THE ULTIMATE GUIDE TO BIM IN 2020

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Everything you need to know about BIM (Building Information Modelling) to bring your designs into the 21st century

If you want to understand Building Information Modelling (BIM), you have come to the right place. BIM is not quite as complicated as it seems, but it is becoming more important. Effectively a technology, technique and process combined into one small abbreviation; BIM is poised to disrupt any number of professions that handle mapping and planning in physical space — construction, renovations, project management, manufacturing and more.

Delivering efficiency increases, enhanced coordination and improved outcomes; construction teams, engineers, architects, interior designers, product managers, building managers and many more stakeholders need to come to terms with BIM. This is your guide to mastering BIM — allowing you to invest in the best technology, update your processes and find the right partners to deliver transformational improvements to your business.

What is BIM (Building Information Modelling)?

BIM is delivering construction and design coordination improvements, quality assurances and cost savings. But, before learning how you can benefit from BIM, you need to understand BIM — something that is easier said than done.

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BIM design 101

In 2002, Autodesk popularised the term 'Building Information Modeling' to a wide audience in a white paper to define their strategy towards the building industry for their products. This was further aided by their acquisition of the parametric modelling software package Revit in the same year. However, it is important to note that the creation of this phrase was not an immaculate conception on Autodesk's part and came on the back of the development of previous phrasings used throughout the 1990s in architectural academic research.

As a transformation process, BIM is rooted in two things: the inclusion of functional design characteristics in structural 3D modelling and a 'database-first' approach to these models. Of the two, the database aspect is more unique to BIM specifically, but both are critical to the utility of the platform as a holistic design engine and solution.

Why you need to understand BIM

Historically, computer-aided designs (CADs) have simply been digital versions of the previously existing physical plans used by architects, designers, engineers and construction teams. These digital versions are more easily shared, edited and duplicated. However, fundamentally, they are 'graphics-first' plans.

This means that although all of the 'information' about a plan may be 'digital', it is frozen in the format in which it was created. Data represented graphically is effectively just a digital drawing. This is a vastly inefficient way to approach construction because different teams need to access the structural and design information of a project in different ways, often at different times across a project timeline.

Architects often want 'drawings' — plans, sections and elevations. Structural engineers want framing and bracing diagrams. Builders need isometric views of building geometry. Interior designers want to use 3D models. When approached using traditional physical plans or standard CADs, the issue is the same — each graphically represented plan has to be created individually using the original architectural schematics as a guide. Then, any changes made must be propagated across every file manually before being cross-checked for accuracy.

Not only is this time-consuming and laborious (creating a barrier to the practicality of, and interest in, cross-disciplinary collaboration), inconsistencies that remain during the design phase can be incorporated into the planning of particular specialist components. This creates huge challenges — even if these issues are identified prior to construction!

Fundamentally, design is an iterative process that includes many areas of specialisation. Best results are only achieved when input can be made fluidly by any number of people. Keeping track of edits and maintaining a single-source-of-truth using many different 'graphics-first' designs is a huge challenge, and one that currently dominates much of the logistical attention of design processes.

Why BIM is important: single-source-of-truth productivity
BIM resolves these issues by turning the whole process on its head. Rather than being rooted in graphical representations, BIM starts with the information about the building and then presents that data graphically. The structural and design inputs can be made through a graphical interface. The information is stored separately but can be generated in any number of formats.logistical attention of design processes.

How BIM improves communication
'Database-first' modelling means that although designers, architects, construction teams and engineers can access and edit building information in their familiar graphical formats, they are no longer each accessing their own specific files. Rather, all of these files are different representations and aspects of a single dataset. When edits are made, those changes are automatically propagated throughout all of the documentation. This greatly improves collaboration, allowing for superior efficiency, increased quality control and better planning.

"BIM resolves these issues by turning the whole process on its head."

What are BIM objects?

The other half of BIM's revolutionary contribution to design and construction is the inclusion of functional and auxiliary characteristics of a building within the single design platform. This capability is broadly summarised in the term 'BIM object'. Generically, a BIM object is any aspect of a building that is not part of its structural characteristics. BIM objects are subdivided across two types: component and layered objects.

Component objects: have fixed geometric shapes. This could include windows, doors, boilers, piping, air ducts, electrical work etc.

Layered objects: do not have fixed shapes or sizes and include most design features such as carpets, roofing, walls and ceilings.

From a practical standpoint, BIM objects are further subdivided between generic and specific objects. Generic objects are contained within object libraries common to most BIM software and are used during the initial design phase as placeholders. Specific objects (sometimes called manufactured objects) are those that mirror the specific shape, size and capabilities of the end products that are set to be installed. These are generally created for every given project individually.

There are a number of international standards for BIM objects, notably the NBS BIM Object Standard, published in 2014. However, objects often become very specialised to the context in which they are being deployed.

What information is contained in a BIM object?
BIM objects contain whatever information designers input into the system. This means that BIM objects are as useful and as reflective of the final product as you want to make them. They can be made to directly mirror the dimensions, functionality and even ongoing operational costs of any objects to be installed within the building. They can also be approached as placeholders.

The detailed use of objects improves the construction process, allowing installation teams access to the location of every element. Where BIM objects really shine, however, is across the lifecycle of a building. Only 10%-20% of the total cost of a building will be expended during construction. The remainder goes towards maintenance. By having easily accessible and detailed information about functional assets within a structure, building managers are able to complete their jobs more efficiently, which helps to substantially depreciate the total cost of operating a building over time.

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Are BIM objects actually new?

In short, no. The ability to include non-graphical/ functional characteristics within designs has been around for a while, especially in line manufacturing. Product modelling was developed as a reaction to demand for higher quality and lower cost manufactured products produced in a shorter time against a backdrop of increasing computerisation.

