World Economic Forum

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Shaping the Future of Construction

# An Action Plan to Accelerate Building Information Modeling (BIM) Adoption

In collaboration with The Boston Consulting Group

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# Executive summary

To keep pace with innovation and be more productive, the infrastructure and urban development (IU) industry must embrace digitalization. Building information modeling (BIM) is an important first step towards that. BIM is a collaborative process in which all parties involved in a project use three-dimensional design applications, which can include additional information about assets' scheduling, cost, sustainability, operations and maintenance to ensure information is shared accurately and consistently throughout total assets' lifecycles. BIM acts as the centrepiece of the industry's digital transformation. It powers new technologies such as prefabrication, automated equipment and mobile applications for team collaboration. It also enables new services, and helps determine which new assets best complement existing built environments.

BIM adoption has been slow, despite its many advantages. Only about one-third of IU companies describe themselves as using at least BIM Level 2.[1] Design and engineering firms have been among the earliest adopters, followed by construction firms. BIM has great potential to transform operations and maintenance (O&M), but adoption by asset operators lags behind other players, largely because the technology is inaccurately perceived as a purely 3D design application. Furthermore, commercial BIM applications to support O&M remain scarce. Other deterrents include a lack of clear benchmarks to determine return on investment (ROI), substantial start-up costs, which can deter design firms and other stakeholders working at the beginning of projects to use BIM, and limited use of cost- and benefit-sharing agreements.

To identify actions that could facilitate faster BIM adoption, the World Economic Forum's Future of Construction Initiative – in collaboration with The Boston Consulting Group, the Government of the United Kingdom, and Atkins and Arup – hosted the "Accelerating BIM Adoption" roundtable on 17 October 2017 in London. Among the participants were 35 representatives from leading global design, engineering and construction firms, asset operators, industry associations, governments and academia who convened to create the action plan outlined in this report.

Providing players in the IU value chain with the right motivation and understanding of BIM's benefits could serve as a foundation for faster adoption. It would also help highlight BIM's potential as a value creator rather than a cost factor. In addition to the financial benefits, players must understand BIM's strategic role as an essential first step to industry digitalization.

Successful BIM adoption requires a high level of collaboration among stakeholders. Steps toward that include increased use of integrated contracts and open standards for data sharing. Adoption also requires a coordinated effort to attract new talent with digital and BIM skills, upskill existing workers, and changing corporate cultures to support new processes. As major owners of built assets, governments must make a long-term commitment to the technology by piloting it in public works projects and creating regulations conducive to its acceptance, including backing innovative forms of financing.

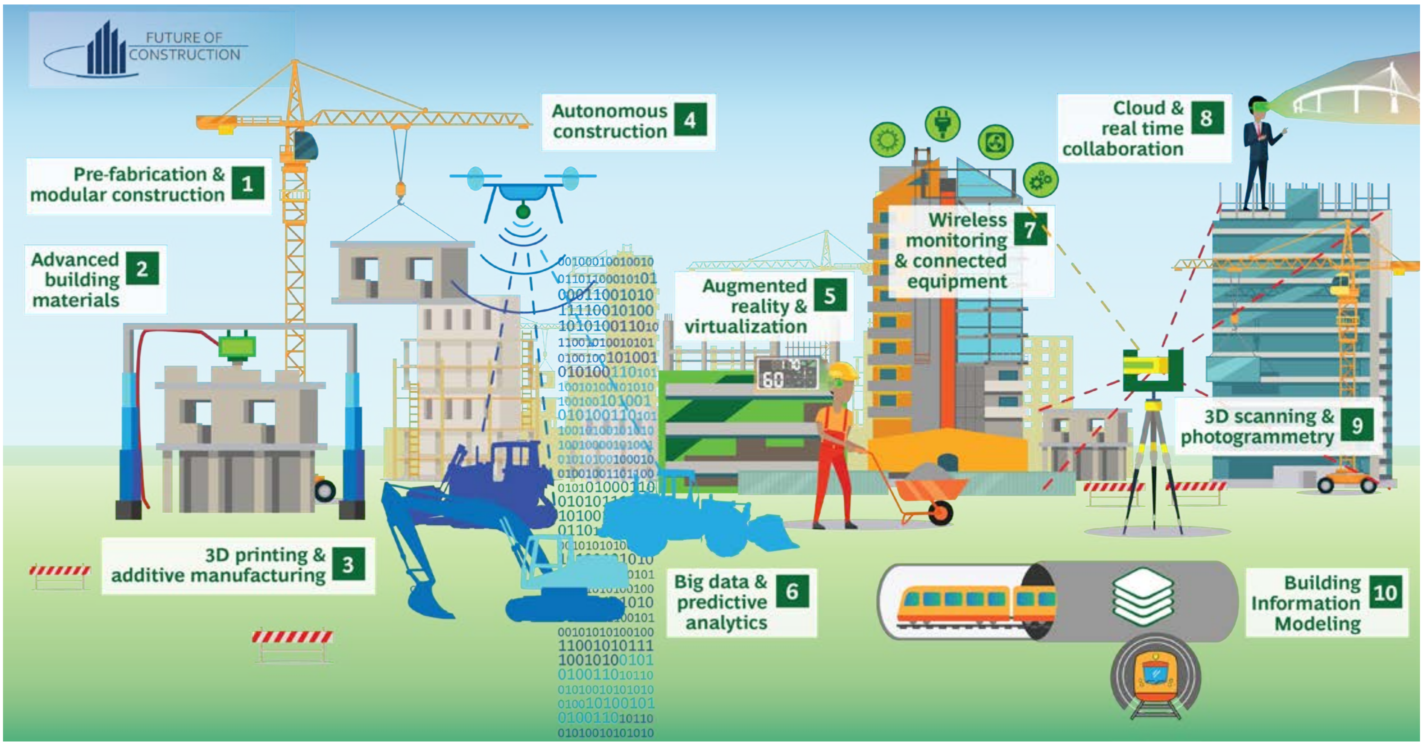
[1] BIM Survey 2015 Results, Conject, 2015

