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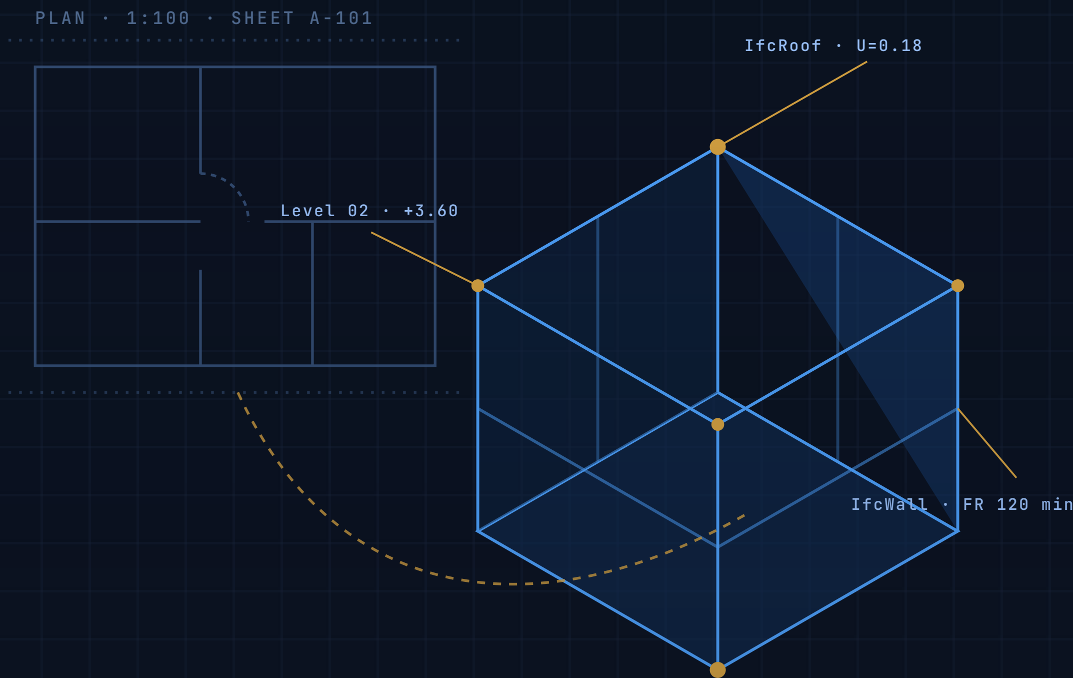

THE HISTORY OF BIM

The Living Model

How buildings learned to carry their own information: from a light pen in 1963 to the digital twins of today.

A **CONSTRUBIM** NARRATIVE
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The Living Model

The History of BIM

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The Living Model — The History of BIM. A ConstruBIM narrative. First free digital edition, September 2026.

All diagrams in this book were drawn by ConstruBIM for this edition. Project images are those published on construbim.com for the projects concerned. Historic measured drawings of the Frederick C. Robie House (1963) and the Edith Farnsworth House (2009) are from the Historic American Buildings Survey, US National Park Service, held by the Library of Congress and reproduced via Wikimedia Commons; they are in the public domain. Photographs of people, buildings and machines are reproduced from Wikimedia Commons under their own licences; see Appendix D.

Every date in this book has been checked against published sources, listed in Appendix C. Where the popular account of BIM's history is contested or simply wrong, the text says so. Corrections are welcome at **info@construbim.com**.

Continue learning free at the ConstruBIM Academy: **construbim.com/bim-academy** — a categorised database of more than 200 BIM tools, 800+ answered questions and free certification in four levels.

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FOREWORD

Why a consultancy wrote a history book

Every week someone on a project asks us a version of the same question. *Who invented BIM?* Sometimes it is a young modeller on their first federated model. Sometimes it is a client's director who has been told, in a tender document, that BIM was "coined in 1992 by a British architect". That sentence is wrong in two places at once, and it keeps getting copied.

We wrote this book because the true story is better than the myths, and because it is useful. Building Information Modeling did not arrive as a software release. It arrived as an argument, made by a handful of researchers more than fifty years ago, that a building should be described to a computer as *things with properties* rather than as lines on paper. It then took the construction industry about four decades, several generations of hardware, a few very unusual buildings and a number of governments to act on that argument.

Knowing that sequence changes how you work. It explains why the modelling problem was solved long ago while the *information* problem was not. It explains why open standards matter more than any single product. And it explains why ISO 19650, the standard that governs most of the work we do today, barely mentions software at all.

We are ConstruBIM, a BIM implementation and digital delivery consultancy. Our teams have worked inside some of the chapters described here: the federated model of the new Mexico City International Airport, the hexagonal skin of the Soumaya Museum, the governance of digital delivery at NEOM. We have tried not to let that make us the heroes of the story. The heroes are Ivan Sutherland, Charles Eastman, a group of engineers from Liverpool, a start-up in Budapest, two researchers in Delft, and thousands of people who spent their careers making models that other people could trust.

This book is free. Read it, print it, give it to your team, put it in a university reading list. If you find an error, tell us and we will fix it in the next edition.

CONSTRUBIM
September 2026

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PROLOGUE · BEFORE 1960

The Paper Problem

> *For five hundred years, a building existed twice: once in the world, and once as a stack of drawings that were never quite sure they agreed with each other.*

Imagine a door. On a traditional set of construction documents that single door appears in many places. It is drawn on the floor plan as a gap and a quarter circle. It appears again on an elevation, again on a section, again at a larger scale on a detail sheet, as a line in a door schedule, as a paragraph in a specification, and as a number in a cost plan. Each of those appearances was made by hand, usually by a different person, at a different time.

Now move the door thirty centimetres to the left. Every one of those representations has to change, and nothing forces them to. If a single sheet is missed, the drawings now describe two different buildings. Multiply that by the hundreds of thousands of elements in a hospital or an airport and you have the central problem that Building Information Modeling set out to solve.

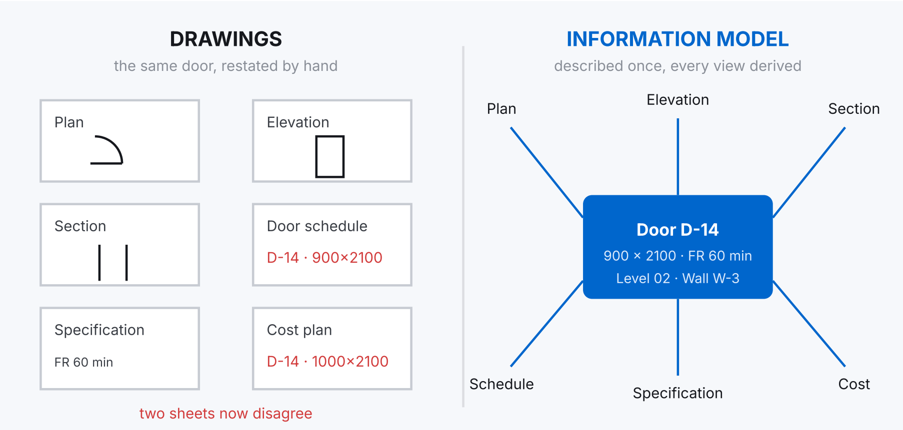


Figure 0.1. The paper problem. In a drawing set, each view is an independent record that can drift out of step. In an information model, the element exists once and every view is generated from it.

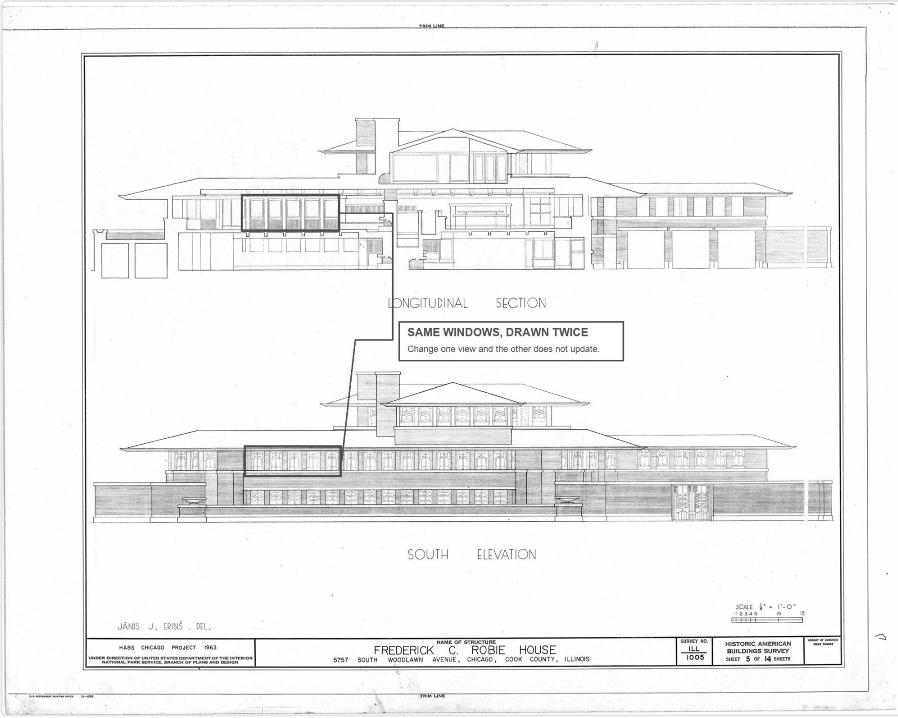


Plate 1. A real drawing set. Longitudinal section and south elevation of Frank Lloyd Wright's Frederick C. Robie House, Chicago (1909), measured and hand-inked in 1963. Blue annotations added by ConstruBIM. The section and the elevation describe the same walls, roofs and windows twice; only the care of the draftsman keeps them in agreement.

Historic American Buildings Survey, HABS ILL-1005, Library of Congress. Public domain.

An old and brilliant compromise

None of this means drawings were a mistake. They were one of humanity's most successful information technologies. Renaissance theorists such as Leon Battista Alberti, writing around 1450, already insisted that an architect's drawings should be measured plans and elevations rather than a painter's perspective, so that a builder could take dimensions from them. At the end of the eighteenth century the French mathematician Gaspard Monge formalised descriptive geometry, the rigorous method of representing three-dimensional objects on flat projections that engineering drawing still follows. In the nineteenth century cheap copying processes, most famously the cyanotype "blueprint", let one set of drawings be reproduced for many trades.

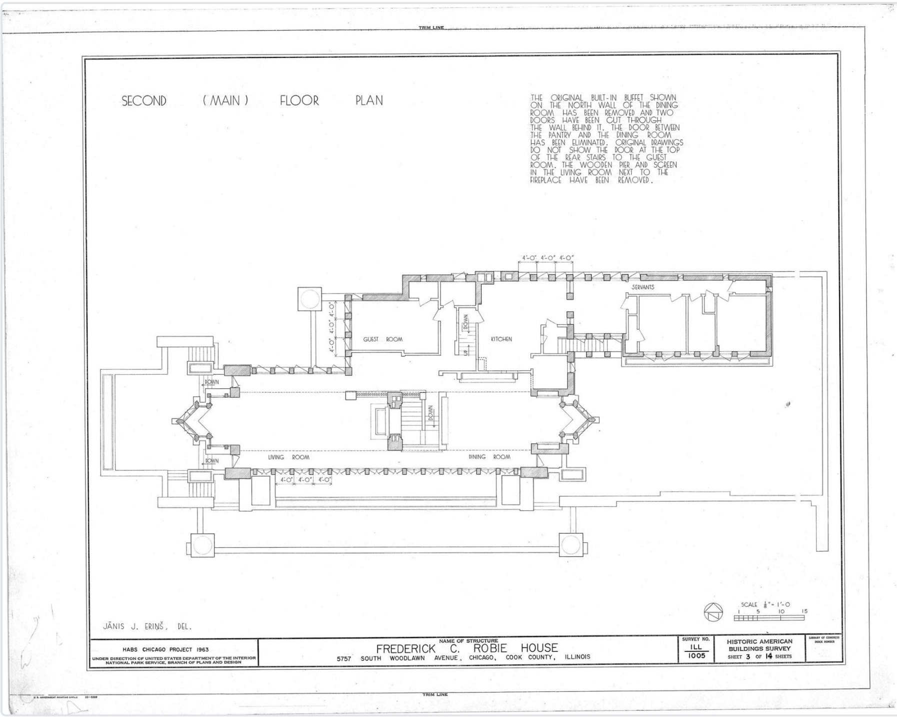


Plate 2. The same house in plan: the second (main) floor of the Robie House, from the same 1963 survey. A plan tells you where every wall and window is, but not what the wall is made of, what it costs or what passes through it.

Historic American Buildings Survey, HABS ILL-1005, Library of Congress. Public domain.

