Thinking in BIM
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Behind every element and subassembly of elements that an architect inserts into a drawing or model of a project there is, implicitly, a supply chain resulting in the delivery and placement of that element or subassembly on the construction site. Traditional architectural drawings and CAD models abstract away from that supply chain, but Building Information Modeling (BIM) databases make it explicit, designable, and manageable. This is opening up new ways to think about designing and producing buildings and – as we are beginning to see – new formal and functional possibilities.

Tool Affordances and Biases
To place the emergence of BIM systems in perspective, it is worth recalling that architects’ tools aren’t neutral. They have particular affordances and biases, and they implicitly embody particular assumptions and values. An old-fashioned parallel bar, for example, suggests that parallel straight lines will feature prominently in projects. Adding a wooden or plastic right triangle to the drafting toolkit implies that right angles and rectangles will also be important. Adding compasses signals a further interest in circles, arcs, and Euclidean geometric constructions.

Availability invites use. Furthermore, sets of convenient and efficient tools privilege the shapes and constructions they readily generate while marginalizing the shapes and constructions they don’t.

What comes first, the shapes and compositional moves or the tools to enable them? It is a notorious chicken-and-egg question. Architects tend to think in terms of forms for which they have tools, and simultaneously, to look for tools to represent forms they have imagined. From time to time, this circularity gets broken when someone invents a new tool—a spline curve instrument, for example—that puts new shapes and constructions into play. On other occasions, architects decide that they want to break out of the conventions embodied in their current tools and either work freehand or improvise new tools to meet their requirements. In general, a designer’s toolkit represents a provisional equilibrium of capability and demand.

Ellipses, for example, are outside the design universe implicit in traditional drafting instruments. In contrast to circles, it is laborious to construct them by means of standard drafting operations, and it is not easy to perform tasks such as uniformly subdividing their circumferences. Except in the work of a few convention-busting Baroque virtuosos, then, you don’t see many of them in historic buildings. Even when you encounter something that looks like an ellipse it often turns out to be an approximation—an oval constructed from circular arcs.

Tool Invention and Appropriation
For centuries, the standard way to create a new drawing tool was to invent some sort of analog computation device. Descartes, for example, invented a simple instrument, consisting of two pins and a piece of string, for drawing ellipses. Palladio illustrated, in his The Four Books of Architecture, the use of pins and a thin elastic rule to draw spline curves for the entasis of columns. Gaudi employed tension wires and weights to construct catenaries. In all these cases, specialized physical mechanisms quickly computed curves that would otherwise be very difficult. And, in receptive hands, they all provided pathways to architectural innovation.

When digital computer graphics emerged in the 1960s, functions that computed sequences of coordinates—which could then be plotted—replaced both the standard mechanisms of hand drafting and the more exotic ones. Not surprisingly, the first architectural software toolkits
directly mimicked the capabilities of commonplace drafting instruments – providing straight lines, circles and arcs, parallels, perpendiculars, tangents, bisectors and other Euclidean geometric constructions. They did little to expand the range of things that architects thought about and explored. On the contrary, in fact: by making traditional shapes and constructions quicker and easier to work with than ever before, while leaving others uneconomically slow by comparison, they exerted a conservative influence.

Meanwhile, in parallel, different software toolkits being developed for use by automobile and aerospace designers, and by computer animators. These, of course, mimicked the operations familiar to designers in those particular fields. They emphasized curved lines and surfaces, together with the use of union and intersection operations for constructing complex three-dimensional surfaces and solids from simpler ones, and parametric modeling for managing relationships and exploring variations – thus opening up for exploration a radically different formal universe than that familiar and comfortable to architects. They also assumed different prototyping and fabrication technologies – the technologies of digitally controlled cutting, milling and deposition printing.

After about two decades of parallel development and application, the two streams of software tool development and application finally converged in the late 1980s. The project that definitively marked the moment was Frank Gehry’s Fish on the Barcelona waterfront, constructed in from 1988–1992. This began as a physical model, with wooden splines defining the curved surfaces. Using CAD software that was intended for manufacturing rather than architectural applications, the physical model was then digitized and further manipulated to create a digital curved-surface model. Eventually, this model was used for design development, visualization, and CAD/CAM prototyping and component fabrication.