Product modelling is the natural evolution of some of the ideals set out in the MIT technical reports on early CAD development around 1960. These ideals included the concepts of the geometric drawing being refined and guided by computed constraints and simulation analysis on shared data. The initial concepts of product modelling were developed across the late 1980s with the rise of Computer Integrated Manufacture (CIM) and advanced computer methods that could add significant information to geometry workflows, such as computer simulation, to supplement the lifecycle theory that had been in use since the 1970s. Product modelling is a central part of product development in manufacturing and serves as a repository of all data about a product to serve various activities in the products lifecycle by homogenising "islands of information" that existed - a definition which bears a strong similarity with many BIM descriptions.

Traditionally, this technology in AEC has been called 'object-oriented' CAD. With architectural drawings, this information was included as simple metadata notes. Construction teams and building managers alike have access to forms of this type of information regardless of their access to 3D models or interoperable communication abilities.

BIM objects are set apart by the level of detail that can be included, and (more importantly) by their rooting in database/non-graphical storage. By including an object within a BIM file, that information is translated across all documentation associated with the project, while also being viewable in isolation. The increased level of detail, greater flexibility and improved communication is what really defines BIM. The ability to store and access BIM object information has simply grown out of older forms of graphics-first designs. The utility of object information, however, has advanced in accordance with the collaborative and efficiency improvements that BIM delivers to the entire system.

What are BIM deliverables? BIM deliverable

s are simply the different formats in which BIM data can be accessed. Due to the fact that the information is stored in a structured way, the data can effectively be generated in a format that is supported by the designated system. Therefore, BIM deliverables include all of the different ways in which data within a BIM model or Common Data Environment (CDE) can be accessed, viewed and/or edited. What this actually means will be specific to the information you have included within your BIM model and the software you have available. Some of the most common BIM deliverables are:

- 3D models
- 3D validation models
- 3D model take-off
- 3D digital survey models
- BIM models maintenance
- 2D CAD drafting
- 2D CAD drawing from a 3D BIM model
- 4D/5D modelling
- PDF plan drawings
- Schedules
- Room numbering diagrams
- Colour filled diagrams
- Bracing diagrams
- Isometric building plans
- Spool drawings
- Employers Information Requirements (EIR)
- Project Information Requirements (PIR)
- Clash prevention
- Clash detection reports
- Visualisations: renders and animations
- Virtual tours: walkthroughs, fly-throughs
- BIM Execution plan (BEP)
- BS (PAS) 1192 — Parts 1 to 5 or BS ISO 19650
- Classifications
- Digital Plan of Work (describing level of detail — LoD/CIC Work Stages)
- Intelligent 3D libraries
- Asset performance optimisation
- COBie (Construction Operations Building Information Exchange)

What is scan-to-BIM? (point cloud to BIM)

Although BIM is primarily thought of as a design-first technology and process for new build, this is not strictly true. There is a growing use case for the development of post hoc BIM style schematics for existing assets, or using reality capture technology to inform the foundations of an as-built BIM dataset.

Scan-to-BIM is achieved by using 3D laser scanners on location to build an exact point cloud dataset and model. Although several different scanning technologies can be employed, this is most often completed using LiDAR (Light Detection and Ranging) techniques and technology. Terrestrial laser scanners use LiDAR to deliver the most accurate and precise means of collecting data in three-dimensional space, providing the level of robust results needed to accurately create scan-to-BIM schematics that match the requirements of BIM processes.

Using the right techniques, scan-to-BIM can deliver models of real space with accuracy levels of millimetres. This finished point cloud data can then be uploaded into BIM software and accessed and edited in the same way that as-built BIM schematics operate.

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What is scan-to-BIM? (point cloud to BIM)
Scan-to-BIM technology can deliver four important outcomes:

1. Improve renovation/extension planning of structures without existing structural and design plans in a digital format.

2. Improve the planning of construction projects being undertaken around or in sensitive/challenging locations — natural or urban.

3. Enable building/facility managers of older buildings access to the types of efficiency improvements BIM delivers to newer structures.

4. To provide quality assurance through construction, comparing progress to planning, either on-site or in reference to off-site prefabricated materials as well as enabling clash detection for early issue detection.

For example, if a new building is being constructed in a tight urban environment (particularly if surrounded by listed historical buildings), or being built as an addition and/or otherwise connected to an existing structure, being able to integrate those surrounding buildings into the design model will help maintain construction procedures and ensure a best practice outcome.
The same might also be true if a building is being constructed in a precarious location, such as on a cliff, or around other natural features that might pose a challenge to construction and design.

For renovations, the use case is even more powerful. By scanning a site, the project can then be undertaken using the same advanced construction techniques and processes that would be brought to bear on a new project.

Even where no renovation is required, scan-to-BIM processes can be undertaken to provide building or facility managers with the level of visibility possessed by their counterparts managing more modern locations. The vast majority of a building's costs are spent on maintenance, not construction. By improving the efficiency of building management, large amounts of money can be saved further down the line.

Point cloud technology is so accurate that it can be used to precisely compare each stage of a project to designs, allowing for the highest achievable level of quality assurance. The step-by-step planning and detail that can be delivered by BIM is encouraging the greater adoption of prefabricated manufacturing techniques that improve quality and speed while reducing waste. However, that can only be achieved if prefabrication is done accurately. Point clouds and scanning technology deliver the capability to make sure that prefabrication is done correctly and consistently.

3D point clouds and BIM

Scan-to-BIM is rapidly becoming a more widely used technology because of the growing importance of BIM (and 3D models) to construction and building maintenance. But, it is also growing in popularity because of the increasing accessibility of point cloud technology.

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Point cloud surveys have always been slowed down by 'registration'. This is the process of taking the many different scans that are required to gain total scene coverage and fitting them together with the same level of accuracy and precision that each scan possesses individually.

To achieve this, surveyors have either had to use artificial targets placed strategically within fields of overlap between adjacent scans, or accessed software capable of achieving similar results using distinct natural features. Both have downsides that drive up the labour costs and time that is needed to create a point cloud survey. Placing targets slows down the scanning process and traditional targetless registration software requires significant oversight and regular cross-checks throughout processing.