# Introduction

The IU industry[2] is an integral part of the global economy. Engineering and construction (E&C) activities (the core part of the industry) generate approximately $10 trillion in annual revenue, which equates to about 6% of global GDP. In recent years, however, the industry has failed to keep up with productivity gains made in other industries, hampering national economies' wider growth. Digitalization has the potential to change this situation. Connected sensors, intelligent construction equipment, mobile devices and software applications could boost productivity, manage complexity, reduce project delays and cost overruns, and enhance safety and quality. Within 10 years, full-scale digitalization could help the industry save an estimated 12% to 20%, equal to $1 trillion to $1.7 trillion annually, according to The Boston Consulting Group.[3]

The following graphic shows some of the most promising digital technologies for improving productivity in the industry (see Illustration 1).

**Illustration 1:** 10 Technologies that Can Improve IU Industry Productivity




Source: World Economic Forum, The Boston Consulting Group

Most of these technologies require accurate, consistent data from different project stakeholders. BIM systems that allow stakeholders to produce, collect, store and share asset information can provide the data. As the successor to traditional computer-aided design (3D CAD), BIM stores and provides 3D object data. It also can include shared information on scheduling (4D), cost (5D), sustainability (6D) and operations and maintenance (O&M) (7D).

Modern prefabrication, for example, relies on accurate information from BIM models to produce 3D objects and scheduling data that allow for accurate production and just-in-time delivery of modules from factories to construction sites. Beyond supporting new technologies, BIM optimizes and automates asset design, supports scenario testing and decision-making, verifies constructability, enables clash analysis, improves project and investment planning, ensures project control and stores information for preventive maintenance, among other functions.

[2] Engineering and construction (E&C) represent the core of the infrastructure and urban development (IU) industry, but it also includes all other parts of the built environment value chain, from provision of building materials to asset operation and maintenance (O&M) as well as real estate and urban services.

[3] The Transformation Power of Building Information Modeling, The Boston Consulting Group, 2016

Through these functions, BIM can reduce the design phase of a construction project by 30% and its design cost by 8%, according to a University of Maryland study.[4] According to the same study, BIM can cut 10% from a project's construction phase and 3% from the construction cost. In addition, BIM enables new services and can help determine which new assets best complement existing built environments.

