buildingSMART Germany

DIN

Mark Baldwin

The BIM Manager

A Practical Guide for BIM Project Management

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Foreword

Richard Petrie
CEO buildingSMART International

These are exciting times in which we live. We stand at the onset of Industry 4.0, the fourth industrial revolution. Innovation is occurring at record pace around us and while there is much speculation about what the future may hold, there is still much to be defined. This engenders equal measures of uncertainty and enthusiasm. The former can provoke resistance, but also healthy scepticism. The latter stimulates innovation.

Industry 4.0, the 4th industrial revolution, refers to digital automation and data exchange in the manufacturing industry. It includes such concepts as 'the Internet of things' and cloud computing.

Innovation can be best promoted, and uncertainty best mitigated, by recognising the four principles of Industry 4.0:

– Interoperability
– Information transparency
– Technical assistance
– Decentralised decisions.[1]

These principles are directly applicable to what we are striving for in the digitalisation of the built-asset sector. As a leader in this area, the international organisation of buildingSMART is dedicated to information **transparency** and **interoperability** through the development of open standards. This means the creation of **technical mechanisms** to support the **decentralisation** (i.e., open sharing) of project information and decision-making processes.

buildingSMART is an international organisation leading the development of openBIM standards.

Of course, this effort is not without its challenges. And I must admit that the digital transformation has been slow coming to one of our oldest and perhaps most change-resistant industries: the construction industry. Nevertheless, the process is underway, and we have seen previews of what this transformation could bring.

Computational design is now a mainstay of most large architectural and engineering practices, allowing for more complex design, and enabling early-stage and more accurate design assessment. Laser scanning, BIM-to-Field mobile devices and computer-controlled excavation equipment are

BIM (Building Information Modelling) is a method of using digital models to support the design, construction, and operation of built facilities.

1 *Hermann / Pentek / Otto* (2016): Design Principles for Industry 4.0 Scenarios, published in: 49th Hawaii International Conference on System Sciences (HICSS), 2016.

ISO
is the International Organization for Standardization that develops and publishes International Standards.

CEN
(French: *Comité Européen de Normalisation*) is the European Committee for Standardization. It is a public standards organisation responsible for developing and publishing European Standards (ENs).

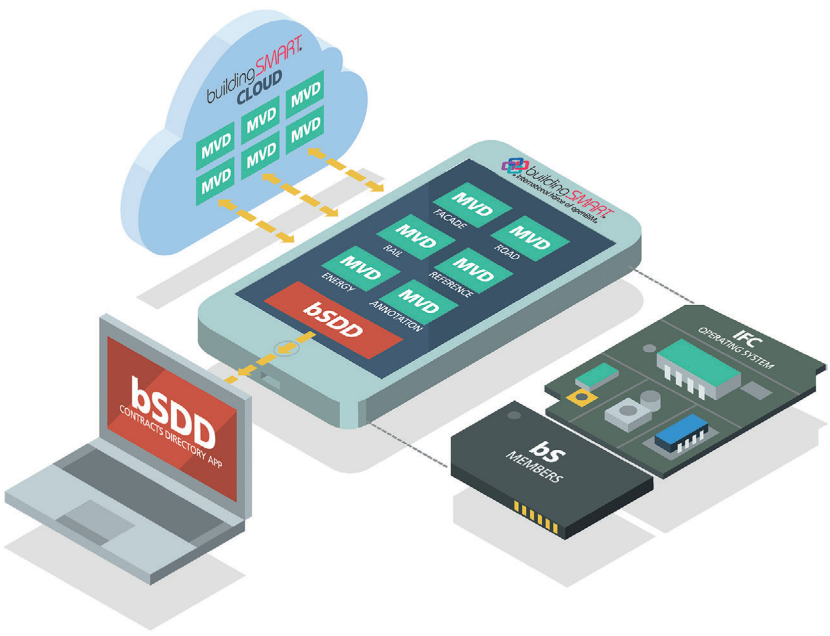
IFC
(Industry Foundation Classes) is an open standard to exchange model data between different software applications.

more frequently appearing on the construction site, increasing safety and productivity. And computer-aided facility management tools and cloud-based building automation systems are making the operation of our buildings smarter, more responsive, and more cost-efficient.