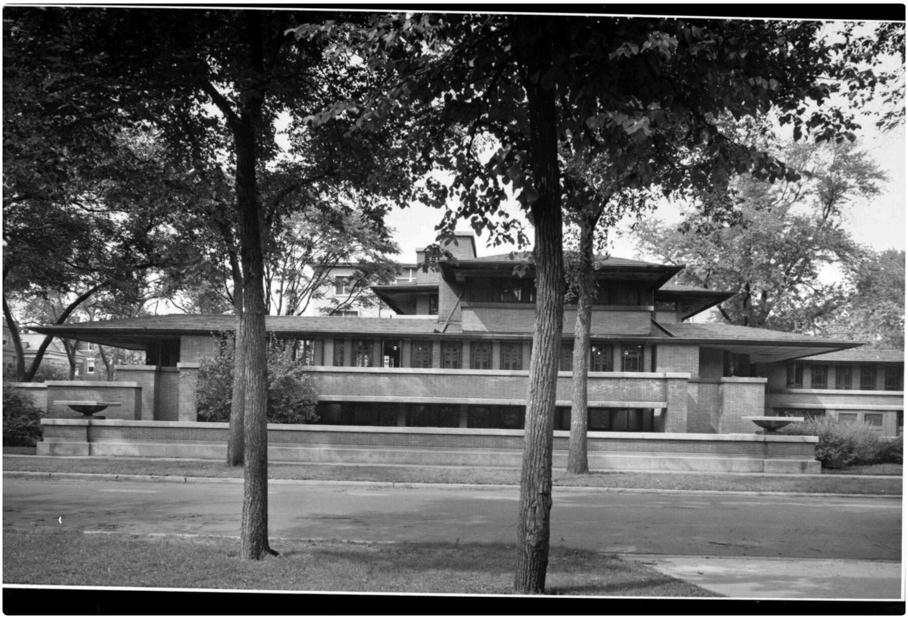


Figure 0.2. The building the drawings describe: the Robie House from the south, photographed by Cervin Robinson for the same survey in August 1963. One building, and a stack of sheets that each describe a slice of it.

Historic American Buildings Survey. Public domain, via Wikimedia Commons. Cropped by ConstruBIM.

Drawings were compact, portable, legally robust and readable by anyone trained in the conventions. Their weakness was that they were a *projection* of a building, not a description of it. A plan tells you where a wall is. It does not tell you that the wall is fire-rated, who supplies it, how much it costs, or that three ducts pass through it. That information lived in schedules, specifications, calculations, and in people's heads.

What the computer first changed, and what it did not

When computers arrived in design offices they were first put to work making the old compromise faster. Computer-aided drafting, which spread rapidly after the launch of AutoCAD in 1982, digitised the pencil. The lines became vectors, the sheets became files, and copying and editing became trivial. But a line in a drafting file was still only a line. Move the door on the plan and nothing told the section.

This is the most important distinction in the whole history that follows, and it is worth stating plainly. **Computer-aided design** can be purely geometric. **Building information modelling** describes the building as a set of objects that know what they are, carry data, relate to one another, and generate the drawings as a by-product.

The drawing age did not end because drawings were bad. It ended because buildings became too complex for independent sheets to stay in agreement.

The remarkable fact, as the next chapters show, is that the second idea is almost as old as the first. It was described in detail in the 1970s, long before the industry had the machines, the incentives or the standards to use it.

1

1957–1963

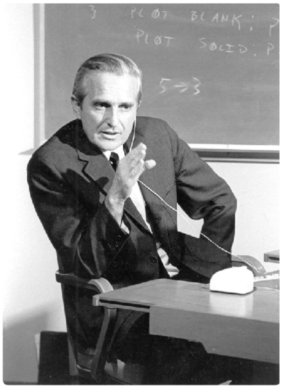
A Pen Made of Light

The first time a person drew on a computer screen, the drawing already knew rules.

The story of BIM begins, like much of modern computing, in the United States during the Cold War, with machines that filled rooms and cost more than buildings.

By the late 1950s the aerospace and automotive industries had begun using computers to control machine tools. Patrick Hanratty's PRONTO system, developed in 1957, is often cited as the first commercial numerical-control programming system and earned him the informal title of a father of CAD/CAM. These systems dealt in geometry for manufacturing. They had nothing to say about architecture. But they established that a shape could be stored as data and turned directly into a physical thing.

1962 An architect at a console



Douglas Engelbart in December 1968, rehearsing the demonstration now known as "the mother of all demos".

SRI International. CC BY-SA 3.0, via Wikimedia Commons.

In 1962 Douglas Engelbart, a researcher at the Stanford Research Institute, published a report titled *Augmenting Human Intellect: A Conceptual Framework*. It is famous as the intellectual seed of the mouse, hypertext and the modern graphical computer. Less often remembered is one of the scenarios Engelbart used to explain his vision: an architect, working at a computer workstation, designing a building.

In Engelbart's description the architect does not draw lines. He enters specifications, the machine assembles them, and he examines and adjusts the result from different points of view while the computer keeps track of the underlying data. In Engelbart's own words, "A structure is taking shape." Read with modern eyes, it is a startlingly close sketch of what BIM authoring became forty years later. Engelbart had no software to do it. He was describing a way of thinking.

1963 Sketchpad

The following year a doctoral student at MIT turned part of that way of thinking into a working program. Ivan Sutherland's thesis, *Sketchpad: A Man-Machine Graphical Communication System*, ran on the TX-2 computer at MIT's Lincoln Laboratory. The user drew directly on a cathode-ray screen with a light pen.

Figure 1.2. Ivan Sutherland at the console of the TX-2 at MIT Lincoln Laboratory, drawing with Sketchpad using a light pen. Photograph from his 1963 dissertation.

That alone made Sketchpad a landmark: it is widely regarded as the ancestor of every computer-aided design program and one of the first complete graphical user interfaces. But two of its ideas matter especially for our story.

The first was **constraints**. In Sketchpad you could tell the machine that two lines must stay parallel, that a line must keep a certain length, or that a joint must stay attached. Change one element and the program adjusted the others to keep the rules true. This is the direct ancestor of parametric modelling: the idea that a design is a set of relationships, not just a set of shapes.

The second was the **master and instance**. A shape could be defined once as a master and then placed many times as instances. Change the master and every instance changed. Anyone who has edited a door family in Revit, a GDL object in Archicad or a block in AutoCAD has used Sutherland's idea.

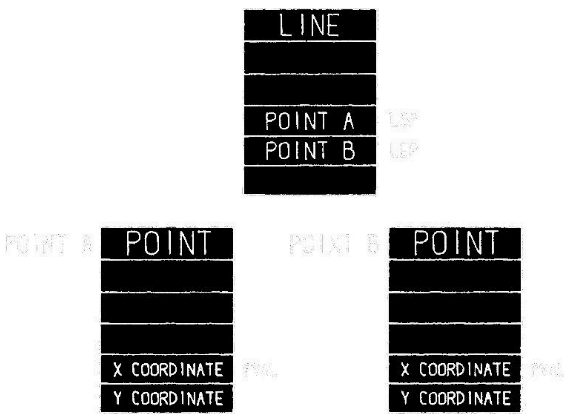


Figure 1.3. Objects that refer to objects. A figure from Sutherland's Sketchpad dissertation shows a line stored as an element that points to its two end points, each holding its own coordinates. Move a point and every line that refers to it moves too.

Sutherland, Ivan Edward. CC0, via Wikimedia Commons. Inverted to black on white by ConstruBIM.

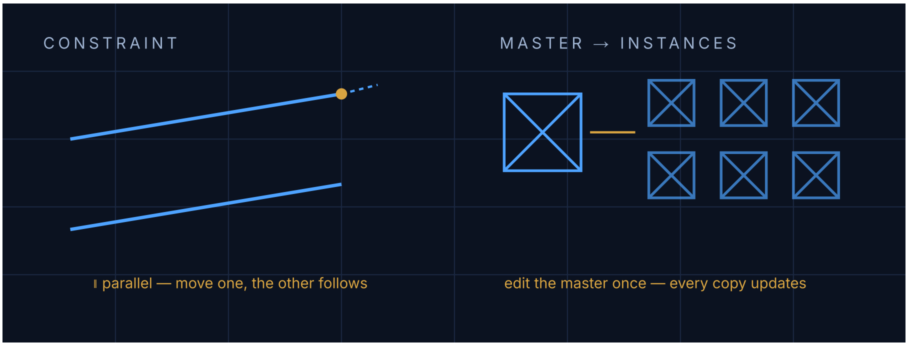


Figure 1.1. Sketchpad's two gifts to BIM, redrawn. Geometric constraints became parametric relationships; master and instance became families, types and objects.

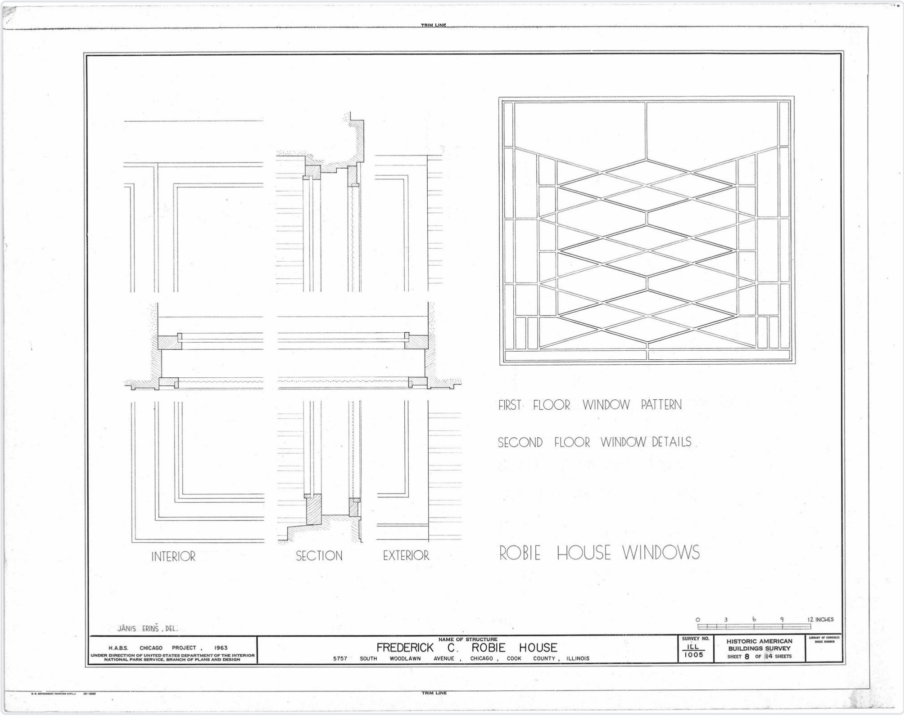
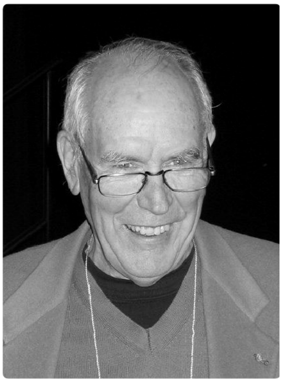


Plate 3. The drawing office in the year of Sketchpad. In 1963, while Sutherland drew with light at MIT, survey teams in Chicago were still hand-drafting window details of the Robie House at full precision on paper. This sheet and Sketchpad are exact contemporaries.

Historic American Buildings Survey, HABS ILL-1005, Library of Congress. Public domain.

Sutherland received the Turing Award, computing's highest honour, in 1988. Sketchpad itself was never an architectural tool. The TX-2 was a unique research machine, and the hardware to run such programs in an architect's office would not exist for another two decades. But from 1963 onward the principle was established: a drawing on a computer could be a structured model governed by rules, rather than a picture.



Ivan Sutherland at the Computer History Museum on his 70th birthday, 2008.

> **WHY THIS CHAPTER MATTERS ON A PROJECT TODAY**
>
> When a modeller asks why a Revit wall "refuses" to move, or why a Dynamo graph breaks after a type is renamed, they are meeting Sutherland's constraints and instances. Parametric behaviour is not a feature added to BIM; it is the oldest layer of the technology.

The missing ingredient

What Sketchpad did not have was *meaning*. Its lines were constrained, but a line did not know that it was a wall. The leap from geometry with rules to building elements with information would come a decade later, from a young professor at Carnegie Mellon who had studied architecture and who thought drawings were a remarkably inefficient way to describe a building.

2

1967–1982

The Professor Who Refused to Draw

> *Describe the building once, as elements, and let the drawings follow. It took the industry forty years to take the advice.*

Charles M. Eastman was born in 1940 and joined Carnegie Mellon University in Pittsburgh in 1967. His early research was not about software at all but about how designers think. A 1969 paper on the cognitive processes of design is regarded as one of the first studies in the field of design cognition. That interest, in how designers actually hold and manipulate information, shaped everything he built afterwards.

1964–1969 A generation thinking about design and computation

Eastman was not working alone. Through the 1960s a small group of thinkers began to treat design itself as something that could be analysed, structured and partly computed. Christopher Alexander's *Notes on the Synthesis of Form* (1964) described design problems as networks of interacting requirements. Nicholas Negroponte founded the Architecture Machine Group at MIT in 1967 to explore how computers and architects might work together. Herbert Simon's *The Sciences of the Artificial* (1969) argued that design is a science of its own. In the same year Ian McHarg's *Design with Nature* layered environmental data over maps, a method that anticipated geographic information systems. BIM would inherit something from each: structured requirements, human–computer collaboration, a theory of design, and layered data.