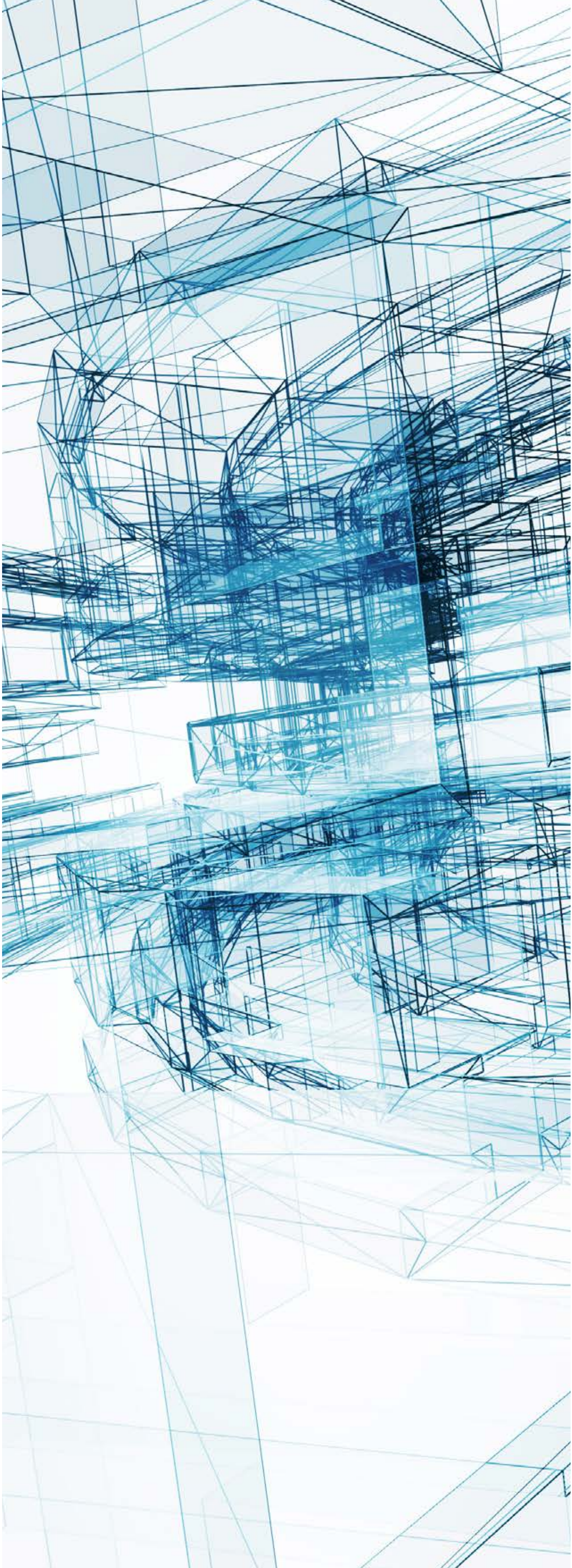
Many industry players have yet to fully adopt BIM, despite its advantages. Design and engineering firms lead the way, followed by construction firms. Even though BIM could significantly transform O&M, asset operators lag behind other industry players, mainly because BIM is still inaccurately perceived as being a purely 3D design application, and because commercial BIM applications to support O&M remain scarce. O&M applications account for just 10 of 206 commercial applications listed in an industry database of open-source BIM applications.[5]

Slow adoption rates means few organizations are using the most sophisticated versions of the technology. In the UK, for example, BIM is classified by level of maturity. In BIM Levels 0 and 1, little or no collaboration exists between parties working on a project; data is presented as 2D or 3D CAD drawings and information is shared via email or on paper. At BIM Level 2, stakeholders use 3D CAD, exchange information in common file formats and share data electronically through a centralized information management system called a Common Data Environment (CDE). At BIM Level 3, also known as BIM in the cloud, all parties collaborate through digitally shared space.

BIM adoption varies greatly by country and level of economic development.[6] In more advanced economies, most firms use BIM, though not on all projects and not at the highest levels. A mandate to use BIM on government-sponsored projects has made the UK frontrunner. Even so, only 46% of the country's IU companies describe themselves as using BIM Level 2. In Germany, where BIM use is not yet fully mandated, just 25% of IU companies use BIM Level 2. In emerging and developing countries, adoption rates are even lower.[7]

To improve productivity, the IU industry must accelerate BIM adoption. Towards that end, governors of the World Economic Forum's Future of Construction Initiative have prioritized BIM adoption as a critical step toward transforming the industry.

This report summarizes the key insights and recommended actions that were made at the October 2017 roundtable in London. It highlights the recommended actions that companies, industry organizations and governments are advised to implement to accelerate BIM adoption and better capitalize on what the technology can offer.



