Modeling:
http://www.construction-innovation.info/images/pdfs/BIM_Guidelines_Book_191109_lores.pdf

BIMForum: bimforum.org

bimSCORE: www.bimscore.com

BIM Task Group (UK): www.bimtaskgroup.org

buildingSMART International: www.buildingsmart.org

National Institute of Building Sciences: www.nibs.org

National Institute of Building Sciences "The COBie
Guide": www.nibs.org/?page=bsa_cobieguide

Penn State Computer Integrated Construction
"BIM Execution Planning Guide": bim.psu.edu

RICS (Royal Institution of Chartered Surveyors):
www.rics.org/us/knowledge/bcis/about-bcis/forms-and-documents/bim-downloads/

Singapore, Building Design and Construction
Authority, BIM Guide: www.corenet.gov.sg/integrated_submission/bim/BIM/Singapore%20BIM%20Guide_V2.pdf

U.S. General Services Administration, Building
Information Modeling: www.gsa.gov/bim

US National BIM Standard:
www.nationalbimstandard.org

■ Design and Construction Intelligence

SmartMarket Report

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