1970s The Building Description System

In the mid-1970s Eastman and his colleagues developed a prototype called the **Building Description System**, or BDS. In 1975 he set out its argument in a paper whose title reads today like a manifesto: *The Use of Computers Instead of Drawings in Building Design*.

Eastman's reasoning went to the heart of the paper problem described in the prologue. Drawings, he argued, are redundant: the same information is restated across many sheets, and every change must be repeated by hand on each of them, which guarantees inconsistency. They are also incomplete: a drawing shows geometry but cannot be interrogated for quantities, costs or performance.

His proposal was to describe the building in a single integrated database of elements. From that one description the system would produce plans, sections and perspectives, and would also support quantitative analysis. A change made once would appear consistently everywhere. The elements could be defined parametrically, and the database could be sorted and queried by attributes such as material or supplier.

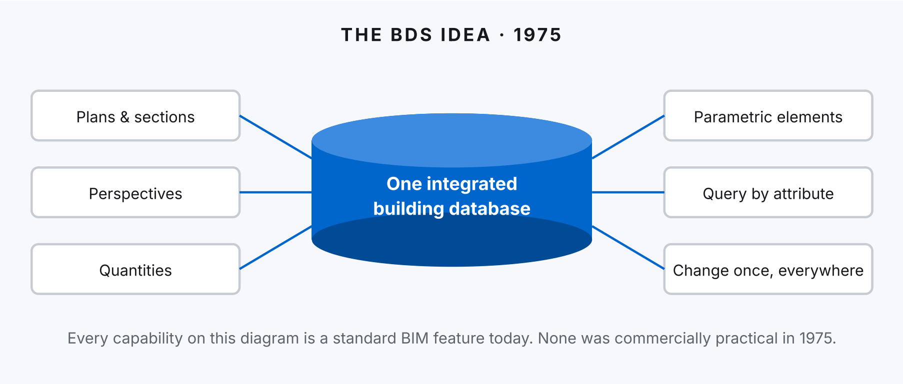


Figure 2.1. The principles of Eastman's Building Description System, as summarised from his 1975 paper and later accounts. Diagram by ConstruBIM.

Figure 2.2. The Edith Farnsworth House by Ludwig Mies van der Rohe (1951), seen from the southwest in 1971. A building of almost nothing but columns, slabs and glass, and still documented, decades later, as separate plans, elevations and sections.

Jack E. Boucher, photographer. Public domain, via Wikimedia Commons.

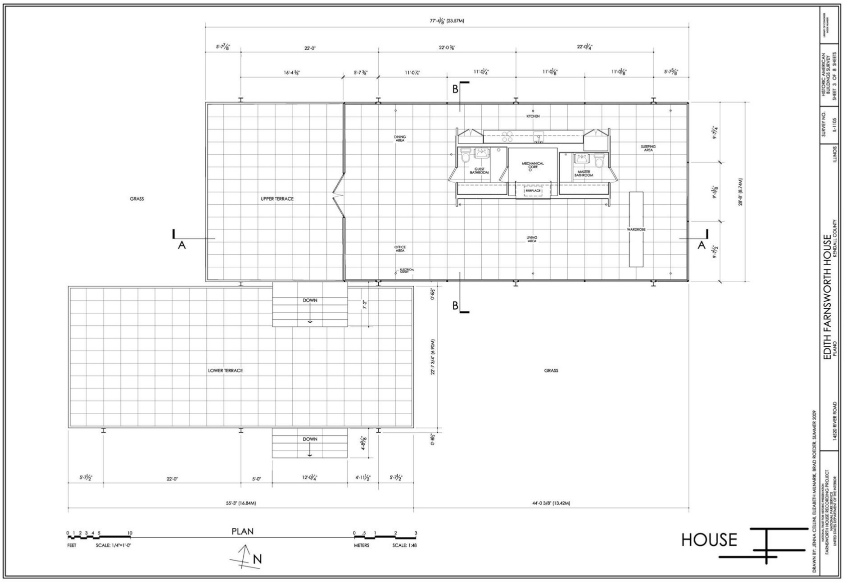


Plate 4. Eastman's problem, still visible decades later. Plan of Mies van der Rohe's Edith Farnsworth House, Plano, Illinois (1951), drawn in CAD in 2009. Even a precise digital drawing is still one view among many that must be kept consistent with the elevations and sections by hand.

Historic American Buildings Survey, HABS IL-1105, Library of Congress. Public domain.

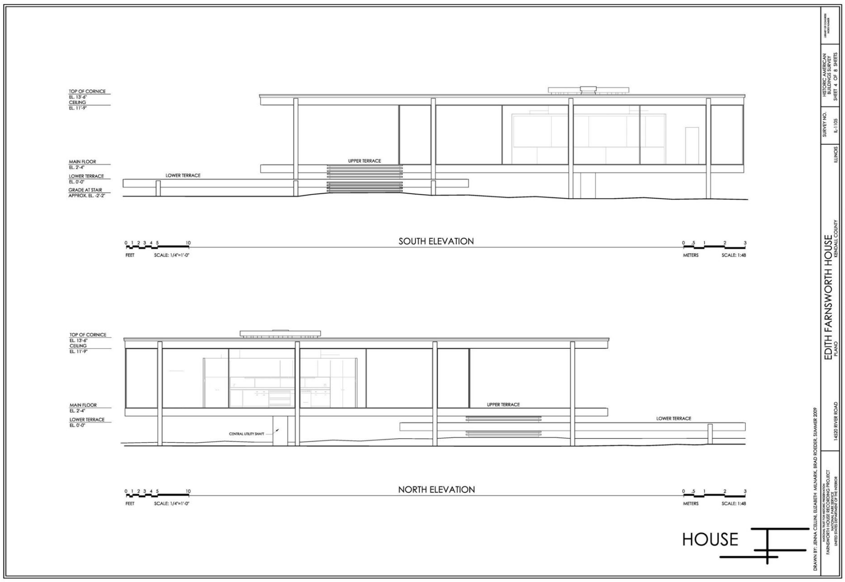


Plate 5. South and north elevations of the same house, on a separate sheet. Move a column in the plan and this drawing does not know. That is exactly the redundancy the Building Description System was designed to remove.

Historic American Buildings Survey, HABS IL-1105, Library of Congress. Public domain.

Read that list again and it describes, almost feature for feature, the pitch of every BIM vendor of the 2000s. Eastman had the concept complete. What he did not have was a computer an architecture practice could afford, a screen that could display a complex model at a usable speed, or an industry that saw any reason to change.

1970s GLIDE and solid modelling

At Carnegie Mellon Eastman also led work on GLIDE, the Graphical Language for Interactive Design, research into solid modelling that was supported by the US Army Corps of Engineers. Solid modelling, the ability to represent objects as closed volumes rather than collections of surfaces or edges, was a necessary step. A wall that is a true solid can be cut, measured and checked for intersection with a duct. A wall drawn as two lines cannot.

From research to industry, and back

In 1982 Eastman founded a start-up, Formtek, to commercialise parametric modelling, and sold it to Lockheed in 1987. The destination is telling. In the 1980s the people who could pay for information-rich product models were aerospace and defence companies, not architects. The construction industry was fragmented into thousands of small firms, worked project by project, and was paid for drawings. The technology went where the money was.

Eastman returned to academia, first at UCLA and then, from 1996 to 2018, at the Georgia Institute of Technology, where he became the field's most influential teacher. He founded the professional community ACADIA and helped establish CIB W78, the international working group on information technology for construction. In 1999 he published *Building Product Models*, and in 2008, with Paul Teicholz, Rafael Sacks and Kathleen Liston, the *BIM Handbook*, which became the standard textbook for a generation of students and practitioners.

Eastman is widely called the father of BIM, and on the evidence of the 1975 paper the title is deserved. What he never did was give the idea its name.

Charles Eastman died in November 2020. By then the idea he had described in 1975 had become an international standard, a legal requirement in several countries and a multi-billion-dollar software market. The industry did not lack the idea for forty years. It lacked the hardware first, then the incentive, and then a common language.

A MYTH WORTH CORRECTING

BIM is sometimes presented as a product of the 2000s software industry. In fact its core principles, including a single integrated database, parametric elements, derived drawings and quantity analysis, were published in 1975. What the 2000s delivered was affordability and adoption, not the concept.

3

1970S–1996

The Liverpool Line

> *While American research described the building model, a small British lineage of engineers quietly built one and used it on real projects.*

The popular history of BIM tends to leap from Eastman's research straight to Graphisoft and Autodesk. That skips one of the most interesting chapters, which unfolded in Britain and produced some of the first building modelling systems used on commercial architecture.

1970s RUCAPS

In the early 1970s two graduates of Liverpool University, Dr John Davison and John Watts, began developing a system that became known as RUCAPS. From the late 1970s it was developed and sold through GMW Computers, a company connected to the architectural practice GMW Architects, and commercial sales began in 1977. One of its early uses was on GMW's work for a large university project in Riyadh, Saudi Arabia.

RUCAPS ran on minicomputers made by Prime Computer and Digital Equipment Corporation, expensive machines far beyond the reach of most practices. What set it apart was that it did not simply store drawings. It worked with building components assembled in three dimensions, from which drawings could be produced, and it was used on large projects, including work at London's Heathrow Airport referenced in a 1986 paper by Robert Aish.

1985–86 The words "building model"

The vocabulary of BIM arrived gradually, and this lineage supplied an important piece of it. The term *building model*, in something close to its present meaning, appears in a paper written by Simon Ruffle in 1985 and published in 1986, and in a 1986 paper by Robert Aish, who was then working at GMW Computers. Aish's paper discussed the use of building modelling in construction, including the sequencing of work, an idea that later matured into what we now call 4D.

Mid-1980s Sonata and Reflex

By the mid-to-late 1980s RUCAPS was being superseded by a successor called Sonata, developed by Jonathan Ingram. Some accounts consider Sonata more advanced in its modelling approach than the PC-based tools emerging at the same time, but it still depended on expensive workstation hardware. GMW Computers was renamed T2 Solutions in 1987.

Ingram went on to develop another system, Reflex, which continued the object-based approach. In 1996 Reflex was acquired by Parametric Technology Corporation, PTC, the Massachusetts company whose Pro/ENGINEER software had brought feature-based parametric modelling to mechanical engineering in the late 1980s.

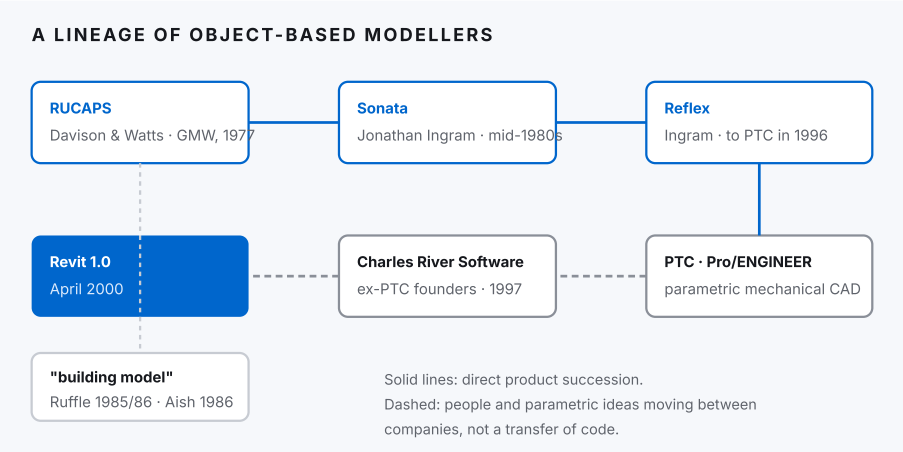


Figure 3.1. From Liverpool to Massachusetts. The British modellers and the American parametric tradition met at PTC; Revit's founders later came from PTC. Diagram by ConstruBIM based on the sources in Appendix C.

A thread through PTC

The next link in the chain should be stated carefully, because it is a link of people and ideas, not of software. PTC's Pro/ENGINEER had shown that engineers would pay for a modeller in which a change to one dimension propagated through a whole design. In 1997 two developers who had worked on Pro/ENGINEER, Leonid Raiz and Irwin Jungreis, left to found a company in Massachusetts with a simple ambition: to bring that kind of parametric modelling to buildings. Their product would be called Revit. Its story belongs to Chapter 8.

Robert Aish, meanwhile, went on to a long career in computational design. He led the development of GenerativeComponents at Bentley Systems and later DesignScript at Autodesk, work that fed into the visual and scripted design tools discussed in Chapter 12.

> **WHY THE LIVERPOOL LINE IS FORGOTTEN**
>
> RUCAPS and Sonata ran on minicomputers and workstations that only a few firms could buy, and they did not survive the move to the personal computer. History tends to remember the products that reached the mass market, not the ones that proved the idea first.