[4] Estimating the Impact of BIM Utilization on Building Project Performance, University of Maryland, 2012

[5] BIM application list, buildingSMART, January 2018

[6] Scotland Global BIM Study, Scottish Futures Trust and dotBuilt Environment, July 2016

[7] BIM Survey 2015 Results, Conject, 2015

# Key insights and recommended actions

Increasing BIM adoption requires greater collaboration and that stakeholders be motivated and given the right capabilities (see Illustration 2). Industry stakeholders must understand how BIM benefits them, adds value rather than cost, and is the necessary first step towards industry digitalization. Adoption requires better teamwork through using integrated contracts, new forms of collaboration and open data-sharing standards to bypass the limitations posed by proprietary software. It also requires helping workers develop new skills, and changing behaviours to support new processes. At the government level, it requires a long-term commitment and innovative financing to get the technology into the hands of stakeholders who need it. Specific steps are further delineated in 27 actions listed in the Appendix (see Table 1) and described in more detail in the rest of the report.

**Illustration 2:** BIM Adoption Circle


## 2.1 Set the right motivation for BIM adoption

### 2.1.1 Articulate BIM's benefits across the entire lifecycle

Although BIM can help stakeholders improve quality and reduce costs throughout a built asset's lifecycle, it is still seen primarily as a 3D design application, and commercial BIM applications to support O&M remain scarce. As a result, BIM is used mainly in design and engineering, less in construction and even less so in O&M. That is unfortunate because O&M stands to gain the most from adopting BIM given that those functions span the longest period of a built asset's life and offer the greatest potential for cost savings and additional revenue. For example, in the UK, capital expenditures (CAPEX) for planning, design, engineering and building assets amount to £89 billion annually while operational expenditures (OPEX) for O&M run to £122 billion.[8]

[8] Moving from BIM to a Digital Economy in infrastructure and city programmes, Digital Built Britain, 2017

To reap BIM's full potential, asset operators and service providers should develop and pilot use cases that include BIM 6D and 7D applications (Action 1). For example, analysing 6D BIM information on energy use could reveal ways to curb consumption. Similarly, O&M staff could use 7D BIM data to check the status of components and schedule preventive maintenance. Architects and engineers working on a new asset's design should use BIM data to optimize design regarding O&M costs (Action 2).

If asset operators and service providers use BIM, it would create a technology pull that would force stakeholders in earlier phases of an asset's lifecycle to use it, just as BIM models for O&M must be created when an asset is designed. As major owners and operators of built assets, governments can play a leading role by using BIM in O&M for public assets, including using pilot projects to demonstrate its benefits (Action 3).

Stockholm's New Karolinska Solna Hospital (NKS) is an example of a public-private partnership (PPP) using BIM in O&M. The hospital's BIM system supports predictive maintenance by offering instant access to relevant data about objects such as elevators, including data on location, installation and use. Repair manuals and information identifying spare parts and remedial procedures ensure that maintenance crews respond faster and more efficiently when equipment fails. A 3D representation of the building makes cleaning and other daily operations more efficient.

### 2.1.2 Think of BIM as a value creator, not as a cost factor

Initial BIM costs can be substantial because of the investment needed in software, technology infrastructure, consultants and training. Organizations also incur project-specific costs for setting up BIM models and changing workflows and team processes. However, companies seeking to estimate BIM's financial benefits often find limited information. This lack of detailed cost-benefit analysis may lead some to opt against making the investment.

To combat this problem, companies and industry associations must create benchmarks against which BIM costs and benefits can be measured (Action 4). Ideally, these benchmarks would be published as anonymized data other industry stakeholders could use. Companies should also create pilot projects that allocate BIM costs and savings separately from other financial data to create transparency (Action 5). Companies can pool their experiences with pilot projects to develop industry standards for calculating BIM ROI (Action 6). Governments can publish pilot project-based BIM ROI assessments to convince other stakeholders of the technology's benefits (Action 7).

Comprehensive ROI assessments should consider that BIM's value goes beyond reducing project costs. The technology also reduces risk, enhances product quality and accelerates delivery. Ultimately, BIM will be a strategic imperative for the IU industry, similar to the way in which it has become standard in the oil and gas industry, where companies recognize using it is necessary to remain competitive.

### 2.1.3 Approach BIM as the essential first step to IU digitalization

Autonomous equipment, wireless monitoring and other digital technologies need the platform that BIM provides for stakeholders to store, manage and share information. If the IU industry is slow to adopt BIM, it could impede adoption of other digital technologies. Companies must take a comprehensive approach to digitalization starting with implementing BIM as a platform to ensure successful and sustainable adoption of related applications (Action 8). Research and development (R&D) to improve interfaces between BIM and other digital technologies would accelerate the adoption of both.