Our goal must be to make the use of digital technologies not just best practice, but common practice. This requires open and accessible standards that support all stakeholders across the supply chain.

buildingSMART is the world authority on openBIM and is tasked with developing and maintaining openBIM standards, several of which have now been adopted by ISO and CEN. You might be familiar with the Industry Foundation Classes (IFC) ISO 16739, the standard for describing the structure of data exchange. This is the core buildingSMART standard upon which all other buildingSMART standards are based. It is also the foundation from which all openBIM exchange processes can occur.

I often define IFC as the buildingSMART 'operating system'. The other buildingSMART standards can be seen as the 'apps' that extend the functionality and useability of IFC. These include the buildingSMART Data Dictionary (bSDD), the Information Delivery Manual (IDM), Model View Definitions (MVD) and the BIM Collaboration Format (BCF).



Source: buildingSMART International

Figure 1: buildingSMART standards "smartphone" analogy

I mention these standards here only in passing, as they are described in some detail in this book. Sufficient to say, the function of these buildingSMART 'apps' is to capture complex exchange processes in the form of digital best-practice templates. They are an important step in simplifying and standardising workflows of the future, and in enabling digital exchange and collaboration within project teams and across national borders.

The buildingSMART initiatives are important at both national and international levels. I invite you to join this movement, to support openBIM and help accelerate the realisation of Industry 4.0 within the built-asset industry.[2]

2 More information can be found at www.buildingsmart.org. For specific chapter contacts, refer to the chapter directory: www.buildingsmart.org/chapters/chapter-directory

Editor's Preface

Rainer Sailer
Director AEC
Mensch und Maschine Deutschland GmbH

This is a book for BIM Managers and those engaged in their organisation's implementation and application of Building Information Modelling in the project environment. Its purpose is to give insight and guidance into the core principles of BIM that can be directly applied to your business.

This is not a theoretical book or a speculation on the future. It seeks to give clarification and context to key concepts of Building Information Modelling. More than anything, it is a practical guide on how BIM projects are being planned and delivered around the world.

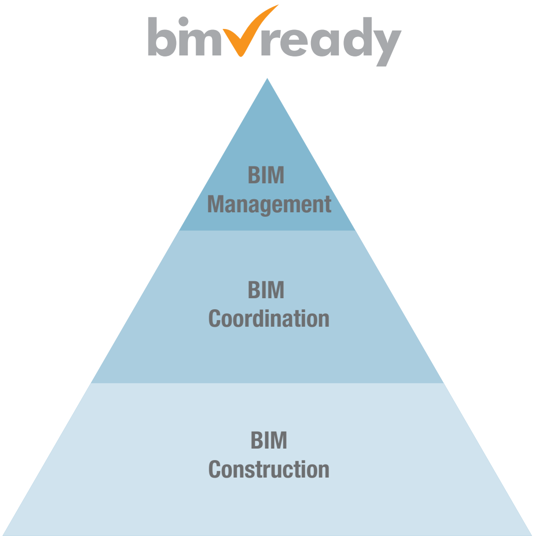
The BIM Manager represents the knowledge and principles that drive Building Information Modelling at Mensch und Maschine. This book reveals the methodology we apply throughout our work, in our **BIM Ready** training programme, in client consultancy, and in project support.

The Mensch und Maschine **BIM Ready** training programme is a keystone of our BIM services. It addresses the practical needs of industry professionals at planning, coordination, and management levels, and has been delivered to over 3,000 individuals in Germany, Austria, Switzerland, and abroad. **BIM Ready** is coordinated with the *buildingSMART* Professional Certification programme.

The success of our approach can be seen in the work of our clients, who include some of the most renowned facility owners, contractors, and design firms in the DACH region. Within this book, you will find contributions and project examples from Siemens, Strabag, SBB (Swiss Rail), Implenia, Losinger Marazzi, OBERMEYER, Herzog & de Meuron, Burckhardt & Partner, Boll und Partner, Hild und K, and many others.

Mensch und Maschine
(Man & Machine) is a German Technology company supporting the construction, infrastructure, GIS and mechanical engineering industries. With over 750 employees, the company is active across Europe.