4

1982–1987

A Virtual Building in Budapest

> *The idea became software an ordinary architect could buy on the least likely side of the Iron Curtain.*

In 1982 the most important obstacle to building modelling was not intellectual. It was economic. A model-based system needed a powerful computer, and powerful computers cost as much as a small office. The breakthrough that finally put a building model on an architect's desk came from Budapest, in communist Hungary, at a time when Western computer technology was difficult and politically complicated to obtain in the Eastern Bloc.

1982 Graphisoft

Graphisoft was founded in Budapest in 1982 by Gábor Bojár. The company's first work was terrain modelling software for microcomputers, which required representing real three-dimensional surfaces efficiently on very modest hardware. That constraint turned out to be excellent preparation.

In 1984 Bojár met Steve Jobs at a trade fair in Germany. Jobs was looking for software that showed what Apple's machines could do; Bojár needed hardware good enough to run a three-dimensional building modeller. Graphisoft's early architectural software was shown running on the Apple Lisa, a commercial failure as a computer but a showcase for the program. Western computers were subject to export restrictions behind the Iron Curtain, and company accounts relate that Macintosh computers had to be smuggled into Hungary so development could continue.

Figure 4.2. An Apple Lisa (1983), the kind of machine on which Graphisoft first showed its architectural software, now at the Computer History Museum.
Marcin Wichary from San Francisco, Calif.. CC BY 2.0, via Wikimedia Commons.

From 1984 Graphisoft worked on Apple computers, and development began on an architectural product. The company's approach, which it called the **Virtual Building**, treated the design as a three-dimensional model of building elements, such as walls, slabs, roofs, doors and windows, from which plans, sections and elevations were generated.

1987 ArchiCAD

ArchiCAD was released in 1987. It is often described as the first CAD product on a personal computer able to create both 2D drawings and a 3D model from the same underlying data, and some accounts regard it as the first commercial implementation of BIM. Whether one accepts that title or reserves it for RUCAPS and Sonata, the significance is clear: ArchiCAD ran on hardware that a practice could realistically buy. It moved building modelling from the research lab and the corporate minicomputer to the architect's desk.

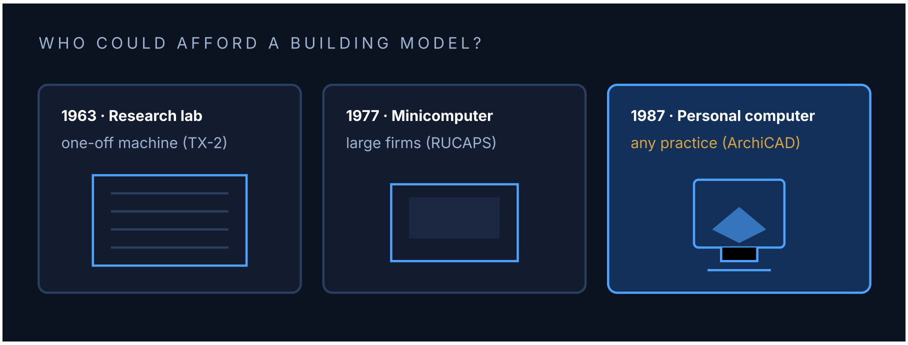


Figure 4.1. The hardware ladder. Building modelling became an industry only when it reached machines ordinary practices could buy.

The drafting detour

ArchiCAD's arrival did not trigger an immediate revolution, and the reason is instructive. The same decade saw computer-aided drafting sweep the industry. AutoCAD, launched in 1982, and Bentley's MicroStation, from a company founded in 1984 by Keith and Barry Bentley, digitised the drawing office at enormous scale. Drafting was an easy sell: it did what firms already did, faster, and it produced the deliverable clients paid for, which was a set of drawings.

Modelling was a harder sell. It demanded a different way of working, more upfront effort and more skilled people, and in return delivered benefits such as coordination, quantities and consistency that often accrued to someone else further down the supply chain. For most of the 1980s and 1990s, 2D CAD won. In hindsight it was a detour of roughly fifteen years, but it also trained a generation to design on screens, which made the eventual move to modelling possible.

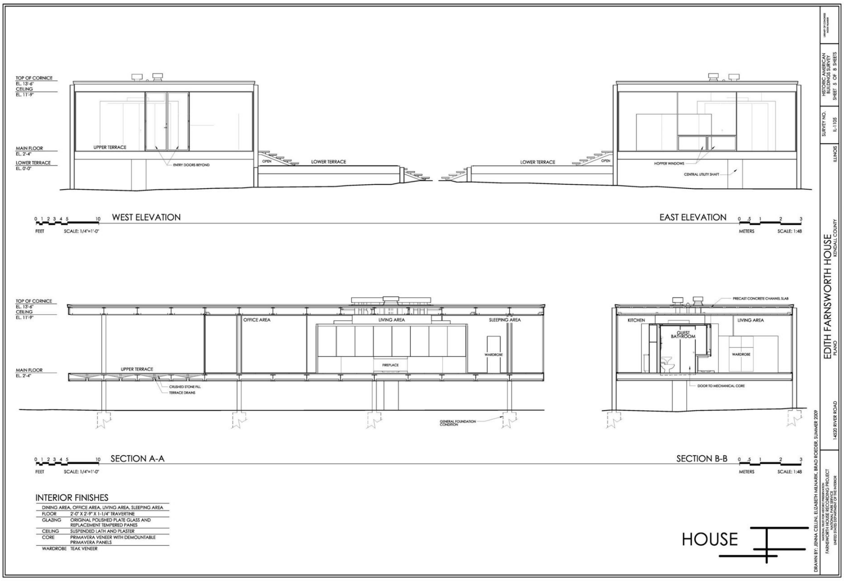


Plate 6. Drafting at its best, and at its limit. West and east elevations with sections A-A and B-B of the Farnsworth House, drawn in CAD in 2009. The work is precise, but plan, sections and elevations remain separate drawings: the 2D detour that the industry took while modelling tools waited for their moment.

Historic American Buildings Survey, HABS IL-1105, Library of Congress. Public domain.

Graphisoft afterwards

Figure 4.3. Gábor Bojár (at the lectern) unveils a statue of Steve Jobs at Graphisoft Park, Budapest, on 21 December 2011, a tribute to the Apple partnership that helped Graphisoft survive its first years.

Graphisoft became one of the great survivors of the story. It listed on the Frankfurt Stock Exchange in 1998 and was acquired by the German Nemetschek Group in 2007. Its Teamwork technology, which let several people work on one model at the same time, anticipated the collaborative workflows that cloud platforms would later make universal. Archicad, as the product is now spelt, remains one of the leading BIM authoring tools in the world, especially in Europe, Japan and among architecture-led practices.

By 1987 all the pieces of BIM existed somewhere: constraints from Sketchpad, the integrated database from Eastman, object modelling on real projects from RUCAPS, and an affordable modeller from Graphisoft. What did not yet exist was a name.

5

PART II · THE NAME AND THE MARKET · 1992

Whoever Wrote It Down First

> *The phrase "Building Information Model" was printed by two researchers in the Netherlands, a decade before any vendor used it.*

By the early 1990s the field had many names for the same idea. Researchers spoke of *product models* and *building product models*. Graphisoft marketed the *Virtual Building*. Others used phrases such as *integrated project model* or *single building model*. The concept was converging. The vocabulary was not.

1992 Delft

In 1992 two researchers, G. A. van Nederveen and F. P. Tolman, working in the Netherlands in the circle of Delft University of Technology, published a paper titled *Modelling Multiple Views on Buildings* in the journal *Automation in Construction*. Its subject was a problem that anyone who has coordinated a project will recognise: an architect, a structural engineer and a building services engineer look at the same building and need different information about it. The paper explored how one model could serve several such views.

In the course of that argument the paper used the term **Building Information Model**. It is, as far as the published record shows, the earliest documented use of the phrase. The name of the discipline that now employs millions of people was first written down not in a marketing brochure, but in an academic paper on the problem of multiple viewpoints.

A MYTH WORTH KILLING

A sentence circulates widely in tenders, training slides and even some textbooks: that BIM was "coined in 1992 by Jerry Laiserin, a British architect". It is wrong twice over.

The 1992 first use belongs to van Nederveen and Tolman. And Jerry Laiserin is an American industry analyst and writer, not a British architect. His real contribution came a decade later, and it was arguably more useful than coining a word, as the next section explains.

2002–2003 Getting competitors to use one word

For the rest of the 1990s the phrase stayed largely inside the research community. Then, around the turn of the millennium, the major software vendors converged on the idea at the same moment, each under its own banner. Autodesk had acquired Revit and was about to publish a white paper titled *Building Information Modeling*. Bentley Systems was promoting its own integrated project modelling approach. Graphisoft still spoke of the Virtual Building.

Jerry Laiserin, writing in his newsletter in 2002 and then convening a public exchange with Autodesk, Bentley and Graphisoft in 2003, argued that the industry should standardise on a single term for this shared concept, and that the term should be *Building Information Modeling*. The vendors, who were competitors with every reason to protect their own labels, broadly agreed. Laiserin helped popularise and standardise the name rather than invent it.

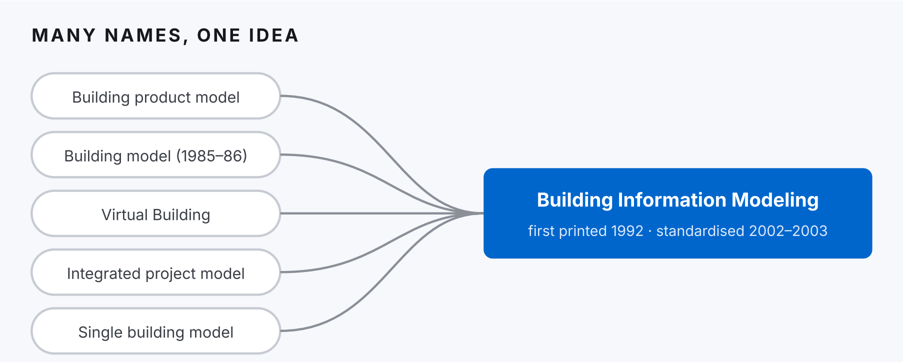


Figure 5.1. The convergence of terms. A research phrase from 1992 became the industry's common name only after the vendors agreed to share it.

Model, modelling, management

The acronym has since been stretched in several directions. *Building Information Model* is the thing: the structured digital description of an asset. *Building Information Modelling* (or Modeling, in American spelling) is the activity of creating and using it. In the 2010s some practitioners began to speak of *Building Information Management*, to emphasise that the value lies in governing information rather than making geometry. ISO 19650, the international standard discussed in Chapter 10, largely sidesteps the argument by speaking of *information management using building information modelling*. All three meanings are legitimate. The history shows why the third one eventually became necessary.

Naming a thing is easy. Getting three competitors to use the same name is the hard part, and it was the moment BIM became a market.

6

1977–2014

Borrowing the Aircraft Industry's Brain

> *Some buildings were simply impossible to describe on paper. Their architects went looking for the software that designed jets.*

While architecture spent the 1980s and 1990s drafting in 2D, the aerospace and automotive industries were modelling in 3D and building the software to do it. The most influential of those programs was CATIA.

1977 A French fighter-jet program

CATIA began in 1977 at Avions Marcel Dassault, the French aircraft manufacturer, as an in-house tool for designing aircraft. It was later commercialised by Dassault Systèmes and became one of the dominant 3D product design systems in the world. Its best-known triumph in the early 1990s was the Boeing 777, widely described as the first commercial airliner designed entirely on computer, with digital pre-assembly used to check that parts fitted before anything was built. The idea of catching clashes in a model before they reach the factory floor, which the construction industry would later adopt as clash detection, was proven first on aircraft.

Figure 6.1. The Boeing 777 prototype on display in Geneva in September 1995. The airliner was designed on CATIA with digital pre-assembly, the technique architecture would later call clash detection.

Aero Icarus from Zürich, Switzerland. CC BY-SA 2.0, via Wikimedia Commons.

Early 1990s Frank Gehry's fish

The architect Frank Gehry was famous for sculptural, curving forms that were extraordinarily difficult to draw, dimension and build using conventional documents. In the early 1990s his office, led in its technology efforts by partner Jim Glymph, adopted CATIA to translate physical models into precise digital geometry that fabricators could use. The turning point was the large fish-shaped sculpture Gehry designed for Barcelona's Olympic waterfront in 1992. Accounts of the project describe a contractor repeatedly failing to

Frank Gehry in 2006, at the Walt Disney Concert Hall in Los Angeles.

Eric Richardson. CC BY 2.0, via Wikimedia Commons.

build a mock-up from two-dimensional drawings, until Glymph turned to CATIA and the sculpture was delivered from the digital model.

The approach went far beyond visualisation. The digital model became the reference from which steel and cladding fabricators worked, reducing the ambiguity that would otherwise have made such forms prohibitively expensive or impossible to build.

Figure 6.2. *Peix*, Frank Gehry's fish sculpture at the Port Olímpic in Barcelona (1992): the project that brought aerospace modelling software into Gehry's office.