BIM applications generally model a single asset. BIM is even more valuable when multiple assets are modelled together to form a comprehensive digitized built environment. So-called "digital twins" of entire systems, such as transport or healthcare systems, could improve their planning, construction and operation. In particular, digitized built environments could help determine which new assets would best complement existing built environments.

A fully digitized built environment could have an even greater impact, namely optimizing all services based on the built environment. In the UK, the cost of providing Advanced Urban Services (AUS) such as energy, waste and water management or urban security and safety, equals approximately £597 billion annually.[9]

To realize the benefits of digitized built environments, governments need to coordinate with the industry to develop BIM standards and specifications so models of single assets can be incorporated into comprehensive digitized infrastructure systems and cities (Action 9). Governments must create central "digital twin" models of the built environment and use them for simulations to optimize strategic and financial planning (Action 10).

[9] Moving from BIM to a Digital Economy in infrastructure and city programmes, Digital Built Britain, 2017

# 2.2 Enhance collaboration on projects

## 2.2.1 Use integrated contracts and redefine risk-return mechanisms

BIM costs and benefits are not equally distributed over a project's lifecycle. The bulk of the cost of creating BIM models happens during design and engineering, while most of the benefits occur in the downstream phases of the value chain. As a result, stakeholders working on the early phases of a project may lack the incentive to set up BIM models. In addition, upstream players often have exclusive access to project information to cover risks via claims. As such, they may lack motivation to participate in projects where BIM models make that information more transparent.

To correct the situation, BIM costs and benefits must be distributed more equitably. One option for doing that is using integrated contracts to line up stakeholders' financial interests for all project activities and redefine risk-return mechanisms.

The IU industry commonly uses design bid build (D/B/B) contracts, in which a project owner maintains separate contracts with individual stakeholders for design, engineering and construction, with little coordination between stakeholders. As a result, projects with D/B/B contracts are likely to realize only incremental benefits from adopting BIM.

In integrated contracts, owners enter into a single agreement for design, engineering, construction and possibly O&M services, making the success of each dependent on the others' contributions. Integrated contracts increase incentives for using BIM since the technology benefits the entire project even if those benefits vary across different project phases. One type of integrated contract is a design build (DB) contract. In it, a project owner either enters into a contract with with a single designer-builder or pursues a joint venture between a designer and a contractor to provide both services. Another type of integrated contract is the integrated project delivery (IPD) contract. In it, a single contract covers an entire project team, including the architect, general contractor, engineers, fabricators, subcontractors and asset operators. In public private partnerships (PPP), in the form of design build finance maintain operate (DBFMO), the contracting parties take over the separate tasks associated with the asset for a set number of years. This provides the contracting parties with a vested interest in setting up a BIM model at the beginning to save costs and reduce risks throughout an asset's lifecycle.

For any type of integrated contract, stakeholders who bear the cost of setting up BIM models reap some of the benefits and consequently have more incentives to adopt it. At the same time, including BIM allows downstream players to develop new competences.[10] Governments should use their power as the industry's largest client to increase projects that use DB, IPD, PPP and other integrated contracts (Action 11).

Project owners typically take more than BIM into consideration when choosing the best contract for a building project. However, increasing the number of projects with integrated contracts would promote BIM adoption.

## 2.2.2 Set up early collaboration and communication among stakeholders

To ensure BIM models cover a built asset's lifecycle, requirements for all phases must be identified when models are created at the beginning of a project. This coordination requires collaboration and open communication between stakeholders. That is not always easy given the construction industry's highly disintegrated value chain, in which players often focus exclusively on the scope of their own work without considering how it affects other stakeholders. In large projects, coordinating multiple stakeholders can be particularly challenging. Without proper collaboration and communication, BIM models may lack essential data and functions that stakeholders need to perform their work. For example, if a built asset is meant to have sensor-based smart-facility management, a sensor integration plan should be mapped out and built into the BIM model in the project's design phase. Companies must revise their corporate cultures, organizational structures and processes to allow for more comprehensive and efficient collaboration (Action 12).

Formal mechanisms would support stakeholder collaboration. An example of such a mechanism is the UK government's Construction Industry Council (CIC) BIM Protocol, a standardized supplementary legal agreement for common construction contracts.[11] The protocol requires deliverables to be created for specific project stages and outlines stakeholders' BIM-related obligations, liabilities and limitations. It also introduces two key project elements. The first is a model production and delivery table, which shows who is responsible for preparing the data and details that BIM models must incorporate at each project stage. The second element is a call for projects to include an information manager to implement the BIM protocol, including keeping the model production and delivery table updated. Additionally, the information manager oversees information exchange processes and procedures, creates and implements a project and asset information plan, and prepares data drops and other project output.