BIM Ready
is a training concept from Mensch und Maschine that addresses three core areas of BIM: Modelling, Coordination and Management.



Source: Mensch und Maschine

Figure 2: Man and Machine BIM Ready Schulungskonzept

Mark Baldwin brings thirteen years of experience in designing, constructing, and consulting on BIM projects in Australia, the Middle East, and Europe, to the creation of this book. Combining his project experience, technical competence, and a solid conceptual understanding of BIM, Mark delivers a significant contribution for BIM practitioners. He is able to cut through myth and misunderstanding to present a clear and structured methodology for BIM implementation and project delivery.

I trust that you will find in *The BIM Manager* the resources you need to successfully plan, implement, and deliver BIM within your business.

Author's Preface

Mark Baldwin
Head of BIM Management
Mensch und Maschine Schweiz AG

Building Information Modelling certainly is nothing new. Over the last decade, BIM has been successfully applied on tens of thousands of projects around the world. Supporting technologies and processes have been developed and refined, contributing to an international wealth of knowledge and experience. Out of this evolution, concrete principles and guidance documentation have been created to support the planning, implementation, and delivery of BIM projects. It is the purpose of this book to convey these principles in a simple and straightforward way.

That's not to say the story is complete; BIM is a field of innovation and development. Many initiatives are still "works in progress", including the cornerstone of openBIM: IFC (see Chapter 3). There is still much to be defined and improved in the BIM world. Confusion abounds as we receive incomplete and sometimes conflicting messages. This book seeks to provide clarity amidst some of the misrepresentations. It draws on recognised standards and best practices to map out a robust method for BIM implementation and project management.

The content of this book can be divided into three sections. The first section provides context and introduces general concepts of Building Information Modelling. The second section lays out a methodology for the strategic planning and implementation of BIM within an organisation. The third section describes the activities and processes of BIM project management, from project definition and planning to execution to facility handover.

BIM is a complex topic that covers multiple disciplines, phases and project types. The scope of this book is restricted to the planning and construction phases of general construction projects. This is principally from the perspective of architectural and engineering design firms. Civil and infrastructure projects are not covered in any depth in this book, nor are operation and facility management. Nevertheless, the principles covered are applicable to all project stakeholders across all construction sectors.

Acknowledgements

This is by no means an isolated work. It is a small thread in a global tapestry that is still being woven. I have made every attempt to credit the origins and authors of ideas discussed in this book. However, as the field is in rapid development, it is not always clear from where or from whom concepts have originated. I apologise in advance for any error or omission in the acknowledgement of authors and references.

From the outset, I must acknowledge the decades of pioneering work and innovation that have influenced my understanding of, and contribution within, the domain of Building Information Modelling. This groundwork has enabled us to stand where we are today, with the privileged position to learn from and challenge earlier developments. *Our* contribution is only a snapshot of the story that is unfolding. In this light, I would also like to recognise the next generation that may draw on my small contribution, and that will further develop, question, and continue to improve this shared body of knowledge.

If there is a heart to the global BIM movement, a wellspring of knowledge, then it is without question buildingSMART, the international not-for-profit organisation responsible for the development of openBIM standards. I am indebted to the individuals who stand behind the organisation, those well-known personalities that are synonymous with pioneering openBIM developments, as well as the lesser known individuals who are engaged in development and administration activities. The buildingSMART community remains my greatest source of knowledge, inspiration, and peer-exchange in the field of BIM.

Many people have directly supported and inspired my understanding of BIM throughout my career, beginning with my formal introduction to BIM in 2005 by Architectus Sydney Design Technology Director, Rodd Perrey. From my time in the Middle East, I thank my learned Director at Oger International Abu Dhabi, Gerard Couturier, as well as my outstanding colleagues and BIM Managers, Alexander Kolpakov and Lee Coombs. To my colleagues and good friends at Mensch und Maschine I also extend my thanks for these past years of great collaboration.

This book would not have come into existence without the instigation and support from Mensch und Maschine AEC Director, Rainer Sailer, nor without the vision and continued encouragement from my Branch Director, Thomas J. Müller. I'm grateful to Germar Wambach for the design of the illustrations and graphics, to Shawna Lessard for her editorial work and to Reimer Dietze for the book's translation into German. I am also grateful to the team at Beuth Verlag, specifically to Sarah Merz, Sven Bergander and Katharina Förster.