1997 Bilbao

The Guggenheim Museum Bilbao, which opened in 1997, made the method world-famous. Its titanium-clad curves could not have been delivered through a traditional drawing process at anything like the cost and time achieved. The building did something no white paper could: it showed architects, clients and contractors that a computational model could be the working heart of a complex building, not just a way to make pictures of it.

Figure 6.3. The Guggenheim Museum Bilbao (1997). Its titanium curves were engineered and fabricated from a digital model rather than from conventional drawings alone.
kallerna. CC BY-SA 4.0, via Wikimedia Commons.

Figure 6.4. Complex geometry remains the proving ground. Guggenheim Abu Dhabi, a project on which ConstruBIM has provided modelling and coordination support. Image: construbim.com.

2002–2014 Gehry Technologies and Digital Project

Gehry's office went on to design the Walt Disney Concert Hall in Los Angeles, which opened in 2003. In 2002 it spun its technology expertise into a separate company, Gehry Technologies, which developed Digital Project, an architecture and construction product built on the CATIA platform. Digital Project was used on a number of the most geometrically demanding projects of the following decade. In 2014 Gehry Technologies was acquired by Trimble.

Figure 6.5. The Walt Disney Concert Hall, Los Angeles (2003), photographed by Carol M. Highsmith in 2005. Gehry's office spun off Gehry Technologies in 2002, while the hall was under construction.

What architecture learned from aerospace

The Gehry story is sometimes treated as a curiosity: a famous architect with an unusual software habit. It was more important than that. It demonstrated three lessons that mainstream BIM would absorb over the next twenty years.

First, a model can be a contractual reference for fabrication, not merely a design aid. **Second**, digital pre-assembly, the ancestor of clash detection, saves more money than it costs when the geometry is difficult. **Third**, the construction supply chain, including steel fabricators, curtain wall specialists and precast manufacturers, is ready to work directly from models when someone gives them a reliable one.

A DIFFERENT LINEAGE FROM REVIT AND ARCHICAD

Mechanical and aerospace modellers such as CATIA are excellent at precise geometry and manufacturing, but they were not built around building semantics such as spaces, storeys, systems and room data. That is why complex-geometry projects today often combine tools: a computational or surface modeller for form, a BIM authoring tool for documentation and information, and open standards to link them.

Bilbao proved that the model could build the building. It took another decade for ordinary buildings to adopt the same idea.

7

1994–2024

Teaching Models to Talk

> *A model locked in one vendor's file solves one office's problem and creates everyone else's.*

By the mid-1990s it was clear that the construction industry would never run on a single piece of software. An architect, a structural engineer, a mechanical designer, a steel fabricator, a cost consultant and a facility manager each needed specialised tools. If their models could not exchange information, the paper problem would simply reappear in digital form, with each discipline re-entering data from the others' drawings.

1994 A consortium of twelve

In 1994 Autodesk convened a consortium of twelve US companies, including the telecoms firm AT&T, the HVAC manufacturer Carrier, the controls company Honeywell and the architecture practice HOK, to explore how software applications used in building could share data. The group gave its first public technology demonstration at the A/E/C SYSTEMS '95 trade show in Atlanta in June 1995, and in September 1995 opened membership to any interested organisation.

The members quickly concluded that a standard controlled by one vendor would never be trusted by the others. In 1996 the organisation was renamed the **International Alliance for Interoperability**, the IAI, and committed to non-proprietary standards. Competitors including Bentley and Nemetschek joined.

1996–97 The Industry Foundation Classes

The IAI's central product was a data model called the **Industry Foundation Classes**, IFC. The first version was released in the mid-1990s. IFC did not come from nowhere. It borrowed heavily from STEP, the international standard for exchanging product data in manufacturing (ISO 10303, first published in 1994), including STEP's EXPRESS language for defining data schemas.

IFC defines, in a vendor-neutral way, what a wall, a slab, a space, a pipe segment or a storey is, what properties it can carry and how elements relate to one another. A wall exported to IFC from one application can be read by another as a wall, with its type, materials, properties and relationships, not just as a collection of triangles.

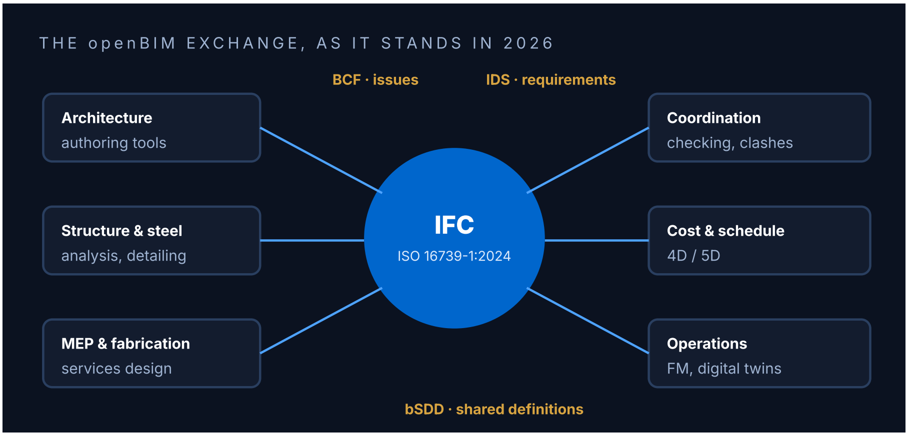


Figure 7.1. Open exchange. IFC carries the model; BCF carries coordination issues; IDS states machine-checkable information requirements; the buildingSMART Data Dictionary (bSDD) publishes shared definitions. Diagram by ConstruBIM.

2005 buildingSMART

In 2005 the IAI renamed itself **buildingSMART**, partly because members found the old name long and hard to explain. The organisation became the custodian of what is now called openBIM: IFC and a family of related standards and services, developed by volunteers from software companies, clients, consultants and universities through national chapters around the world.

From schema to international standard

IFC matured through several major versions. **IFC2x3**, released in 2006, became the long-lived workhorse of the industry and is still encountered on many projects. **IFC4** followed in 2013, and in the same year IFC became an international standard, **ISO 16739**. That institutional step mattered as much as any technical improvement: from 2013 a client could require open exchange of building data in a contract by citing an ISO standard.

The next great extension was infrastructure. **IFC 4.3** added the entities needed to describe roads, railways, bridges, ports and waterways, including alignments along which such assets are laid out. It was published as **ISO 16739-1:2024**, turning IFC from a buildings standard into a standard for the built environment as a whole.

The supporting cast

Exchanging models turned out to be only part of the problem. Teams also needed to exchange *issues about* models without sending the model itself. Development of the **BIM Collaboration Format**, BCF, began in 2009, initiated by the software companies Solibri and Tekla; a BCF topic carries a title, status, assignee, comments and a camera viewpoint that points at specific elements.

Clients needed to state what information they required in a form software could check. The **Information Delivery Specification**, IDS, an XML standard for machine-readable information requirements, was approved by buildingSMART as version 1.0 in 2024. And everyone needed shared definitions of properties and classifications, which the **buildingSMART Data Dictionary**, bSDD, provides as a public online service.

> **OTHER EXCHANGE STANDARDS OF THE PERIOD**
>
> IFC was not alone. CIS/2, a standard for exchanging structural steel models, was approved by the American Institute of Steel Construction in 2000. gbXML was developed for exchanging building geometry with energy analysis tools. COBie, described in Chapter 9, focused on handover data for facility managers.

IFC's great achievement is institutional, not technical: it turned "please send us your model" into something a client can specify, audit and enforce.

8

1997–2007

Revise Instantly

> *A small start-up in Massachusetts built a modeller around one promise: change anything, anywhere, and everything else follows.*

The event most people associate with BIM going mainstream is the rise of Revit. The story begins, as Chapter 3 described, with parametric mechanical engineering.

1997 Charles River Software

On 31 October 1997 Leonid Raiz and Irwin Jungreis, who had both worked as developers on PTC's Pro/ENGINEER, founded Charles River Software in Newton, Massachusetts. Their goal was to apply the parametric modelling that had transformed mechanical CAD to the building industry. Unlike mechanical parts, buildings are made of a vast number of elements with constant relationships between them: walls hosted on levels, doors hosted in walls, dimensions tied to grids, schedules tied to everything. The founders designed their software so that a change anywhere would propagate everywhere, in every view, in every sheet and every schedule.

In January 2000 the company renamed itself Revit Technology Corporation. The product name was a contraction of *revise instantly*, which described the pitch precisely.

2000 Revit 1.0

Revit 1.0 was released on 5 April 2000, and new versions followed rapidly over the next two years. It was not the first building modeller, as the previous chapters make clear, but it arrived at the right time. Personal computers had become powerful enough to handle large parametric models, and a generation of architects fluent in 2D CAD was ready for something better.

2002 Autodesk buys the future

In 2002 Autodesk, the dominant supplier of 2D drafting software, acquired Revit Technology Corporation for US$133 million. It was a striking decision: Autodesk's own AutoCAD business had helped entrench the 2D drafting workflows that Revit was designed to replace.

In the same year Autodesk published its white paper *Building Information Modeling*, and, as Chapter 5 described, Laiserin's campaign helped the industry settle on that term.

From that point BIM stopped being a research programme and became a product category, with everything that implies: large investment, fast improvement, aggressive marketing, and claims that often outran what the software could actually do on a real project.

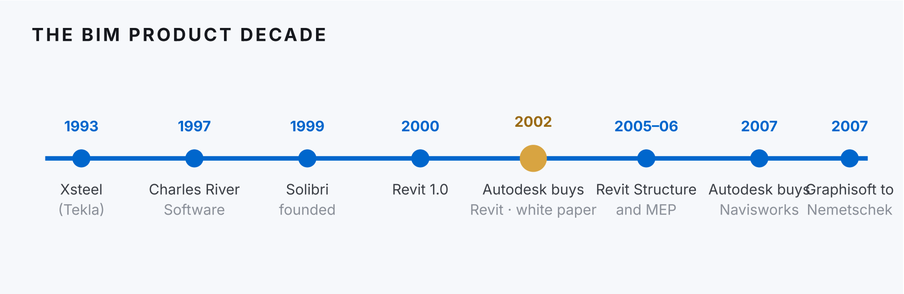


Figure 8.1. Between the mid-1990s and 2007 the tools that define most BIM workflows today were founded, released or consolidated.

The disciplines arrive

Revit began as an architectural tool. Revit Structure was introduced in 2005 and Revit MEP in 2006, when the original product was renamed Revit Architecture. In 2013 the three were unified again into a single Revit product. The progression mirrored the industry's realisation that BIM only pays off fully when every discipline models in a coordinated way.

Other disciplines had their own pioneers. The Finnish company Tekla released the structural modeller Xsteel in 1993, which became Tekla Structures and one of the leading tools for steel and concrete detailing. Trimble acquired Tekla in 2011. Bentley Systems built a broad portfolio for buildings and, above all, infrastructure on its MicroStation platform.

2000s The clash detection era

If modelling was the promise of BIM, coordination was where it first paid for itself on ordinary projects. A software product originally called JetStream, developed in Sheffield in the United Kingdom, became Navisworks: a tool that could combine large models from many sources into one federated view, navigate it smoothly on an ordinary computer and detect where elements collided. Autodesk acquired Navisworks for US$25 million on 1 June 2007.

At the same time Solibri, founded in Finland in 1999, developed rule-based model checking, which looked not only for physical clashes but for missing information, incorrect classifications and breaches of design rules. It was acquired by the Nemetschek Group in 2015.

Clash detection transformed the coordination meeting. Instead of overlaying drawings on a light table, teams walked through a federated model and assigned hundreds of issues before anything reached site. For many contractors this, rather than design authoring, was the first unarguable return on investment in BIM.

FROM THE CONSTRUBIM FIELD NOTES

On large coordination programmes the software is rarely the constraint. The constraint is whether every discipline's model follows the same levels, grids, units, origins and naming. A clash report built on inconsistent models produces thousands of false issues. The discipline of setting those rules first, now written into ISO 19650, was learned the hard way during this decade.

Revit made building models fast to change. Navisworks and Solibri made them worth checking. Together they turned BIM from an architectural idea into a construction method.

9

PART III · THE INSTITUTIONS · 2003–2013

The Owners Take Notice

> *Vendors can make software. Only clients can make an industry change the way it works.*

By the early 2000s BIM had a name, a market, open standards in development and a growing list of impressive projects. It still had a problem. The people who paid for most construction, the building owners, had little reason to demand it. Designers bore the cost of modelling. Contractors and owners enjoyed much of the benefit. Until someone at the top of that chain asked for models, adoption would remain uneven.

The first large owners to ask were public bodies that own and operate enormous estates for decades, and who therefore feel the cost of bad information more than anyone.

2003 The US General Services Administration

The US General Services Administration, which builds and manages federal buildings across the United States, launched its National 3D-4D-BIM Program in 2003. Its Public Buildings Service began requiring BIM for spatial program validation on major new projects from fiscal year 2007, so that the space requirements a client set could be checked directly against the design model rather than by counting rooms on drawings. The GSA published a series of BIM guides covering subjects such as spatial validation, laser scanning, energy performance and circulation, which were widely read far beyond federal projects.