By paving the way for better BIM collaboration, the CIC BIM Protocol could serve as a blueprint for other countries. As the document is purposely generic, it is expected that further developments of formal mechanisms to support stakeholder collaboration include additional detail. Governments should tailor BIM collaboration procedures to their own legal environments and use pilot projects to demonstrate related benefits (Action 13). Ideally, procedures should be harmonized across jurisdictions.

[10] Alignment of Partnering with Construction IT, Delft University of Technology, 2016

[11] CIC BIM Protocol, UK Construction Industry Council (.pdf download)

Even without protocols or other formal structures, stakeholders can still collaborate successfully, as demonstrated by the project team behind The Edge office building in Amsterdam. Early stakeholder engagement is one reason The Edge was hailed as the most connected and sustainable smart building in the world when it opened in 2015.[12] Among the building's many innovations are 28,000 embedded sensors, which enable smart facility management. As a result, cleaners can see which areas are used the most and require cleaning or where to refill paper towel dispensers before they run out. The same system monitors LED lights to predict when bulbs should be changed. The internet of things (IoT) integration was created early in the building's design, and collaboration between designers, engineers, suppliers and other stakeholders led to its success. "We integrated the solutions on the silicon level instead of just gluing technologies together," said Erik Ubels, Chief Technology Officer for building developer, OVG.

### 2.2.3 Establish data-sharing standards and open systems

To work as intended, BIM applications need data on design, costs, schedules, sustainability and O&M. However, inconsistent conventions for generating data as well as closed systems, lack of data exchange standards and concerns about stakeholders' intellectual property (IP) create inefficiencies and make processes difficult to repeat or link. Global conventions for generating and sharing data along with data marketplaces and clear IP regulations could overcome these hurdles.

Differing conventions for data generation undermine the consistency essential for proper BIM applications. For example, methods used to calculate the area of floor space in identical buildings varies considerably between countries, and sometimes within countries, owing to different measurement conventions. It is necessary that agreement is found in global conventions, mapping processes and approaches to generate the consistent data needed for BIM models. One such global data generation convention is the International Property Measurement Standard (IPMS).[13] Alongside this, IU companies should support work from institutions like the Royal Institution of Chartered Surveyors (RICS) to develop global conventions for data generation and apply them accordingly (Action 14).

Examples outside the IU industry show that data-sharing standards are an effective way to increase efficiency and interoperability when they are developed from the bottom up. One example is the World Wide Web Consortium (W3C), a group of 430 organizations that develops web standards. IU companies should support similar bottom-up consortia to standardize BIM data exchange (Action 15). One such consortium exists – buildingSMART, which developed the Industry Foundation Class (IFC), the only open (non-proprietary) BIM data exchange standard – but more needs to be done.

[12] The Smartest Building in the World, Bloomberg, September 2015
[13] International Property Measurement Standards, RICS, January 2018

To improve data sharing, IU companies should also support emerging data marketplaces (Action 16). Data marketplaces provide digitized building objects, which designers and engineers can reuse to improve productivity. Such marketplaces also offer sensor-generated data from existing assets, which can be used to optimize the design of new assets. For data marketplaces to succeed, both supply- and demand-side stakeholders must use them. Marketplaces also represent an opportunity for IU companies to bring in new revenue from trading data or selling physical products and services connected to the data. The NBS National BIM Library is an example of such a data marketplace. Objects sold on it meet internationally-recognized BIM standards requirements. Manufacturers promote and deliver products on it directly into digital processes, enabling planners to choose their products.

To address concerns about potential IP losses that could undermine BIM adoption, governments should develop regulations to protect BIM IP and data ownership (Action 17). As an example, the UK's CIC BIM Protocol clarifies IP use in BIM models. Within the guidelines of the protocol, project stakeholders can use BIM model data under a permitted purpose licence. Stakeholders may use BIM data only in ways that are consistent with the applicable level of detail and purpose for which the model was prepared. Permitted purpose licences further stipulate that the information provider retains all rights, and if the owner seeks to acquire IP rights, the contract supplement must be revised.

## 2.3 Enable all stakeholders

### 2.3.1 Establish BIM skills along the full value chain

A lack of employees with sufficient BIM skills both within the IU industry and among its clients is slowing BIM adoption. BIM skills are core capabilities in a digitalized construction industry, and as a result, they cannot be outsourced to third parties. Organizations have three options for increasing their BIM talent pool: hiring new talent with the required skills, upskilling the existing workforce, and simplifying BIM technology and processes to reduce required skills.