New software has solved this issue by introducing multi-stage, vector-based, point cloud processing software that delivers faster and more robust outcomes with less oversight. By breaking registration into three stages (vector-enabled rotational alignment, and 2D vertical/horizontal point density alignments), vector-based software can accelerate the entire procedure by as much as 40%-80%. Manual tasks can be front-loaded, or are relegated to the end of the process. Not only can field scanning be approached without targets, scans can be queued up for hands-off processing and registration.

By breaking registration into three stages (vector-enabled rotational alignment, and 2d vertical/horizontal point density alignments), vector-based software can accelerate the entire procedure by as much as 40% - 80%.

This innovation is drastically reducing the costs of commissioning a point cloud survey, allowing for greater access to scan-to-BIM technology and improves the use case across the board. However, similar to BIM in general, adoption is far from universal. To access these results, project managers, building teams, engineers, interior designers and architects need to partner with surveyors who are themselves empowered by being at the cutting-edge of their own industry.

Why BIM is important: Who uses BIM — when, where and why?

Architects, structural engineers, CAD designers, 3D modellers, interior designers and the construction/ building teams themselves all the benefits of BIM. But, BIM goes beyond that — following a structure throughout its lifecycle, helping with maintenance long after construction is complete.

What exactly BIM delivers depends on what you end up 'labelling' BIM. We will get into some of these definitional and regulatory disagreements in the next section. Here, we will explore the revolutionary impact of what BIM delivers when approached as the transformational, single-source-of-truth, database-first and object-oriented system described in the previous section.

From this perspective, BIM delivers massive productivity and efficiency improvements by transforming collaboration and enabling coordinated communication. But, it goes beyond that — BIM changes the reality of what is possible in construction.

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Why BIM is better than CAD (computer-aided design)

Many people see BIM as a competitor to computer-aided design. This, however, is not fundamentally true. More accurately, BIM is an extension of CAD, and effectively incorporates CAD capabilities (often even existing CAD software formats) in an improved workflow environment. BIM allows multiple professionals to use their own specialised CAD programs while still coordinating in a single data environment. This improves communications and can even improve the types of projects that can be delivered.

How BIM improves project outcomes (the benefits of BIM to modellers, interior designers, architects, engineers and more)

Designing a building, facility, or any large structure is a highly complex undertaking that requires input from specialists. Once an architect has completed a design, it is necessary for engineers to undertake rigorous structural assessments under different physical strains such as seismic events. Interior designers need to craft usable spaces and various specialists have to design air ducts, electrical work, plumbing etc. Each layer of the project must be crafted with the others in mind, but often without directly viewing the other aspects at that given moment in time.

Once complete, all of these layers need to be combined into a single 'building plan', and a 'build order' execution plan must be created. But, again, throughout the building process, separate schematics need to be provided for the practicality of viewing, while still maintaining flawless consistency across the entire stack of information.

BIM enables all of this to be undertaken flawlessly. Each segment of the plan can be viewed, manipulated and edited within whatever format is necessary. But, it remains part of a central dataset that informs all of the other plans as well. This not only automates the updating of changes, making the process easier, it increases the ability for specialists involved in the design to share their insights and expertise.

Rather than being limited by the challenges of integrating changes across all documents, designers and specialists are able to collaborate with whatever degree of iterative regularity actually suits the project. For example, designers and architects are able to experiment more freely with materials and work closely with structural engineers to find solutions that work. Interior designers can take a more radical approach and easily alter iterations based on client feedback. Administrative tasks associated with change and collaboration are removed, allowing for increased communication and delivering improved outcomes in a more fluid and dynamic work environment.

How BIM improves quality assurance

Even though a BIM-enabled design process will include greater collaboration and more iterations, there is less chance of design clashes or missed updates. Alterations do not need to be manually propagated across all other plans because each specialist is simply editing the same dataset. Fewer mistakes will occur, and no mistakes will result from incomplete information being present in some particular subsection of the building design.

BIM improves quality assurance while reducing the amount of time that has to be invested in cross-checking documents. Keeping data in a single dataset makes it easy to use automated tools to perform clash detection between the different elements of building functionality that are addressed by different building and design teams.

How BIM improves the construction process

The improvements delivered by BIM move past design to construction itself. Keeping all of the information about a project together makes it easy to create sequential models for each phase of construction. This is an essential part of architectural planning that is both made easier and improved by BIM.

BIM software allows for the creation of detailed models for each stage of the project. These can be completed with animations, coordination notes and a predictable path to the desired outcome. These can be viewed sequentially and in the context of the final design. It is easy to look at information both in the very specific context and format that is needed by construction specialists and in the wider context of the project.

For example, project managers can view the exterior end-product rendering, then zoom in to inspect structural supports, then look at the plumbing and electrical work in isolation. Builders can simply look at the construction schedule for specific rooms, floors or areas. Designers can look at those same areas as an end result and see how sunlight impacts visibility at different times of the day using visualisation software.

Designers and construction teams are able to interact with effectively any level of detail that is desired, while still maintaining confidence that the information they are viewing is accurate and not clashing with other elements of the project. This allows for the detailed investment in the pre-fabrication of materials using any number of different tools.

How point clouds take BIM to the next level (scan-to-BIM)

All of these construction improvements are augmented by the connection to existing physical space that point cloud technology can deliver to BIM designs and processes. As we have covered in the 'Scan-to-BIM' section, laser scans can be used to create 3D models of existing physical space to either inform the basis of an as-built BIM design, or to create a BIM-like schematic for an existing structure.

Depreciation in the cost of commissioning a point cloud survey, however, delivered by multi-stage, vector-based processing and registration software, is allowing laser scans and point clouds to be directly integrated into the construction processes in previously undiscovered ways. Rather than simply taking a plan and moving forward with the project, each stage of development can be scanned and compared to the model in exacting detail. This allows for an exponential increase in quality assurance and error detection.