2007 The Nordic clients

Around the same time several Nordic public clients began requiring models, and in particular open IFC models. In Finland the state property agency Senate Properties introduced BIM requirements for its projects in 2007. Danish state clients moved in a similar direction in the same period, and Norway's public construction agency Statsbygg became a prominent advocate of IFC. These clients cared less about which software their consultants used and more about receiving information they could keep, check and reuse. Their insistence on open formats did a great deal to make IFC a practical reality.

2007 COBie and the handover problem

One of the most expensive failures of the paper era happened at the very end of a project. At handover, owners received boxes, and later discs, of drawings, manuals and spreadsheets from which their facilities teams had to re-type asset information into maintenance systems. Much of it was never captured at all.

In 2007 Bill East, a researcher at the US Army Corps of Engineers' Construction Engineering Research Laboratory, created **COBie**, the Construction Operations Building information exchange. COBie replaced the paper handover with structured data about spaces, equipment types, components, systems, documents and warranties, delivered progressively during the project. Its genius was modesty: COBie can be delivered as an ordinary spreadsheet as well as through IFC, so a facilities manager with no BIM software can still use it. COBie was approved as part of the US National BIM Standard in December 2011, and in the UK its code of practice was published as BS 1192-4 in 2014.

2007 A national standard for the United States

The first part of the **National BIM Standard – United States**, NBIMS-US, was published in 2007 through the National Institute of Building Sciences. Rather than prescribing software, it gathered consensus practices, reference standards and information exchanges into a single framework. It has been revised several times since; Version 4 was unveiled in 2023.

1988 A research centre for integrated practice

Much of the academic groundwork was laid at Stanford University's Center for Integrated Facility Engineering, CIFE, founded in 1988 with Paul Teicholz, a construction information technology pioneer, as its first executive director. CIFE brought researchers and industry members together around what it called virtual design and construction, and trained a stream of doctoral students who carried four-dimensional, schedule-linked building models into practice.

2008 The textbook

In 2008 Charles Eastman, Paul Teicholz, Rafael Sacks and Kathleen Liston published the *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*. It gave the field a shared reference, organised by the roles of the people involved rather than by software, and it trained a generation of students and professionals. Its subtitle is itself a small history lesson: by 2008 BIM had become something every party to a project had to understand.

2004–2013 How developed is "developed"?

As models were exchanged between parties, a new kind of dispute emerged. If an architect sends a model to a contractor, how far can the contractor rely on it? Is a duct in the model a real routing decision or a placeholder? The answer the industry developed was the **Level of Development**, LOD.

The idea grew out of work at Vico Software in the mid-2000s on describing model progression. The American Institute of Architects formalised levels from LOD 100 to LOD 500 in its E202 document in 2008, and from 2013 the BIMForum in the United States published an element-by-element LOD Specification that interprets those levels for each building system. In Europe and in ISO 19650 the concept later evolved into the **Level of Information Need**, which asks not "how detailed is this element?" but "what geometry, data and documentation is needed, for which purpose, at which milestone?" That approach became an international standard as ISO 7817-1 in 2024.

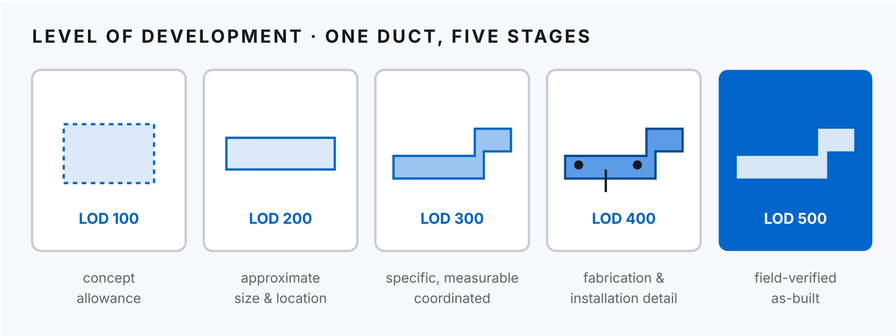


Figure 9.1. The LOD ladder, simplified. The levels describe how far other parties can rely on an element, not how pretty it is. LOD 350 was later added for coordination interfaces. Diagram by ConstruBIM.

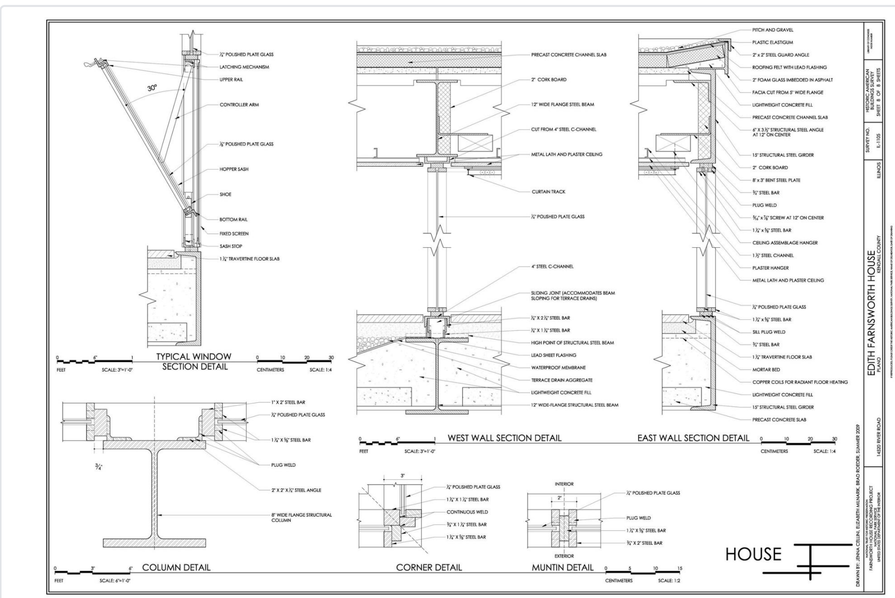


Plate 7. What "detail" used to mean. Wall, window and column details of the Farnsworth House (2009 survey): typical window section, wall sections and corner details. In a BIM process much of this information moves into the model elements themselves, which is what the higher levels of development describe.

Historic American Buildings Survey, HABS IL-1105, Library of Congress. Public domain.

2006 Early adopters in Asia

Public housing and building authorities in Asia were also early movers. The Hong Kong Housing Authority introduced BIM in 2006 to improve the design of its very large programme of public housing. Singapore's Building and Construction Authority began building the policy framework that would, in the following decade, make it one of the first places in the world to require BIM for regulatory submissions.

The owners' contribution was not technical. It was to ask for information they could keep, and to keep asking until the supply chain delivered it.

10

2008–2025

When Governments Started Asking

> *Adoption curves in construction bend when someone with a very large budget insists.*

If one country turned BIM from a good idea into a condition of doing business, it was the United Kingdom. The British approach was notable not for inventing new technology but for treating BIM as an instrument of public policy, with a clear target date, a public description of what compliance meant and a set of freely available standards to go with it.

2008 The wedge

In 2008 Mark Bew and Mervyn Richards drew a simple diagram that became one of the most reproduced images in the history of BIM. The BIM maturity model, often called the Bew–Richards wedge, described a progression from Level 0, unmanaged CAD drawings exchanged on paper, through Level 1, managed CAD with some 3D and shared file structures, to Level 2, collaborative working in which each discipline produces its own model and exchanges information in a common format and environment, and finally Level 3, a fully integrated and interoperable model shared by all parties.

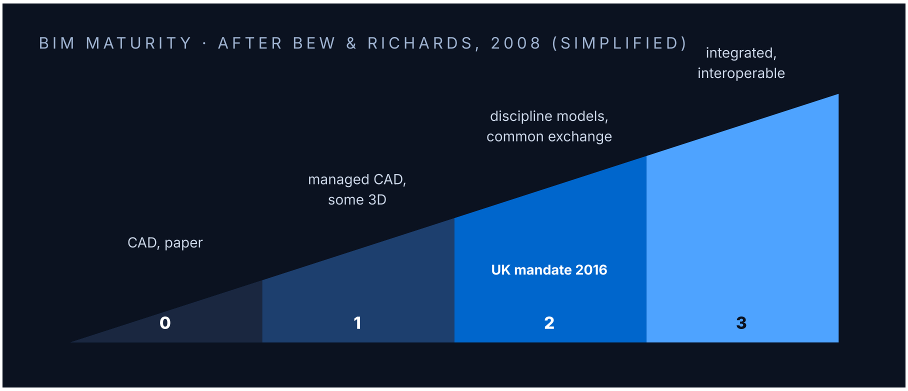


Figure 10.1. The maturity wedge. Level 2 became the UK government's target. Today ISO 19650 has replaced "levels" with a description of information management processes. Redrawn by ConstruBIM.

2011 The mandate

In May 2011 the UK government's Chief Construction Adviser, Paul Morrell, called for BIM to be adopted on public projects. In June 2011 the government published its Construction Strategy, which required fully collaborative 3D BIM, meaning Level 2, on centrally procured public projects by 2016. A BIM Task Group was established to help government departments and their supply chains get there.

The strategy's timing was deliberate. It gave the industry five years' notice, enough to invest and train, with a date that concentrated minds. And because the requirement was defined by process rather than by software, it did not favour any vendor.

2013–2015 The PAS 1192 series

To say what Level 2 actually meant, the UK published a series of freely available specifications. **PAS 1192-2:2013** defined how information should be specified, produced and managed during the delivery of a project: employer's information requirements, BIM execution plans, delivery plans and a common data environment with defined states. **PAS 1192-3:2014** extended the approach to the operational phase and the asset information model. **BS 1192-4:2014** codified COBie. **PAS 1192-5:2015** became the first specification to address security in BIM, asking owners of sensitive assets to consider what their models revealed.

These documents shifted the conversation decisively. BIM was no longer described by software features but by responsibilities: who requires what information, when, in what structure, and who checks it.

2014–2023 The world follows

Public procurement rules in Europe opened the door for others. The European Union's public procurement directive of 2014 allowed member states to require electronic tools such as building information modelling on public works. An EU BIM Task Group of public-sector representatives published a handbook for introducing BIM in the European public sector in 2017.

National programmes multiplied, each shaped by local conditions:

2013–15	**Singapore** · BIM e-submission phased in for architectural plans from 2013, engineering plans from 2014 and all new projects over 5,000 m² from 2015. Its successor system, CORENET X, followed in the 2020s.
2014–15	**Dubai** · Dubai Municipality Circular 196 (2014) required BIM for large and complex buildings; Circular 207 (2015) widened the scope.
2014	**France** · The Plan Transition Numérique dans le Bâtiment was announced in December 2014, focusing on experimentation, training and adoption by smaller firms.
2015	**Germany** · The federal transport ministry's Stufenplan (December 2015) set a path to BIM on new federal transport infrastructure from the end of 2020.
2018	**Italy** · A government decree phased in BIM requirements for public works, reaching full scope by 2025.
2018	**Hong Kong** · BIM required on government capital works projects above HK$30 million from 1 January 2018.
2018	**Saudi Arabia** · Requirements arrived through client standards rather than a single national mandate, beginning with BIM standards from the Royal Commission for Riyadh City and later the giga-projects.
2019	**Mexico** · The Ministry of Finance published a national strategy for implementing BIM (Modelado de Información de la Construcción) on federal investment projects in March 2019, with a phased eight-year roadmap.
2023	**Japan** · BIM announced as a requirement for public works from fiscal year 2023.

The United States took a different path. There is no single federal mandate; instead, large owners such as the GSA, the US Army Corps of Engineers, state transport departments and major universities set their own requirements, supported by NBIMS-US.

2018 ISO 19650: BIM grows up

The UK approach was then internationalised. In 2018 the first two parts of **ISO 19650** were published, with national adoptions such as BS EN ISO 19650 following into early 2019. Part 1 sets out concepts and principles; Part 2 describes the delivery phase of assets. The series continued with Part 3 on the operational phase and Part 5 on security in 2020, Part 4 on information exchange in 2022, and Part 6 on health and safety information in 2025. The UK consolidated its guidance into the UK BIM Framework, and the Level 2 language gradually gave way to the vocabulary of ISO 19650.

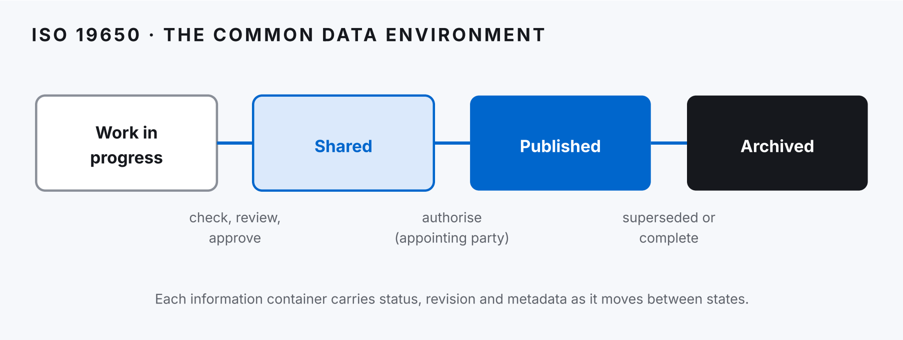


Figure 10.2. The information states of a common data environment. The same principle, controlled movement of information from team work to authorised record, underlies every CDE platform.