Finally, I wish to thank the person who is at once my strongest advocate and harshest critic; part-time translator, loyal navigator and companion – my dear wife, Maria-Luise. Maria-Luise and our beautiful daughter, Mia-Sophie, are my two magnificent reminders of all that is great outside the world of BIM!

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Contents

1 Introduction

There is nothing quite so useless, as doing
with great efficiency something
that should not be done at all.

Peter Drucker

Building information modelling (BIM) affords an opportunity to rethink the way we work. It allows us to collaborate in a dynamic and immediate way; to test and validate our design decisions with exceptional speed and accuracy; and to access, integrate, and analyse the contributions of all project collaborators. BIM facilitates communication across the project team and supports quality management by enabling the automatic detection of design errors, conflicts and omissions.

Perhaps more than anything, BIM is a project management tool, enabling project teams to accurately estimate cost, reduce material waste, optimise scheduling, simulate construction activities, and streamline operations. It is also a mechanism to support contract administration, assign and track tasks, manage variations, and generally plan and report on project progress.

BIM does not threaten, as many fear, the professions of architecture and engineering. The success of a construction project is as much dependent on the competence of the people involved in it, as by any other factor. We need now, as much as ever, well-educated and experienced industry professionals.

BIM does, however, change the way we work. Manual and repetitive tasks can now be automated, meaning some traditional activities will become obsolete. New roles are emerging (the 'Information Manager', the 'BIM Coordinator', and the 'BIM Manager') as old technologies are making way for digital ways of working.

Despite this progress, the expectation of BIM is often far beyond what is actually being practiced. Much of what is promised seems unrealistic, maybe unachievable.

So how can we translate this vision to our day-to-day business? What do we really need to know and which steps can we take to make this a reality?

It is the purpose of this book to answer these questions, and to provide a concrete understanding of what BIM is and how it can be practically applied on project work.

1.1 Construction and the Digital Transformation

Digital technologies are transforming our lives. The Internet is now irreplaceable to most of our business processes. With the proliferation of smartphones and other mobile devices, digital connectedness has altered almost every aspect of our professional and private interactions. It has changed the way we communicate, bank, shop, plan holidays, learn, share opinions and engage with our peers.

Innovation is continually changing the rules of play. Google and Wikipedia transformed the ownership and exchange of information (making encyclopaedias and other static sources of information almost obsolete). Amazon, eBay, zalando and others turned the retail business on its head, shifting the market from outlet to online. iTunes did the same to the music industry as did Booking.com, TripAdvisor and others for the leisure business.

Disparity between small and large providers has narrowed, but more significantly, the consumer is in the driver's seat. Experiences and reviews of everyday consumers affect how these companies operate. We now have access and resources to translate our choices into direct actions. We shop, communicate, and transact with the click of a button. In fact, now even the button is gone – replaced by the touchscreen.

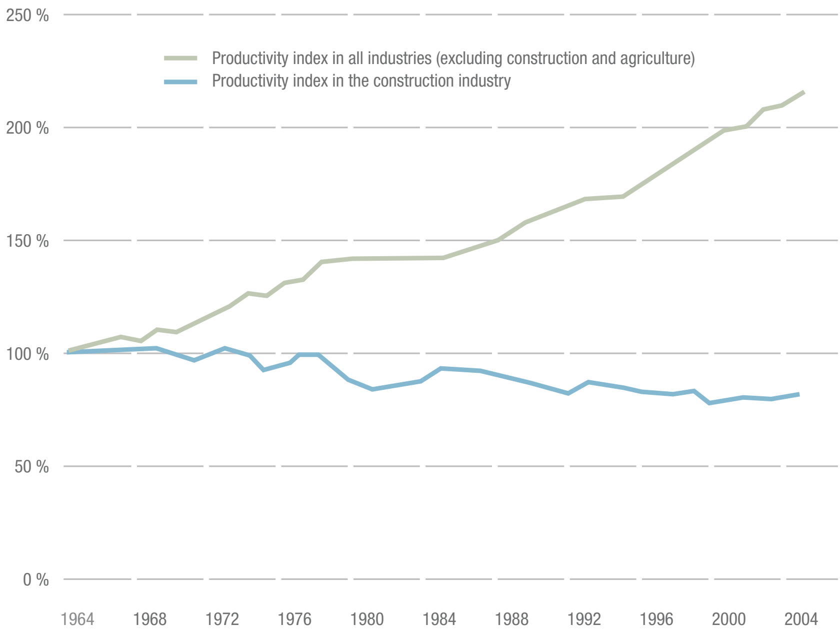
Industries	Disrupted Businesses	Digital Disruptors
Travel	Travel Agents	Booking.com, Expedia, Skyscanner
	Car Rental	Rhina Car hire, Kayak
	Taxi's	Uber
Retail	Fashion	Zalando, Outfittery
	Supermarket	eBay, Wayfair
	Book/Music	Amazon, Alibris
Media	Encyclopedia	Google, Wikipedia
	Music	iTunes, Spotify
	Cinema	YouTube, Netflix