Using this method, any faults are detected immediately and can be rectified before issues are compounded by the investment in further construction. The same technology and processes can be deployed on an object level, allowing pieces to be pre-fabricated off-site, scanned and directly compared with the design to achieve absolute certainty in their compatibility. This is enabling the increased use of cutting-edge manufacturing technologies such as 3D printing on an ever increasing scale and with greater confidence — decreasing costs and improving outcomes.using any number of different tools.

The benefits of BIM to project managers

As leaders of projects, BIM delivers project managers information and visibility in an intuitive format that is unmatched in quality or ease of use. This is of paramount importance and can mean the difference between a flawless result and failure.

Reading technical diagrams is a learned skill, and most specialists who understand one type of diagram don't know how to read those used by their colleagues in other fields. Project managers can be expected to review all of this information and often end up relying on the consultation of others.

BIM software allows all of this information to be reviewed in 3D models that are easy to understand. Site visits are diminished and the amount, quality and viewability of catalogued information is increased. This is further augmented by the use of scan-to-BIM techniques throughout a project, all in addition to maintaining a single-source-of-truth that makes it much easier to manage what is going on in all the relevant and specialist corners of a project.

Why BIM is important to facility/building managers

Despite the many benefits that BIM delivers throughout design and construction, it continues to add value to post-construction maintenance and management. BIM schematics follow a structure throughout its lifecycle, passing from the designers to construction teams and finally the building/facility managers.

The level of information included in a BIM schematic and the ease and flexibility with which it can be viewed is indispensable to those tasked with maintaining a building or facility. As discussed, a BIM design does not simply include structural information, but also 'object' data — information about all of the assets within a building. In addition to providing locational information about things such as air ducts, generators, electrical switches and more, a BIM will include information about the cost of an operation, how often (and when) building components need to be serviced, as well as the cost of replacement, operating costs and their predicted expiry date. All of this can be investigated in intuitive 3D models.

The digital format of this information also enables the deployment of predictive and reactive maintenance procedures and technology including airborne sound analysis, thermal video analysis or x-ray cameras. This approach is fundamentally changing how industrial and building maintenance is undertaken and cannot be accomplished without digital schematics to control the procedures.

How to gain a competitive advantage with BIM

By accessing the collaborative, quality assurance, improved visibility and single-source-of-truth capabilities delivered by BIM, a competitive advantage in nearly ensured. It is simply important to embrace the process changes that this technology allows. These capabilities allow for the development of better designs, faster, more efficiently and at lower cost. Experimental materials can be investigated, dynamic designs embraced and improved outcomes ensured.

The delivery of a competitive advantage comes down to acquiring database-first design technology and following through with process improvements that match the capabilities of the technology. These factors are only elevated if BIM designs are augmented with point cloud technology for scan-to-BIM starting points and the reassessment of results using LiDAR techniques throughout project stages or to assess prefabricated materials.

How BIM can help you win project presentations

In addition to allowing teams to produce better results at lower costs more quickly (something every client values), BIM can be a great tool for communicating with clients and prospective clients. Just like BIM enables team communication and provides simple and intuitive formats for sharing highly detailed information between different professional specialists, non-professionals are given the same level of access.

3D models have become a key part of pitching projects. BIM data can be easily presented in 3D models, allowing clients to view projects in breathtaking detail. BIM goes even further than traditional presentations by enabling the visualisation of site assets and functionality. You can show where costs are, both in terms of capital investments and ongoing operating expenses, and enable the simple understanding of how the building will function when finished using animations and embedded details.

Simulations can even be paired with VR or augmented reality technology to enable the most immersive experience possible. The level of versatility offered by BIM to improve project presentations is only exceeded by the number of options BIM provides to architects, engineers, designers and construction teams themselves.

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UK BIM regulations (and Levels of BIM) that you need to understand

BIM is a technology and a process, but it is also a regulation. The UK regulatory terms 'BIM Levels 0-3' are critical to understand if bidding for a government construction contract. They also perfectly illustrate how BIM terminology is properly and improperly applied.

The most important things to grasp about BIM are the impacts on processes and design. However, it is also important to understand some of the terminology and the developing requirements for the use of digital tools in construction.

Without this, you are likely to make the wrong investments or miss opportunities.

What is the BIM mandate?
In April 2016, a UK government mandate came into effect requiring 'BIM Level 2' for all publicly funded construction projects. But, this immediately begs the question, what is BIM Level 2, and are there other levels of BIM.

What is BIM Level 2 (What are BIM Levels?)

BIM Level 2 is the name given to the digital collaborative way of working and design technology required by the UK government for any construction project to receive public funding. This is where the confusion of terminology of BIM is reintroduced. For all intents and purposes, BIM Level 2 is not BIM, at least not in the context with which we have been discussing BIM throughout this document. BIM Level 2 could be more accurately described as a requirement to use structured data within a Common Data Environment (CDE) using interoperable export standards. But, to explain that, let's back up to BIM Level 0.

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BIM Level 0
During the 1980s, architects began using computer-aided designs (CADs) to aid their design process. The easy ability to create and view many layers within these CADs expanded the ability to detail information about buildings that could not be easily included in plotted drafts. Per the new UK regulations, this technology is now considered 'BIM Level 0'.

BIM Level 1
During the 1990s, 'objects' were introduced to these designs. These are non-graphical pieces of data about the building or its components stored alongside the graphical representations. This introduced the capability to automate certain tasks, such as scheduling and room numbering, along with allowing even more information to be stored within a file. These new types of software also introduced 3D modelling, but the systems were still limited by their rooting in graphics-first representations. Per the new UK regulations, this is now considered 'BIM Level 1'.