ISO 19650 is the point at which BIM stops being about software at all. It is an information management standard: organisational, asset, project and exchange information requirements; appointments and responsibility matrices; delivery plans; the common data environment and its approval states; and naming, metadata and security. It does not mention which modelling tool anyone should use.

Sixty years after Sketchpad, the defining BIM standard is not about geometry. It is about who is accountable for information.

11

2011–2026

Models the Size of Cities

> *At a certain scale, drawings cannot hold a project together. The information itself has to be engineered.*

The 2010s were the decade of the megaproject model. Airports, rail networks, hospitals, stadiums and entire urban districts were delivered by teams that could number in the thousands, spread across countries and time zones. On such programmes BIM stopped being an optional productivity tool. It became the only practical way to keep hundreds of design packages, fabricators and contractors working from the same version of the truth.

This is also the part of the story in which ConstruBIM's own teams took part. We have tried to report our projects the way we report everyone else's: with what was done, what was measured and what it taught, rather than with adjectives.

2011 The Soumaya Museum, Mexico City

The Soumaya Museum in Mexico City is one of the city's most recognisable buildings: an asymmetric, curving volume wrapped in a shimmering skin of hexagonal panels. It is a direct descendant of the Gehry lesson in Chapter 6. A form like this cannot be clad from drawings alone; every panel is a different shape in a different position.

The museum, designed by the architect Fernando Romero, also closes a loop with Chapter 6: Gehry Technologies was retained to coordinate the complex three-dimensional engineering using its Digital Project software, and the facade contractor used laser surveys of the built structure to adapt the model to the real shape of the frame, an early example of reality capture feeding the model on site.

ConstruBIM's work on the project involved BIM-driven fabrication coordination for the facade, from concept geometry through to installation, for **14,808 unique hexagonal panels**, alongside a federated architectural, structural and MEP model. The model was not an illustration of the facade. It was the facade's manufacturing and installation reference.

Figure 11.1. Soumaya Museum, Mexico City (2011). Its facade of hexagonal aluminium panels required model-based fabrication coordination.

Gadi-kab. CC0, via Wikimedia Commons.

2015–2016 NAICM, the new Mexico City International Airport

The new Mexico City International Airport, known by its Spanish acronym NAICM, was one of the most ambitious aviation programmes of its era, with a terminal of around **743,000 m²** whose flowing roof structure required architecture, structure and building systems to be resolved together rather than in sequence.

ConstruBIM's approach was a single federated BIM model that unified the work of dozens of disciplines. At the time it was the largest federated BIM model in the world. Around the model the team ran a common data environment with controlled workflows for how information was created, checked, approved and shared, the same governance principles that ISO 19650 would formalise internationally two years later.

Three details from the project record show how far BIM had travelled from the drafting office:

A model as a database. The structural model alone held some **26 million structural nodes** in a single database. **Drawings as a by-product.** More than **10,500 drawings** for the construction-document set were generated automatically from the model, which is Charles Eastman's 1975 argument delivered at airport scale. **Clashes prioritised by data.** A custom clash-detection clustering tool grouped thousands of clashes by spatial concentration, so that teams resolved the densest conflicts first instead of working through an undifferentiated list.

In 2015 ConstruBIM also established a dedicated BIM command centre on the construction site, putting the model at the centre of daily site decisions rather than behind office doors; the company describes it as the first of its kind. In 2016 the programme received an **Autodesk AEC Excellence Award**.

History did not treat the airport kindly. Following the change of government in 2018, the project was cancelled before completion. But the delivery system it proved, a federated model governed by a common data environment and used on site every day, did not disappear. It became the template for how large programmes are run.

Figure 11.2. NAICM, Mexico City. At the time, the largest federated BIM model in the world; Autodesk AEC Excellence Award 2016. Image: construbim.com.

Command centres, war rooms and federated truth

The megaproject years changed the physical workplace of BIM. Coordination moved from meeting rooms with printed markups to rooms built around large screens, where federated models were navigated live with designers, contractors and clients present. Issues were assigned in software, tracked to closure and reported as data. Across the world, rail programmes, hospitals and airports adopted variations of the same pattern.

2020s Giga-projects and the governance turn

In the Gulf, a new generation of giga-projects pushed the scale further still, often to the size of cities. On such programmes the challenge was no longer only coordinating models but governing information across hundreds of appointed parties, each with their own software, standards and contracts.

ConstruBIM has led digital delivery at **NEOM** in Saudi Arabia, where the work centres on governance: BIM execution plans, information requirements and common data environment workflows at a scale few teams ever face. On **Guggenheim Abu Dhabi**, the challenge is the older one of complex geometry and high coordination demand across many stakeholders. And on projects of every size, from the **HGA Hospital in Acapulco**, where the BIM model served as the primary source of information for coordination and execution, to the **GAIA Residences in Limassol**, a five-building complex of 150 apartments delivered with coordinated BIM and shop drawings, the same frame of work applies.

WHAT THE MEGAPROJECT YEARS TAUGHT US

1. Federation beats merger. Keep each discipline's model owned by its author and combine them for coordination; do not try to force everyone into one file.

2. Agree the rules before the first element. Coordinates, levels, naming, units and classification decide whether a clash report means anything.

3. Put the model where decisions happen. A model that only lives in the design office is a drawing with extra steps.

4. Measure information, not geometry. The questions that matter are whether the right data is present, checked and approved on time.

The megaprojects did not invent new BIM ideas. They proved that the old ones, from Eastman's database to IFC's open exchange, work at the scale of a city.

12

PART IV · THE LIVING MODEL · 2007–2026

Code, Cloud and the Open Web of Data

The model left the file. It became a database, a script, a shared platform and, finally, a set of open services.

For most of its history a building model lived in a file on somebody's computer. In the years after 2007 three forces pulled it out of that file: designers who wanted to program their models, cloud platforms that let everyone work on one shared set of information, and open standards that let data move between services on the web.

2007 Visual programming for designers

In 2007 David Rutten, working at Robert McNeel & Associates, released a plug-in for the Rhino modeller originally called Explicit History. Renamed **Grasshopper**, it let designers build algorithms by connecting components on a canvas instead of writing code. A generation of architects used it to explore forms that responded to rules, sunlight, structure or fabrication limits. Sutherland's constraints of 1963 had become a visual programming language.

The BIM authoring world followed. **Dynamo**, begun by Ian Keough as an open-source visual programming project for Revit, appeared in beta form around 2011 and was adopted and developed by Autodesk. It absorbed ideas from DesignScript, the design language Robert Aish had led at Autodesk, and became the everyday automation tool of many BIM teams: renumbering rooms, placing thousands of elements, checking data, and exporting information that the standard user interface could not reach. Scripting frameworks such as pyRevit and links such as Rhino.Inside.Revit, which runs Rhino and Grasshopper inside Revit, blurred the line between computational design and documentation.

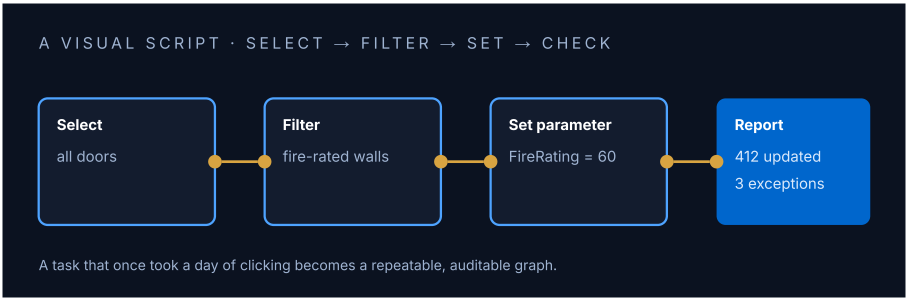


Figure 12.1. The logic of visual programming in BIM. Illustrative example drawn by ConstruBIM.

2010s The model moves to the cloud

The second force was the cloud. Through the 2010s project teams moved from shared network drives and emailed files to web platforms that hosted models, drawings, issues and approvals in one governed place. Autodesk's BIM 360 services, its acquisition of the construction software company PlanGrid in 2018 and the Autodesk Construction Cloud assembled from 2020 were one path; in 2026 those construction products are part of Autodesk's Forma family. Bentley's ProjectWise, Trimble Connect, Procore, Oracle Aconex, Dalux, Catenda and many others offered their own. Collaborative model editing in the cloud, which Graphisoft's Teamwork had anticipated decades earlier, became routine.

These platforms are the practical implementation of the common data environment described in ISO 19650. Their value is not storage. It is control: knowing which version of which model was approved, by whom, for what purpose, and who is working on what right now.

2020–2023 Early design becomes computational

Generative and analytical tools reached the earliest stages of design. Autodesk acquired the Norwegian company Spacemaker in 2020, and its technology became the basis of Autodesk Forma, launched in 2023, which lets planners and architects test site layouts against sunlight, wind, noise and density before a building model exists. Other tools such as TestFit and Hypar automated feasibility studies. The idea that design options could be generated and evaluated by software, rather than drawn one at a time, moved from research into practice.

2022–2026 Models as services

The third force was the open web. Autodesk renamed its developer platform Forge as Autodesk Platform Services in 2022, exposing model data through web APIs. Open-source projects such as Speckle, which grew out of academic research, and IfcOpenShell with its Blender-based authoring tool Bonsai, made it possible to stream, query and edit building data without a single dominant desktop program. That Open Company (formerly IFC.js) and xeokit brought IFC models directly into web browsers.

At the same time the open standards described in Chapter 7 matured into a connected system: IFC 4.3 extended to infrastructure as ISO 16739-1:2024; IDS 1.0 made information requirements machine-checkable in 2024; and the buildingSMART Data Dictionary gave properties and classifications stable web addresses. A client can now write a requirement once, as an IDS file referencing bSDD definitions, and have every delivered IFC model checked against it automatically.

> **FROM FILE TO FACT**
>
> In the file era, the question was "which file is the latest?" In the service era, the question becomes "which fact is authoritative?" That shift, from managing documents to managing data, is still under way in 2026 and explains much of what the next chapter describes.

Eastman's single integrated database finally exists, though not as one program. It exists as a federation of models, platforms and open standards held together by governance.

13

2002–2026

From Model to Twin

> *A building's model used to be finished when the building was. Now the building's life is where the model begins to earn its keep.*

For most of BIM's history the model served design and construction, and then, at handover, it was archived. Yet the operating phase of a building lasts decades and accounts for most of its lifetime cost. The last chapter of the story, still being written, is about keeping the model alive after the contractor leaves.

2000s–2020s Capturing reality

A living model needs to know what was actually built, not only what was designed. Terrestrial laser scanners, which measure millions of points per second, moved from specialist surveying into building projects through the 2000s. The resulting point clouds let teams verify existing conditions, check construction against the design and create as-built models, a workflow now known as scan-to-BIM. The vendor-neutral E57 format, published as an ASTM standard in 2011, allowed point clouds to move between tools. Photogrammetry from drones and phones, mobile mapping systems and 360-degree cameras then made capture faster and cheaper, so that some sites are now recorded every week.

2002 The idea of a twin

The term *digital twin* did not come from construction. The concept is usually traced to Michael Grieves, who presented the idea of a virtual representation linked to a physical product during work on product lifecycle management at the University of Michigan around 2002. NASA used the term in its technology roadmaps around 2010 for spacecraft. The built environment adopted it in the late 2010s.

In the United Kingdom the Centre for Digital Built Britain published the **Gemini Principles** in December 2018, setting out values for a national digital twin: that twins should have a clear public purpose, be trustworthy and function through open, secure data. ISO 19650-3, published in 2020, defined how the asset information model is maintained during operation.

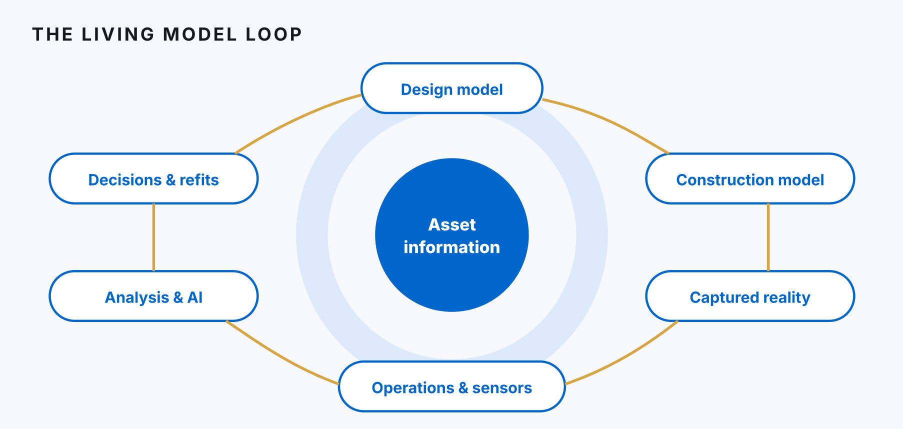


Figure 13.1. The model does not end at handover. Information flows from design and construction into operations, is refreshed by captured reality and sensor data, and informs the next decision about the asset. Diagram by ConstruBIM.