Education must be reformed to provide prospective employees with necessary BIM skills as well as the interdisciplinary skills required for BIM collaboration. Courses should teach students tangible, applicable BIM knowledge through practical, hands-on training. Universities, vocational and professional training providers should integrate BIM into general design and engineering classes rather than offer courses as electives or add-ons (Action 18).

Upskilling the existing workforce can be done on the job or in the classroom. In either case, IU companies and industry associations should work with professional providers and academia to develop upskilling courses (Action 19). Companies should institute a broad set of internal upskilling programmes (Action 20). Some of those could include train-the-trainer programmes, job rotations and (reverse) mentorships.

To mitigate the need for education and upskilling, BIM technology needs to become more user-friendly so it can be used by a range of workers who lack specialized skills or devices. BIM software developers could take advantage of the pervasiveness of mobile devices, tablets and laptops to create applications that workers without special skills could use. Software vendors should also develop BIM software with easy-to-use interfaces (Action 21).

Additionally, project owners lack sufficient workers with BIM skills. This could result in proposals that do not include BIM, or if they do, requests for proposals (RFPs) that have poorly conceived or unrealistic requirements, again undermining BIM adoption. As the IU industry's largest client, government agencies could remedy this by incorporating BIM skills training in public engineering, procurement and O&M organizations (Action 22).

### 2.3.2 Change behaviours and processes, not just technology

Adopting BIM is often seen as exclusively a technology investment, but that ignores crucial human and cultural aspects of the process. Consequently, technical departments often direct BIM implementation without considering what behaviour and cultural changes might be needed. It also means executives often lack sufficient commitment, project managers and other key actors are not involved, and processes are not readily adapted.

Adopting BIM without considering the human element will, however, lead to widespread resistance. If individuals do not to see how BIM adds value to their jobs or careers, they could be reluctant to adopt new skills and instead maintain their existing work habits. Risk-adverse corporate cultures can exacerbate this resistance. This type of attitude can be seen in project managers who use concerns about potential risks as an excuse to avoid implementing new technology.

To deal with potential resistance, companies should adopt BIM as part of a comprehensive change management programme (Action 23). Such a programme should explain BIM's value to employees and the potential risks in not using it. It should include training in required skills (as described in the section above). As part of a change management programme, organizations should commit to creating environments where mistakes and failures are tolerated while people establish new ways of working. Furthermore, a comprehensive programme should lead to revised organizational structures and cultures, key performance indicators (KPIs) and incentives. Organizations should use high-profile role models to highlight BIM's benefits and promote the programme, and reward employees who adopt BIM-related practices.

In many organizations, information is perceived as something to be hoarded instead of shared, but that behaviour could further impede BIM adoption. A comprehensive change management programme coupled with knowledge management practices should encourage employees to collaborate and share information within and beyond their own walls.

To make sure adoption is successful, companies might also assess whether certain internal processes need to be adjusted before they implement BIM. For example, companies should streamline a supplier base that is too large before establishing BIM-based data exchange processes. Companies adopting BIM should use the opportunity to streamline processes (Action 24).

### 2.3.3 Make a long-term commitment and support innovative financing

As with other digital technologies, BIM relies on the network effect, i.e. its value increases as its user base grows. Adoption, however, requires substantial investments. Two factors increase the probability that a company will earn back its investment: Assurances that demand for BIM will last, and lowering the required upfront investment.

To assure companies of future demand, governments and other large IU industry clients must make a long-term commitment to include BIM in projects (Action 25). Commitments should be supported by clear plans that include BIM targets, and requirements for public procurement organizations. To ensure BIM adoption is successful without overburdening companies, BIM requirements should be phased in over time. Germany was relatively late introducing BIM mandates, but the country's Digital Roadmap for Design and Construction Initiative is an example of how public projects can include progressively higher BIM requirements. Launched in 2015, the initiative requires all new German federal transportation infrastructure projects to apply BIM by 2020.[14] The five-year phase was stipulated specifically to make adopting BIM easier for the many small and medium-sized enterprises (SMEs) in the country's construction industry.

Innovative business models could also supporter greater BIM adoption. One potential business model is BIM-as-a-service, where users pay for the technology on a per-use basis and upfront technology investments are smaller. Software vendors should offer BIM-as-a-service, develop low-budget versions of BIM with fewer features, and create other innovative business models (Action 26).