Source: TradeShift Blog

Figure 3: Disrupted industries

1.1.1 The case for BIM

This digital transformation has not affected all sectors of the economy. One of the oldest and most inefficient of industries continues to resist; the construction industry. Looking back over the last several decades we see that all other sectors outperformed the construction industry in terms of productivity. A 2004 study from Stanford University's *CIFE department* highlights that over the previous 40-year period, using 1964 as a benchmark year, the construction industry experienced negative productivity of around 20 % while all other sectors saw an increase in productivity of over 100 % during that same period.[3]



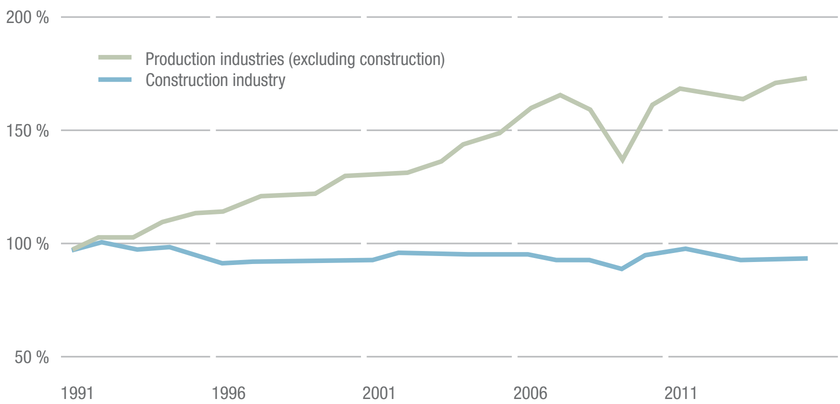
Source: Teicholz, Ph.D. Paul, Professor (Research) Emeritus, Dept. of Civil and Environmental Engineering, Stanford University

Figure 4: Productivity of construction versus other industries

A similar study was conducted in Germany. Covering a 24-year period (1991 to 2015), the study highlights productivity stagnation in the German construction sector compared with an average 70 % increase in other German industries.[4]

3 *Teicholz*, Ph.D. Paul, Professor (Research) Emeritus, Dept. of Civil and Environmental Engineering, Stanford University. Although farming industries were excluded from this study, the US Department of Agriculture indicates that productivity in the agricultural industry also saw a 100 % increase in productivity over that same period.

4 www.ctb.de/_wiki/ctb/BIM_(CTB).php



Source: Federal Statistics Office, Germany

Figure 5: Germany Domestic Product Calculation from 1991 to 2015

It would be good to could say there hasn't been a productivity increase because the construction industry has been operating at maximum efficiency! This is, of course, not the case. The construction sector produces more waste than any other industry. For the year 2014, it was estimated that construction activities generated 33.5 % of all waste in the European Union while contributing to only 5.4 % of the EU GDP.[5]

So, which are the reasons for these inefficiencies?