BIM Level 2
BIM Level 2 takes these object-oriented CADs and introduces new requirements for interoperable export formats and easy sharing tools. All CAD software must be capable of exporting to one of the common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange). There is a further requirement to create a 'common data environment' (CDE), which is effectively a shared data exchange platform. However, within a CDE, all files remain separate but structured. rooting in graphics-first representations. Per the new UK regulations, this is now considered 'BIM Level 1'.

BIM Level 3 and beyond
BIM Level 3 is a still undefined category that effectively covers everything more advanced than BIM Level 2. The irony, however, is that this covers the true definition of BIM — database-first, single-source-of-truth design software and processes. Much of the direction for Level 3 comes from the Government-backed Digital Built Britain strategy now taken up and led from the Centre for Digital Built Britain (CDBB) at Cambridge University.

BIM Level 2 is a positive step. By operating with common export formats and a CDE, collaboration is improved. However, it does not capture the true potential of BIM. BIM Level 2 is an incremental improvement on industry standards, not the evolutionary leap that teams accessing true BIM will experience. It is predicted that even this change will deliver 20% improvements in procurement costs for projects that achieve BIM level 2 standards. But, that should simply highlight the eventual capabilities that 'true' BIM (BIM Level 3 and beyond) will be able to deliver.

What is BIM wash?

'BIM washing' is a term coined to describe the application of the label 'BIM' to a BIM capability or work practice where the competence or understanding is lower than the claim. The UK guidelines (although arguably set up to rationalise terminology) are a perfect example of this.

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In the 'Levels of BIM' system, simple CADs (computer-aided designs) that are effectively just digital versions of traditional architectural blueprints get labelled 'BIM', albeit 'BIM Level 0'. There is no object information or collaborative capabilities at all. The factors that created the need for the new term 'BIM' are nowhere to be found. The UK is called a leader in BIM application because of the BIM Level 2 mandate. But, even here, the database-first approach to design that is arguably central to the original concept of BIM is entirely missing.

None of this is to suggest that the greater interoperable nature of file types and increased communication derived from BIM Level 2 standards are not beneficial. However, it does highlight the importance of looking at actual capabilities when assessing the nature of the technology being adopted. To derive transformational outcomes, architects, engineers, interior designers, project managers and construction teams need to look beyond regulations and the word 'BIM' to find truly meaningful results.

BIM requirements outside of the UK (other names for BIM)

The UK is not the only country to receive a BIM mandate, and BIM is not the only term used to describe this new wave of collaborative and digitally enabled construction environments. But, these differences in terminology bring even greater variety in what is being described.

Different regional terms for BIM are important to understand if you are operating within specific jurisdictions. There has only just emerged in 2019 a BIM global standard in ISO 19650 which it is hoped will grow in acceptance going forward. However, it needs to be stressed that what is really important for improving outcomes and gaining a competitive advantage is the access and utilisation of the types of database-first design and collaboration capabilities outline above. Like in the UK, 'BIM' requirements fall short of the true potential of this developing technology and process approach to design and construction.

BIM in the United States
BIM is used across US construction teams, and several of the large manufacturers of BIM software are American companies. However, there are no Federal regulations on the use of BIM processes for construction projects, government funded or otherwise. Wisconsin, however, does require the use of BIM in public and privately funded projects over a certain size. But, similar to the UK, there are no requirements to use a single data environment.

BIM in Scandinavia
All of the Scandinavian countries were early adopters of BIM-enabled processes. Finland was working on the implementation of BIM as early as 2002. Since 2007, the Confederation of Finnish Construction Industries has mandated that all design software be capable of IFC export. Government projects in Norway have had to use common export formats since 2010, and the practice is seen as so productive in Sweden that it has led to near universal adoption without any regulations.

BIM in Germany
The German government is seeking to accelerate the adoption of BIM across the country by making BIM mandatory for all transportation projects by the end of 2020. Currently, however, there are no requirements for the use of BIM.

BIM in Singapore
Since 2015, BIM e-submissions have been required for all construction projects greater than 5,000 square metres (sq. m.) in Singapore. The government has also been subsidising the adoption of collaborative software since 2010 with grants for training, consultation and hardware upgrades. However, BIM is, again, usually used to describe software with collaboration capabilities, but not necessarily a single data repository.

BIM vs. VDC
VDC (Virtual Design and Construction) is a very loose term with no single agreed upon definition. It suffers from the same terminological creep that BIM has undergone, but fundamentally has no firm basis to start with. The idea, however, is similar to BIM — VDC is a process of workflows that involves the management of multidisciplinary specialisms in an integrated manner, generally using technology.

ÖNORM vs. BIM
ÖNORM is simply the Austrian standard and acronym for BIM. Compared to the UK standards, ⊠NORM A 6241-1 aligns with BIM Level 2 and ⊠NORM A 6241-2 aligns with BIM Level 3.

PTNB vs. BIM
PTNB is the French acronym for BIM. It is covered with multiple levels of standardisation in the French BIM standardisation roadmap. Like with the UK regulations on BIM, the terms are used to cover a number of different levels of collaboration capabilities.

BIM terms that you need to understand

The processes and software of BIM produce a lot of deliverables, new ways of looking at information and new types of information — along with formal standards and common regulations. To engage and update your processes, you need to learn the new terminology.

1. 4D, 5D and 6D
We are all familiar with 2D and 3D aspects of physical space. 4D follows its standard definition in mechanical physics: time. A 4D BIM will contain schedule information about the construction sequence. When it comes to 5D and 6D, industry standard definitions vary slightly, but they most commonly reference cost and lifecycle information. A 5D BIM will deliver information on an object or structural level about the cost of the project. 6D BIM schematics provide further information about the project lifecycle, going beyond upfront capital costs to supply information on maintenance and total cost of ownership.