2018–2026 Twin platforms

Software for operational twins arrived around the turn of the 2020s. Bentley Systems introduced its iTwin platform in 2018. Autodesk launched Tandem in the early 2020s, aimed at turning handover data into an operational twin. Established facilities and asset management systems such as IBM Maximo, Archibus and Planon added BIM and IFC integration, while smart-building platforms connected models to building management systems and Internet of Things sensors. In practice most twins in 2026 are modest and useful: a trustworthy register of assets and spaces, linked to live data for a few critical systems. That is a good start, and far more than the boxes of paper that COBie was created to replace.

2020s The arrival of artificial intelligence

The newest force acting on BIM is artificial intelligence, and it is too early to write its history with confidence. Several strands are visible in 2026. Computer vision compares 360-degree site imagery with the model to measure progress automatically. Machine learning helps classify elements, clean point clouds and cluster clashes. Generative tools produce layout options and render concept images from models.

Most recently, conversational assistants have begun to appear inside authoring tools themselves. Autodesk introduced an AI assistant as a technical preview in Revit 2027, and Trimble previewed a model assistant for Tekla Structures in its 2026 releases. These assistants can answer questions about a model, automate routine edits and connect to other systems through open protocols.

Construction robotics is advancing in parallel: layout robots that print floor plans directly onto slabs from the model, drilling robots guided by BIM coordinates, and legged robots carrying scanners through sites on a schedule. Augmented reality headsets, which once promised to overlay models on every site, have had a more uneven path; Microsoft stopped manufacturing its HoloLens 2 at the end of 2024, even as tablet- and phone-based AR continues to be used.

> **A CAUTION FROM SIXTY YEARS OF HISTORY**
>
> Every generation of BIM technology has been sold with promises that ran ahead of practice. AI will be no different. An assistant can only be as reliable as the information it reads. The organisations that benefit first will be the ones whose models are already structured, classified and governed, which is to say, the ones that took ISO 19650 seriously.

The model has become a living thing: captured, checked, queried, updated and, increasingly, conversed with. Whether it can be trusted is still a human decision.

EPILOGUE

What Sixty Years Teach

The geometry was never the hard part.

Look back across the whole story and a pattern appears that is easy to miss when you are inside it. Almost every important idea in BIM arrived long before the industry was ready to use it. Constraints and instances in 1963. The integrated building database in 1975. Object-based modelling on commercial projects in the late 1970s. The phrase *Building Information Model* in 1992. Open exchange in the mid-1990s. Each waited years, sometimes decades, for hardware, incentives and institutions to catch up.

That pattern teaches five lessons that matter on any project today.

1. The modelling problem was solved long ago. The information problem was not.

Every generation of software has been better at geometry than the last. The recurring failure has stayed the same: nobody defined what the model was for, so it was built to no particular standard and served no particular decision. That is the gap ISO 19650 addresses, and it is why good information requirements usually pay back faster than more modelling capacity.

2. Adoption follows whoever pays.

Research did not spread BIM, and neither did marketing. Clients did: the GSA, the Nordic state agencies, the UK government, Singapore, Dubai, the giga-projects. If you want better information on your projects, write it into the appointment.

3. Open standards outlive products.

RUCAPS, Sonata and Reflex are gone. Products are renamed, acquired and retired every year, and even in 2026 several of the names in this book changed. IFC, BCF, COBie and ISO 19650 persist because nobody owns them. Information that must survive a building's lifetime should live in open formats.

4. Be suspicious of confident claims.

If the widely repeated story of who coined the term BIM can be wrong twice in one sentence and still circulate freely, treat confident claims about BIM maturity, levels and return on investment with the same care. Ask for the source.

5. A model is only as alive as the people who maintain it.

The title of this book is a promise and a warning. A model can carry a building's information from its first sketch to its final refurbishment, but only if someone owns it, checks it and keeps it true. Software makes that possible. It does not make it happen.

APPENDIX A

Timeline of BIM, 1962–2026

Key dates referred to in this book. Dates of software releases and standards are the earliest documented dates in the sources listed in Appendix C.

1957	Patrick Hanratty's PRONTO numerical-control programming system, an ancestor of CAD/CAM.
1962	Douglas Engelbart's *Augmenting Human Intellect* describes an architect designing at a computer.
1963	Ivan Sutherland's Sketchpad at MIT: light pen, geometric constraints, master and instance.
1967	Charles Eastman joins Carnegie Mellon University.
1970s	RUCAPS developed by John Davison and John Watts; GLIDE solid-modelling research at Carnegie Mellon.
1975	Eastman publishes *The Use of Computers Instead of Drawings in Building Design*, describing the Building Description System.
1977	RUCAPS sold commercially through GMW Computers. CATIA begins at Avions Marcel Dassault.
1982	Graphisoft founded in Budapest by Gábor Bojár. AutoCAD launched.
1984	Bentley Systems founded. Graphisoft begins work on Apple computers.
1985–86	"Building model" used by Simon Ruffle and Robert Aish. Sonata succeeds RUCAPS in the mid-to-late 1980s.
1987	ArchiCAD released: 2D and 3D from one model on a personal computer.
1992	Van Nederveen and Tolman print "Building Information Model". Gehry's Barcelona Fish realised with CATIA.
1993	Tekla releases Xsteel, later Tekla Structures.
1994	Autodesk-led consortium of twelve US companies begins work on interoperability. STEP (ISO 10303) first published.
1996	Consortium renamed International Alliance for Interoperability; first IFC release. PTC acquires Reflex.
1997	Charles River Software (later Revit Technology Corporation) founded. Guggenheim Museum Bilbao opens.
1999	Solibri founded in Finland.

2000	Revit 1.0 released (5 April). CIS/2 approved by AISC.
2002	Autodesk acquires Revit (US$133m) and publishes *Building Information Modeling*. Gehry Technologies founded. Grieves' digital twin concept.
2003	Laiserin convenes Autodesk, Bentley and Graphisoft around the term BIM. GSA National 3D-4D-BIM Program. Walt Disney Concert Hall opens.
2005	IAI renamed buildingSMART. Revit Structure introduced.
2006	IFC2×3 released. Revit MEP introduced. Hong Kong Housing Authority introduces BIM.
2007	COBie created. NBIMS-US first published. Senate Properties (Finland) BIM requirements. GSA requires BIM for spatial validation. Autodesk acquires Navisworks; Nemetschek acquires Graphisoft. Grasshopper released.
2008	*BIM Handbook* published. AIA E202 defines LOD 100–500. Bew–Richards maturity diagram.
2009	BIM Collaboration Format (BCF) development begins.
2011	UK Government Construction Strategy requires Level 2 BIM by 2016. Soumaya Museum, Mexico City. Dynamo in beta. Trimble acquires Tekla. ASTM E57 point cloud standard.
2013	IFC4 and ISO 16739. PAS 1192-2. BIMForum LOD Specification. Revit disciplines unified.
2014	EU public procurement directive allows BIM requirements. Dubai Circular 196. BS 1192-4 (COBie). PAS 1192-3. Trimble acquires Gehry Technologies.
2015	Singapore BIM e-submission for all projects over 5,000 m². Germany's Stufenplan. PAS 1192-5. On-site BIM command centre at NAICM. Nemetschek acquires Solibri.
2016	UK Level 2 mandate takes effect. NAICM receives an Autodesk AEC Excellence Award.
2017	EU BIM Task Group handbook.
2018	ISO 19650-1 and -2. Gemini Principles. Hong Kong and Italy requirements. Bentley iTwin. Autodesk acquires PlanGrid.
2019	Mexico's national BIM strategy (MIC). UK BIM Framework.
2020	ISO 19650-3 and -5. Autodesk acquires Spacemaker. Charles Eastman dies.
2022	ISO 19650-4. Forge renamed Autodesk Platform Services.
2023	Japan requires BIM for public works. NBIMS-US V4. Autodesk Forma launched.
2024	IFC 4.3 as ISO 16739-1:2024. IDS 1.0. ISO 7817-1 (Level of Information Need). HoloLens 2 production ends.

2025	ISO 19650-6 (health and safety information).
2026	AI assistants previewed inside BIM authoring tools. Autodesk construction products organised under the Forma name. *The Living Model* published free by ConstruBIM.

APPENDIX B

A Short Glossary

BIM (Building Information Modelling / Modeling)
Creating and using a structured digital description of a built asset, made of objects with properties and relationships, from which drawings, quantities and analyses are derived.

Parametric modelling
Modelling in which elements are defined by parameters and rules, so that a change propagates to related elements. Descends from Sketchpad's constraints.

Federated model
A combination of separately authored discipline models viewed together for coordination, without merging their ownership.

Clash detection
Automatic identification of conflicts between elements in a federated model: hard clashes (physical overlaps), soft clashes (clearance breaches) and workflow clashes.

IFC (Industry Foundation Classes)
The open, vendor-neutral data model for building and infrastructure information maintained by buildingSMART; ISO 16739-1:2024 (IFC 4.3).

BCF (BIM Collaboration Format)
An open format for exchanging coordination issues, with viewpoints and element references, without exchanging the model.

IDS (Information Delivery Specification)
A buildingSMART XML standard, version 1.0 in 2024, for writing information requirements that software can check automatically.

bSDD (buildingSMART Data Dictionary)
An online service publishing classifications and property definitions with stable identifiers.

COBie
Construction Operations Building information exchange: structured handover data about spaces, assets, systems and documents, deliverable as a spreadsheet or through IFC.

LOD (Level of Development)
A scale from LOD 100 to 500 describing how far other parties can rely on a model element at a given milestone.

LOIN (Level of Information Need)
The ISO approach (ISO 7817-1:2024) that specifies the geometry, data and documentation needed for a defined purpose and milestone.

ISO 19650
The international series of standards for managing information over the whole life cycle of a built asset using BIM.

CDE (Common Data Environment)
The agreed source of information for a project or asset, where information containers move through controlled states: work in progress, shared, published and archived.

OIR, AIR, PIR, EIR
Organisational, asset, project and exchange information requirements: the chain of "what information do we need, and why" defined in ISO 19650.

BEP (BIM Execution Plan)
The delivery team's plan for how it will meet the information requirements of an appointment.

AIM and PIM
Asset information model (used in operation) and project information model (produced during delivery).

4D and 5D BIM
Linking model elements to construction schedules (4D) and to cost (5D).

Point cloud and scan-to-BIM
A 3D dataset captured by laser scanning or photogrammetry, and the process of turning it into an as-built model.

Digital twin
An information model of an asset kept connected to its real condition through captured and live data, and used to support decisions.

openBIM
The buildingSMART approach of collaborating through open standards and workflows rather than proprietary formats.

APPENDIX C

Sources and Further Reading

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APPENDIX D

Image Credits

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12. **Figure 6.3.** Guggenheim Museum Bilbao 2.jpg. kallerna. CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0). https://commons.wikimedia.org/wiki/File:Guggenheim_Museum_Bilbao_2.jpg.
13. **Figure 6.5.** Disney Concert Hall by Carol Highsmith.jpg. Carol M. Highsmith. Public domain. https://commons.wikimedia.org/wiki/File:Disney_Concert_Hall_by_Carol_Highsmith.jpg.
14. **Figure 11.1.** Fachada Museo Soumaya 0.5.jpg. Gadi-kab. CC0 (http://creativecommons.org/publicdomain/zero/1.0/deed.en). https://commons.wikimedia.org/wiki/File:Fachada_Museo_Soumaya_0.5.jpg.
15. **Plates 1–3.** Frederick C. Robie House, HABS ILL-1005, sheets 5, 7 and 12 of 14 (HABS Chicago Project, 1963). Public domain. Library of Congress; commons.wikimedia.org.
16. **Plates 4–7.** Edith Farnsworth House, HABS IL-1105, sheets 3, 4, 5 and 8 of 8 (2009). Public domain. Library of Congress; commons.wikimedia.org.

Buildings did not always carry their own information. This is the story of how they learned.

In 1963 a graduate student drew on a screen with a pen made of light. In 1975 a professor argued that buildings should be described as databases, not drawings. It took the construction industry four more decades, a Hungarian start-up, a sculpture shaped like a fish, a consortium of competitors and several governments to act on that idea.

The Living Model tells the real history of Building Information Modeling, correcting the myths along the way:

- Who described BIM first, and who first wrote the words down
- How IFC taught rival software to speak one language
- Why the UK mandate and ISO 19650 made BIM about accountability
- What megaprojects such as the Mexico City airport proved
- How models are becoming digital twins, and what AI changes

Free to read, print and share. Written by ConstruBIM, a BIM implementation and digital delivery consultancy recognised with an Autodesk AEC Excellence Award.