We see three main factors that have influenced this condition:

1. Industry fragmentation

The construction industry is continually becoming more complex and fragmented. Each decade brings new specialist disciplines and trades. With each specialisation, project requirements become more complicated and communication and decision making is more laborious. Managing communication on large projects is an overwhelming task for the majority of contracting firms – most of these being small companies of less than ten employees.[6]

2. Manual, inefficient, and outdated processes

Many of our design and construction practices are antiquated. Trades like masonry and carpentry have changed little in the past centuries and will be progressively sidelined by prefabrication and robotic-assisted assembly. Similarly, our drawing conventions are a hangover from the Renaissance

5 Based on 28 EU member states. Source Eurostat, *October 2016*.

6 In the US, the average (mean) construction company size is 10 persons (US Census Bureau, 2016). In the UK, 66 % of construction companies have 3 or fewer employees (UK Office for National Statistics, 2016).

period and are no longer a viable means to deliver project information on large developments.

Plans must be accompanied by a mass of additional documentation (building specifications, equipment lists, schedules, operational and maintenance manuals, contracts, variation orders) that supplement, and too often duplicate or contradict what is represented in the drawings. There must be a better way of working!

3. Technology resistance

The construction industry is, by and large, conservative and has made only tentative steps in adopting new technologies. There are notable exceptions, such as the development of digital fabrication processes (CAD, CAM) in the steel, timber, and other sectors. These developments are, however, typically isolated and have not inspired change across the supply chain.

CAD
(Computer-Aided Design) refers to the use of digital tools for drafting and design purposes. CAD usually refers to two-dimensional linework, but can also include three-dimensional volumetric modelling.

CAM
(Computer-Aided Manufacturing) refers to the use of digital tools to support machine- controlled manufacturing.

1.1.2 The response

So, how can we address these issues, and which role does Building Information Modelling play?

There is no reversing industry fragmentation. Rather, we should *embrace* specialisation by enabling communication and information sharing in a networked, flexible, and agile manner. New processes need to be adopted that remove antiquated workflows and support integrated, digital ways of working. And a cultural change needs to take place in order to shift our perception and use of technology.

Many of the technologies we need for this digital transformation already exist: cloud computing, mobile devices, digital fabrication technologies, and GPS-controlled site equipment, to name a few. We simply need to make the use of them more commonplace.

Cloud computing refers to data processing that takes place remotely (in data centres), not in our PCs. Personal Computers and mobile devices access the applications over the internet, while the actual computing takes place in the 'cloud'.

Building information modelling is the digitalisation of the construction industry!

Digitalisation enables integrated, structured and highly flexible ways of working. It liberates our specialised industry from, on the one end of the spectrum, cumbersome, centralised processes and, on the other, from fragmented disorganisation. BIM will help us eliminate and automate many of our old, manual, and tedious workflows. And it brings technology to our fingertips in the office, on the construction site, and in the operation and maintenance of our buildings.

1.2 What is Building Information Modelling?

Building information modelling is a digital backbone for the construction industry. It does not replace core design, construction, and operation activities but rather supports them by making project data computer-readable and openly exchangeable. This is dramatically different from digital technologies like CAD that we are currently using.

Traditional 'flat-CAD' is simply a digital duplicate of the drafting process. There is little difference between a line drawn on a drafting board and one drawn on a computer. With CAD we can edit, duplicate or reproduce (print) with little effort. However, it is a static representation of what in reality is a dynamic, shared body of knowledge – the growing project information.

Object-oriented is a term from software development that refers to the use of predefined elements within a software application. These do not necessarily refer to physical objects and may simply be concepts. In the context of BIM, object-oriented often refers to software that recognise building elements as unique entities or objects.

1.2.1 The building blocks of BIM

BIM is object-oriented and parametric. Each object represents a building element – for instance, a wall or a door – and has relationships to other elements (a door is in a wall, walls compose a room, a room is located on a floor, a floor is in a building). These relationships are dynamic; if the wall is relocated, so too are the associated windows and doors. Likewise, if floor-to-floor levels are increased, the associated walls may be automatically extended.

Most significantly, each building element has properties. Object properties describe the nature of the object: its physical dimensions, material attributes, function (load-bearing or not), cost, and approval status. Indeed, the properties that can be associated with any single object are virtually unlimited. They are the hidden value of BIM and their uses are only limited by our own ingenuity.