2. Asset Information Model (AIM), Project Information Model (PIM)
We are all familiar with 2D and 3D aspects of physical space. 4D follows its standard definition in mechanical physics: time. A 4D BIM will contain schedule information about the construction sequence. When it comes to 5D and 6D, industry standard definitions vary slightly, but they most commonly reference cost and lifecycle information. A 5D BIM will deliver information on an object or structural level about the cost of the project. 6D BIM schematics provide further information about the project lifecycle, going beyond upfront capital costs to supply information on maintenance and total cost of ownership.

3. CIC BIM protocol
This is a group of legal guidelines set out by the Construction Industry Council in 2013 to enable a collaborative work environment while still retaining the intellectual property rights of the different liable parties. It was designed to be easily integrated into professional service agreements on a project by project basis. Specifically designed for the disaggregated environment of BIM Level 2, additional project-level agreements should be sought for more collaborative 'true' BIM environments.

4. Information Manager
This is an individual appointed per the CIC BIM protocol to oversee the project and the enforcement of the CIC BIM protocol. This person is also often responsible for other duties, likely design lead or project lead.

5. PAS 1192 Parts 1-5 & ISO 19650
The PAS documents are a set of guidance and standards for BIM Level 2 that pertain to the level of model detail, model information and information exchange capabilities that must be included. There are a large number of subsets and provisions included in this set of requirements. The PAS themselves are specific to the UK and have been foundational to the development of the world standard ISO 19650 launched in 2019 which should aid the adoption of standardised collaborative ways of working in construction and reduce the dilution of terminology and processes understood worldwide under the BIM term.

7. Federated model
This term is used to reference a BIM schematic built from the combinations of several different models by importing one model into another. This might be the result of a BIM Level 2 project in which all teams work separately on graphics-first designs, or could be used to create a BIM Level 3 starting point for an existing structure.

8. Industry Foundation Class (IFC)
This is an object format that enables the exchange of information across different pieces of software. Developed to help create open standards for BIM by the group 'building SMART', the standards are being increasingly adopted to improve cross-project coordination.

9. Information Delivery Manual (IDM)
This is a document that outlines the series of processes to be undertaken during an asset's lifecycle along with information about how these processes should be carried out.

10. Level of Detail (LoD), Level of Information (LoI)
These are both common construction and survey terms that reference the type of information and how detailed that information must be to meet project specifications. In the context of BIM, LoD specifically references the graphical content of models at each defined stage, while LoI references the non-graphical information to be included in the BIM. For BIM Level 2, these categories are defined by PAS 1192-2.

11. Life-Cycle Assessment (LCA)
This is a total environmental impact assessment for a building and all of its assets. It covers materials and energy consumptions, along with waste, pollutants and the consequences of production/activity.

12. Open BIM
This is a term referencing a number of attempts to create open standards for BIM, enabling even greater collaboration. It is occasionally used to reference BIM Level 3, and a true BIM environment in which data can be centrally edited and controlled.

13. Uniclass
This is a classification system used in the UK to simplify the identification of BIM objects. In Uniclass, objects are grouped into numerical headers to enable the grouping according to type and class of the object. This allows for the easier sorting of objects throughout a building's lifecycle.

The best types of BIM software

BIM is much more than software, it is a process. But, it is a process enabled by technology, and software solutions sit at the heart of that technological change. To engage with BIM, you need to understand the types of BIM software that make these improvements possible.

As detailed, what exactly BIM is depends on the definitions used. It could simply be the use of object-oriented CADs, the deployment of shared data environments or the creation of single-source-of-truth central data repositories and database-first design.

"'BIM washing' is a term coined to describe the application of the label 'BIM' to a BIM capability or work practice where the competence or understanding is lower than the claim."

In all cases, software gets used to access and edit different aspects of this data. For certain systems now called BIM, what gets lumped in with BIM software is simply whatever design systems used previously with the caveat that they can export to common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange).

Database-first BIM, however, requires software that is capable of transferring graphical information into abstracted data that can effectively inform the viewing of that information in another format. The software covered here delivers these outcomes (either with universal capabilities or for very specific purposes), or provides a platform aimed to help create a shared data environment.

The major suppliers are AutoDesk, Bentley, Trimble and Nemetschek. These companies all deliver BIM software, planning tools, and collaborative aids to help deliver true BIM (or BIM lite) environments using any number of other design and modelling tools.

AutoDesk BIM software

One of the largest suppliers of modelling and reality capture software, AutoDesk is a specialist in IT services for architecture, engineering and construction (AEC), and the visionary that began BIM in the modern sense — publishing the seminal white paper, 'Building Information Modeling', in 2002. It is unsurprising that AutoDesk has several 3D modelling programs built specifically for BIM processes and workflows.

Revit: Is AutoDesk's multi-purpose BIM-first modelling software. It allows users to manipulate whole buildings or assemblies within a project environment. It is not capable of NURBS modelling, but is considered an industry leader for 3D BIM modelling software. It includes purpose-built features for architectural design, MEP and structural engineering — supporting a multidisciplinary and collaborative design approach within one interface.

AutoCAD: is AutoDesk's flagship computer-aided design (CAD) software. It was their first product, having been on the market since 1982, which they have continued to update and maintain as a competitive solution. Not a BIM specific tool but it can be integrated into a BIM workflow.

Recap: is targeted at AutoDesk's media clients, but contains powerful reality capture capabilities for 2D and 3D modelling. Recap is primarily used in a BIM context to deliver scan-to-BIM 3D models based on point cloud data collected via terrestrial laser scanners, or other reality capture/LiDAR techniques.

Navisworks: is a program purpose-built to create federated models, bringing together elements from designs created using different software — specifically Revit and AutoCAD, although also possessing further interoperability capabilities. This enables teams to develop a single-source-of-truth, 'true' BIM schematic even if using multiple different types of software to begin with.

InfraWorks: is design software built to allow engineers and designers to easily place preliminary designs in real-world contextual environments. Supporting BIM processes and exports, Infraworks is primarily used during planning stages to get client buy-in on project concepts and deliver preliminary test capabilities.