Innovative financing could also spur adoption. New financing models could allow private investors to fund companies' BIM investments in exchange for sharing in future BIM benefits. Governments need to create a regulatory framework for private investors to fund BIM projects (Action 27).

[14] Road Map for Digital Design and Construction, Federal Ministry of Transport and Digital Infrastructure Germany, 2015

# Conclusion

The IU industry must adopt BIM to be more productive and as an important first step toward the digitalization of the industry, but it will only happen if all players in the value chain act and collaborate. Actions that stakeholders can take to promote BIM are summarized in the Action Implementation Matrix (see Appendix, Table 1). Companies can act individually, but should team up on industry-wide efforts through existing associations, new initiatives and other partnerships. As regulators and the IU industry's single largest clients, governments play a significant part in promoting BIM. They can accelerate adoption by mandating it in projects, bringing other stakeholders onto pilot projects, promoting training, and establishing financial and other incentives.

BIM will only succeed if stakeholders work together towards a joint vision through a common plan. Doing so will allow society to enjoy BIM's many benefits, including more affordable infrastructure and housing, safer and more predictable project delivery, a more sustainable and resilient built environment, and higher-quality service delivery for end users.

# Appendix

**Table 1:** Action Implementation Matrix

| | | Companies | Industry Groups | Government |
|---|---|---|---|---|
| Motivation | Articulate BIM's benefits across the entire lifecycle | | | |
| | A1) Develop and pilot use cases that include BIM 6D and 7D applications | X | | |
| | A2) Leverage BIM data to optimize design regarding O&M costs | X | | |
| | A3) Use BIM in O&M for public assets and demonstrate benefits in pilot projects | | | X |
| | Think of BIM as a value creator, not as a cost factor | | | |
| | A4) Develop benchmarks against which BIM costs and benefits can be measured | X | X | |
| | A5) Allocate BIM costs and savings separately from other financial data to increase transparency | X | | |
| | A6) Develop an industry standard for calculating BIM ROI | X | X | |
| | A7) Publish BIM ROI assessments of pilot projects | | | X |
| | Approach BIM as the essential first step to IU digitalization | | | |
| | A8) Implement BIM as platform to store, manage and share data required by new technologies | X | | |
| | A9) Develop BIM standards and specifications for digitized built environments | | | X |
| | A10) Build up digitized built environments and use them for financial planning | | | X |
| Collaboration | Use integrated contracts and redefine risk-return mechanisms | | | |
| | A11) Increase the share of projects that use integrated contracts | | | X |
| | Set up early collaboration and communication among stakeholders | | | |
| | A12) Revise corporate cultures, structures and processes for more comprehensive collaborations | X | | |
| | A13) Develop BIM collaboration procedures (e.g. CIC BIM Protocol) | | | X |
| | Establish data-sharing standards and open systems | | | |
| | A14) Support developing global conventions for data generation | X | X | |
| | A15) Support bottom-up consortia to standardize BIM data exchange | X | X | |
| | A16) Support emerging data marketplaces | X | | |
| | A17) Develop regulations to protect BIM IP and data ownership | | | X |
| Enablement | Establish BIM skills along the full value chain | | | |
| | A18) Integrate BIM into general design and engineering classes | | | X |
| | A19) Create upskilling courses with professional education providers | X | X | |
| | A20) Institute a broad set of upskilling programmes (e.g. job rotation, mentorships etc.) | X | | |
| | A21) Develop simple BIM software that emphasizes usability | X | | |
| | A22) Incorporate BIM skills training in public engineering, procurement and O&M organizations | | | X |
| | Change behaviours and processes, not just technology | | | |
| | A23) Adopt BIM as part of a comprehensive change management programme | X | | |
| | A24) Streamline processes before adopting BIM | X | | |
| | Make a long-term commitment and support innovative financing | | | |
| | A25) Make a long-term commitment to include BIM in projects | | | X |
| | A26) Create innovative BIM business and financing models (e.g. BIM-as-a-service, low budget BIM) | X | | |
| | A27) Create a regulatory framework for private-investor BIM funding | | | X |

# Roundtable participants

A total of 35 individuals from 22 organizations participated in the roundtable "Accelerating BIM Adoption" held in London on 17 October 2017.

### Organizers

Arup
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Consolidated Contractors Company
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Digital Built Britain
DIRTT Environmental Solutions
Imperial College London
Office for Nuclear Regulation
OVG Real Estate
PLP Architecture
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