We can use the object properties as a mechanism for identification. Within the model environment, we can quickly select all instances of an object for visualisation. For example, object properties can allow us to create a filtered view of all doors within a model for a quantity take-off. We can even be more specific and search for all doors with a particular material finish. Or we can use logic-based searches to identify all doors located within walls containing a specific fire-rating, to check whether the doors themselves are suitably fire-rated. These detailed search capabilities enable us to identify design deficiencies in the model and correct them before construction begins.

2D/3D CAD	BIM
digital largely manual static	**digital** object-oriented parametric dynamic

Figure 6: Characteristics of traditional CAD (left) compared to BIM (right)

Parametric means that an entity is constructed of variable attributes or parameters. The term parametric is often used to refer to geometric objects that can be modified. For example, the height and width of a door are geometric parameters. Parameters, sometimes called **properties** or **attributes**, can also be non-geometric, such as material or fire-rating **properties**.

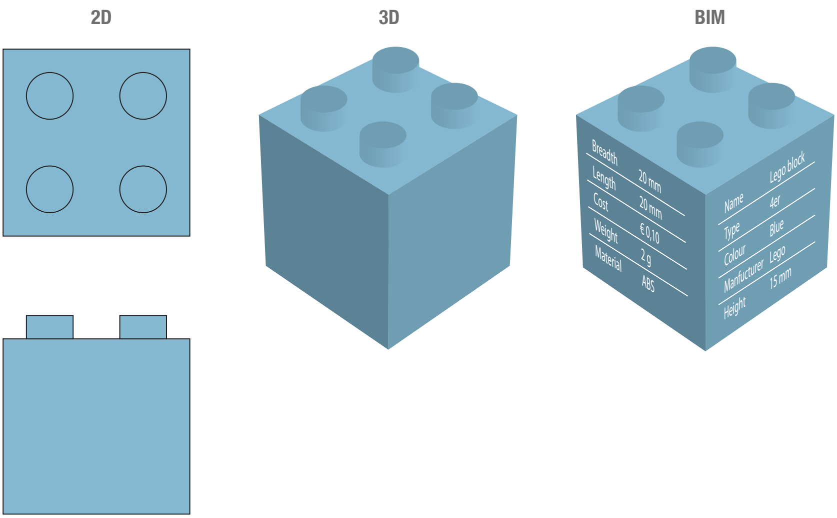


Figure 7: (Lego analogy) From 2D CAD to object-oriented BIM

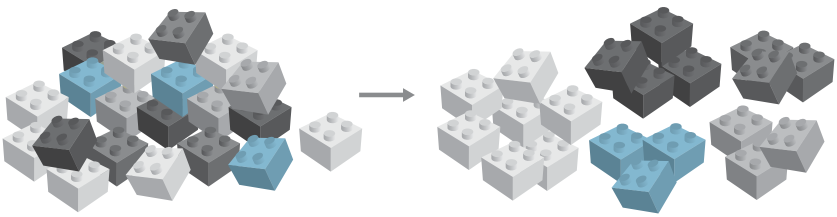


Figure 8: (Lego analogy) Object properties enable powerful search and sorting functions.

Working at the model object level supports communication. We can identify a specific building component by name, for example a light fixture, and request a change to its luminosity. Having a fixed point of reference eliminates confusion about which element or element property is being referenced.

Quantity Take-Off (QTO) is a process of extracting quantity schedules of building elements from a project model.

The model is also particularly valuable for design assessment and validation. This validation may refer to cost estimation – applying cost values to a quantity take-off – or to a more complex structural analysis or energy simulation. By virtue of the exceptional speed and computing power of model-based analysis, BIM becomes a powerful means to compare design options, test scenarios and simulate outcomes.

These concepts and uses of BIM are explored in more detail in the first section of this book (Chapters 2, 3, and 4).

1.3 Implementation

Among the many successful BIM projects, there are those that do not bring the promised benefits, leaving project teams frustrated and behind schedule. So, what differentiates successful projects from unsuccessful ones? The short answer is strategic planning.

There are many factors that have a bearing on the success of a BIM project: complexity, scope definition, design changes, cost or schedule implications, technological constraints, and team competency and experience. While only some of these factors are foreseeable, they can all be managed more effectively with strategic planning.