Civil 3D: is purpose-built BIM compatible software with enhanced tools for civil engineering design/ construction documentation and planning.

BIM 360: is a unified project management platform that pulls together data in real-time from any number of compatible design programs. It supports informed decision making and a central platform from which every aspect of a project throughout its lifecycle can be viewed — empowering design collaboration, documentation and reviews, pre-construction, quality/safety and operations.

Bentley BIM software

Bentley is another long-time architectural, engineering and construction (AEC) specialist, serving the market since 1984. They offer a number of reliable reality capture and 3D modelling software packages that are widely used in civil engineering and construction sectors.

1. **MicroStation:** is Bentley's leading CAD (computer-aided design) software. Capable of producing documents, and visualisations for 2D and 3D designs.
2. **Synchro:** is a similar platform to AutoDesk's BIM 360 or Navisworks. It allows users to pull in data from multiple sources to improve collaboration and break down siloed workflows. It enables static CAD data to be augmented with construction (4D) timetables, and allows for the visualisation, analysis and editing of projects.
3. **ProjectWise:** is effectively a pre-built common data environment (CDE). It allows for the import, sharing and use of any number of different files — models, documentation, deliverables, reports and field management data. It is project management software that allows for the improved accessibility of information, although it is not (strictly speaking) true BIM-enabled software.

Trimble BIM software

Trimble is a giant in the production of both hardware and software components for reality capture and 3D modelling. They develop technology ranging from UAVs, inertial navigation system, GNSS receivers and laser rangefinders, to 3D modelling software, point cloud processing software and BIM information sharing platforms. Founded in 1978, Trimble has an annual revenue stream of nearly $3 billion.

1. **Tekla:** is a software family that is independently branded but owned and produced by Trimble. They offer several products all aimed to fill the needs of specific design and engineering specialists. This includes structural engineering, detail and fabrication programs, platforms for general contractors and project management — together creating a unified BIM network.

2. **Sketchup:** is 3D modelling software that allows models to be turned into documents. It is functional, easy to use and allows designers to start by drawing and then turn those surfaces into 3D forms and communications. Used by architects, engineers and interior designers.

3. **Connect:** is Trimble's answer to the need for central data environments and project management. It allows for the integration of any number of different planning and modelling programs in a single environment.

4. **RealWorks:** is a point cloud processing (reality capture) program. Not strictly speaking BIM software, it is integral to a Trimble scan-to-BIM solution.

5. **Edgewise:** is a 3D modelling software that can be used in tandem with RealWorks to deliver BIM ready designs off the back of reality capture and LiDAR enabled techniques. This solution is delivered in partnership with ClearEdge, which is now owned by Topcon.

Nemetschek BIM software

Nemetschek is the German giant of design software, delivering CAD solutions since the 1980s. They have a number of large subsidiaries that are all major players in the architectural, engineering and construction (AEC) market.

1. **Allplan:** is a family of architectural and engineering software products that, together, offer a complete BIM solution. High quality and easy to use, each software solution delivers exactly what specialists need to get the job done, and interoperability delivers an open BIM software solution.

2. **Graphisoft:** is another family of products (ArchiCAD, BIMx, BIMcloud) that deliver 3D modelling capabilities and real-time collaboration environments.

3. **BlueBeam:** is a collaboration platform that enables professionals to improve project efficiency by allowing for the sharing of information.

4. **Solibri:** is a quality assurance specific program and modeler — providing tools for BIM validation, compliance control and design coordination.

5. **Vectorworks:** is another set of design tools that deliver specific services to meet a number of different professional demands. This includes software for architects that support the entire project from precision drawing through to creative modelling and finished BIM schematics.

Topcon BIM software

Topcon is a Japanese manufacturer of optical survey equipment and software. One of the oldest companies on this list, founded in 1932, Topcon has been hardware focused for most of its life. However, through acquisition, they have entered the software BIM space with a globally competitive solution.

1. **ClearEdge:** is a modelling and design suite that enables the development of structural designs in a coordinated and single environment. Its building modelling is branded 'Edgewise' and is also delivered in partnership as a Trimble product. Capable of integrating with Revit, it allows for the import of scan-to-BIM data.

BiMserver

BiMserver is an open source BIM software provider that is aiming to disaggregate BIM modelling and design tools from their branded silos. It is an open and stable software core that allows for the easy use of different BIM software tools.

How to get started with BIM: the benefits of BIM

You have already completed the first step to getting started with BIM: learning the basics of what BIM means and the possibilities it presents. The next stage is to decide what you actually want to get out of BIM.

Is your interest in BIM simply to meet certain government criteria for a publicly funded construction project? Or, are you attempting to bring your processes in line with true best practices given the current state of technology? Your answers to these questions will impact how you get started with BIM and dictate the investments you need to make today.

BIM Level 2 vs. 'true' BIM

If all you want to do is meet the BIM Level 2 mandate, you simply need to make sure that all of the CAD software being used by members of your team is capable of export to common file formats such as IFC (Industry Foundation Class) or COBie (Construction Operations Building Information Exchange). Then, build a common data environment (CDE) using one of a number of software platforms that can act as a data exchange.

If you want to explore the true potential of BIM, you will likely need to invest in an updated set of software tools. This means looking at purpose-built and database-first software to enable seamless workflows between teams all using their own tools and diagrams while accessing the same common data system.

> "If you want to explore the true potential of BIM, you will likely need to invest in an updated set of software tools."

How to ensure your investment in BIM matters

If you go through the trouble and expense of updating your software, you need to make sure that your processes change as well. If every member of your team continues to work in isolation, very little has been gained by your investments in BIM. More than anything, BIM is a process — it is a collaborative approach to construction that is enabled by technology, but derives its benefits from the actual outcome of specialists working together more closely. If you lose sight of that outcome, no IT investment will impact what you are able to deliver.

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BIM ownership rights: Who owns a BIM model?