Setting realistic goals, managing expectations across the team, and planning and executing projects in a structured way are the components of successful BIM project delivery.

These topics compose the second section of this book (Chapters 5 and 6). It is here that we provide a roadmap and resources for implementing BIM within your organisation.

1.3.1 The BIM Process

To apply BIM effectively on a project requires a working knowledge of the conceptual and technological aspects of BIM, as well as robust project management experience. A useful illustration of the multi-layered nature of BIM and its corresponding areas of activity is presented in Figure 9: The BIM Pyramid.

For many organisations, the first conception of BIM is the 3D *geometric* model. This is an important component of BIM. In the broader context, however, it is really only a fraction of what BIM represents.

Although the benefits of a geometric model may be great, this is overshadowed by the value of the information content. It is the *data* embedded in the model that represent its true worth. Object data, or properties, are the basis for search criteria, simulation and analysis. Information content is the second tier of BIM.

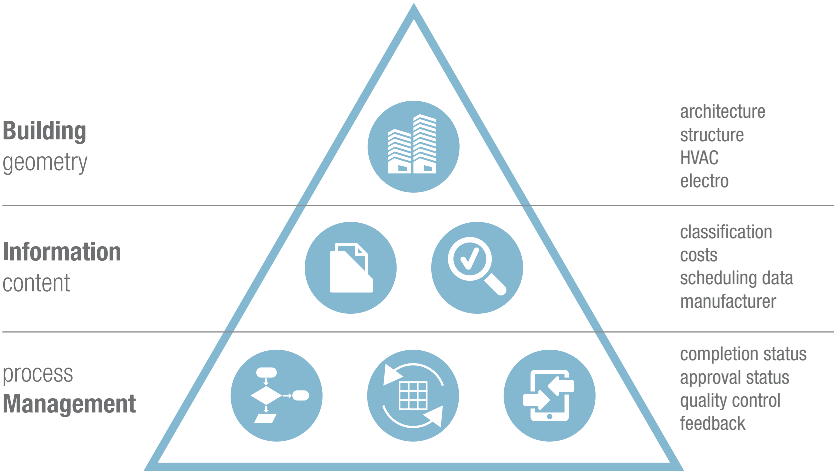


Figure 9: The BIM Pyramid

As BIM Managers, our primary activity is not geometric modelling, nor data creation. Our focus lies in the management of *processes* surrounding these activities: defining model content and delivery requirements; establishing digital workflows; managing changes; controlling quality; and assigning, tracking, and reporting on diverse activities. The BIM Manager is the conductor of the process; the curator (not creator) of content.

To illustrate these three activity areas, we define BIM as Building Information *Management*, represented in the BIM pyramid.

BIM project management is covered in the last section of this book (Chapters 7, 8, and 9).

1.3.2 Taking the first steps

BIM has a broad application and means different things to different people. It can be applied to all disciplines across all phases in the design, planning, and operation of a building. And in each instance, it can take on a new form. We all interpret BIM from our own perspective.

This freedom of interpretation has created confusion and ongoing debates about the terminology and principles that define BIM. Let us explore how a typical (example) design firm might encounter BIM. And by doing so, we will introduce some of the relevant concepts.

Figure 10: The BIM Elephant

1.4 BIM capability and model-use progression

Most organisations make a progressive transition to BIM, moving incrementally from a 2D-workflow to an object-oriented collaborative process. This can follow any number of routes; however, there is often a common pattern. Here we will map out a generalised path that a design firm might follow towards BIM adoption.

Stage 1: the 3D Model

Visualisation is understood here as a 'BIM Use Case' that generates rendered perspective views or animations from a building model.

Architectural practices, in particular, often begin the journey to BIM with early-phase massing or study models. These may be used for internal design studies, visualisations, or basic sun-shadow calculations. Typically, little 'intelligence' is associated with these models. The generic building components often serve a simple function in form-finding exercises. 3D models are often created in tandem with a 2D-planning process. This duplication of work means that the 3D models are abandoned at a later design phase.

In contrast to architectural practices, early-adopter engineering offices often commence projects in a traditional fashion (with 2D sketches, drawing or calculations), then developing 3D models at a later stage for coordination purposes.