Intellectual property (IP) and trade secrets are a concern for many in the construction industry. The retention of clear categories of IP has been a more substantial stumbling block on the road to widespread adoption of fully collaborative design and information processes than many realise.

The reality of BIM ownership can vary between projects. This is something that should be set out and agreed upon at the start of a project. For BIM Level 2 and common data environments (CDE) in which all data remains disaggregated, most teams adopt the CIC BIM Protocol. This gives the client rights to use information contained in models for the 'permitted purpose'.

The problem with further levels of collaborations as expressed in BIM Level 3 is that the data does not remain separate, and the responsibility for edits of design features becomes hard to even identify.

In most projects, ownership of the BIM model is retained by the building owner, meaning that teams will give up more intellectual property on a BIM project than they are used to. But, design plans are often retained in this way even using traditional techniques. The intellectual property debate around BIM is still an evolving one. It comes down to a project by project basis to determine what is right and what actually occurs. When embarking on a BIM-enabled project, it is important to develop a clear vision for ownership and get agreement from the various contracted parties. All parties need to recognise the mutual benefit that the entire industry can gain by giving up some IP protections to create a more collaborative approach to construction and design.

Expanding capabilities with scan-to-BIM: The importance of point clouds to Building Information Modelling

To truly explore the cutting edge of BIM, you need to go beyond processes and software and look at surveys and point clouds. Point cloud technology is effectively the reverse of BIM, it starts with physical space and transforms that into a 3D model. By accessing LiDAR technology and techniques, surveyors can capture detail-rich physical environments with exacting precision, information that can be feed into BIM models for even greater quality assurance and more flexible outcomes.collaborative approach to construction and design.

> "Point cloud technology is effectively the reverse of BIM, it starts with physical space and transforms that into a 3D model."

Rather than just starting with a blank 3D digital space, your BIM diagram can be constructed in a digitally recreated copy of its eventual physical location. This can be a luxury, but it might also be vital to getting the design, integration with surrounding building or structural relationship to natural features correct.

This ability to capture existing information is even more critical for renovation projects. Projects can be undertaken as if the existing structure already has a BIM schematic, allowing teams to edit and manipulate structural and design details in a 3D environment that directly reflects the real location — even creating step-by-step digital plans. This same approach can be ed by building and facility managers to create BIM odels of their structures to provide the maintenance provements that managers of modern structures ith existing BIM schematics enjoy.

Scan-to-BIM throughout construction

This ability to match existing reality with planning can be employed throughout a construction project. Surveys can be conducted at every stage of development to compare in unprecedented levels of detail what has actually been built to the already unprecedented level of detail maintained within the BIM model. This brings exponential improvements to quality assurance.

Scanning technology and point clouds can also be used off-site to quality check prefabricated materials prior to their transportation to location. This improves confidence in this type of construction technique, even using experimental methods of production such as 3D printing. By using these types of manufacturing techniques, construction time can be cut (often by more than a third) while fewer resources are used, better materials utilised and less waste created. Together, point clouds and BIM make the possibilities for prefabricated construction almost limitless.

To do this effectively, project managers, design teams and architects need to not only embrace the collaboration of BIM, they need to look to partner with surveyors who are on the cutting edge of their own industry. Point cloud processing is itself going through something of a renaissance, dropping costs through the development of revolutionary vector-based processing technology that can increase the speed of point cloud processing by 40%-80%.

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The future of BIM and your next steps

You always arrive in the future with the tools you developed in the past. Nothing remains static for long, technology least of all. Making the most out of BIM is about getting ahead of the curve. Here is what you need to know.

The efficiency, coordination and outcome improvements delivered by BIM makes its growing utilisation almost inevitable. There are stumbling blocks and overhead costs that certain segments of the industry will resist. But, the enhancements to efficiency and project capabilities nearly guarantee that construction and design teams which do not embrace the changes delivered by BIM will lose market share and eventually adapt or go out of business.

Opportunities created by BIM

This current period of transformation creates opportunities that forward-thinking architects, engineers, project managers and construction teams can take advantage of. Although change always presents challenges, it delivers a chance for early adopters to create a competitive advantage and outperform existing behemoths in an industry. This is often why periods of upheaval see smaller competitors that can more easily adopt new technology and processes rise to prominence — forming the new 'old guard' for decades to come.

BIM technology is already here: processes have to change

Database-first design software already exists. The types of 3D modelling and interfaces may change as the technology advances. The purchase price of these platforms may decrease. The hurdle, however, facing the construction industry is adopting the processes and collaborative approach to design and construction that the already existing changes in technology have enabled. This is why, although fully integrated BIM capabilities exist, there is much wider-spread adoption of simpler improved sharing and interoperable file formats — as is codified in BIM Level 2 regulations.engineers, project managers and construction teams can take advantage of. Although change always presents challenges, it delivers a chance for early adopters to create a competitive advantage and outperform existing behemoths in an industry. This is often why periods of upheaval see smaller competitors that can more easily adopt new technology and processes rise to prominence — forming the new 'old guard' for decades to come.

The future of BIM is what BIM has always promised to offer — single-source-of-truth database-first design technology that enables specialised professionals from across a project to collaborate on the same data pool using their own industry-specific design tools. The next step is pulling this 3D modelling together with reality capture technology enabled by point cloud processing advances to bring these collaborative and detailed models in touch with physical space.

The hard bit is determining how exactly to use these tools to transform processes and create important differences to outcomes. Teams need to experiment with cross-disciplinary collaboration to tackle design problems that have so far proven impossible. How can, for example, architects, structural engineers, project managers, surveyors and materials specialists work together to create never before possible design plans using new building materials and experimental prefabricated manufacturing techniques? By adopting early, you will have more room to experiment and set trends that will lead construction into the digitally enabled 21st century and beyond. The options are nearly limitless, it is time to get started!

"The hard bit is determining how exactly to use these tools to transform processes and create important differences to outcomes."

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