Finally, software had opened up a new way to think about architecture. Curved surfaces and non-repetitive geometries flooded into projects. Canonical works of the millennium’s end, such as Gehry’s Guggenheim Museum Bilbao [a+u 08:67] and Walt Disney Concert Hall [a+u 04:01], would have been impossible without an ongoing process of CAD/CAM software convergence. Skyscrapers began to twist and taper with abandon. Regular systems began to adapt subtly to irregular contexts, as in Norman Foster’s Great Court of the British Museum [a+u 02:01]. Soon, no self-respecting school of architecture could be without the latest modeling software, laser cutters, CAD/CAM routers, and deposition printers.

This was also a golden age of tool development. Architects, software developers, and students soon discovered that it was far easier to build new design software tools than it had been, in previous eras, to invent, manufacture, and distribute new types of drafting instruments. It was just a matter of writing some code and linking it to existing CAD capabilities. Where designers’ toolkits once had been narrowly and rigidly defined, they now became fluid and extensible.

Beginnings of BIM
The global economic crash of 2008 probably marked the end of this twenty-year era of exuberant formal exploration. At around the same time, there was an increasingly urgent recognition that geometric modeling and component fabrication were only half the story of making a building (or, for that matter, a physical scale model) – and maybe not the most challenging half. Fabricated components must also be delivered and assembled. Producing assemblies of large numbers of parts relies on the ability to represent all the physical objects involved as a whole, and to express the quantity of each component – and all the others – that is required.
components is typically a laborious and costly process – particularly when the components are complex and assemblies are non-repetitive. Several pioneering thinkers began to ask whether new software tools, combined with digitally controlled assembly processes, might help with this.

This was a departure from the long-standing habit among architects of formulating building delivery issues in terms of simple dichotomies – of on-site construction versus prefabrication, and of craft versus industrial production. Now, increasingly, architects recognize that completed buildings result from complex, heterogeneous supply chains. These chains were geographically dispersed, and they often extended globally. Some of the processes that they encompassed were executed under precisely controlled factory conditions and others took place under difficult site conditions. Some were rigorously standardized and some could be customized. Some were difficult and expensive while others were straightforward. Some involved significant uncertainty and risk. But all of them represented design opportunities and constraints, and all of them had to be organized and coordinated to bring the parts of a building together at the right time in the right place. The BIM systems that emerged in the early twenty-first century were intended to support this comprehensive, supply-chain-oriented view.

BIM systems didn’t come from nowhere. They drew upon the general technology of object-oriented computation. Furthermore, there had long been efforts to extend the capabilities of CAD systems in various ways – by shifting their emphasis from the construction and editing of two-dimensional drawings to the construction and maintenance of complete and consistent three-dimensional models, by replacing rigid geometry with object-based parametric modeling, by providing increasingly sophisticated facilities for associating non-geometric properties with geometric entities, by integrating engineering analysis software and by supporting sharing and transfer of information among the various members of design and construction teams. But the pioneering BIM systems attempted to do all this and a good deal more, in a carefully integrated way.

BIM technologies and associated practices are gradually maturing. The term “Building Information Modeling” was first used, as far as I know, in the mid-1980s. Most of the necessary technologies were in place – at least in research contexts – by the late 1990s. A comprehensive handbook, Chuck Eastman et al’s BIM Handbook: A Guide to Building Information Modeling, 2008 has appeared. Today, there is fierce competition among commercial BIM systems, an extensive field of ongoing BIM research, and a rapidly growing number of building design and construction projects are done, from beginning to end, with BIM systems.

Where Will It Lead?
Not surprisingly, practical BIM applications – like the applications of computer drafting systems decades earlier – have mostly begun with the automation of existing, observable design and construction practices. They have often been used, then, for projects that are not attempting to break new architectural ground but are under particularly demanding schedule and budget pressure.

But I suspect that this will be a temporary condition. New tools for organizing and managing construction supply chains will encourage innovative thinking about architectural vocabularies and construction processes – particularly the production of assemblies. This, in turn, will open up new formal and functional possibilities for design exploration in response to the economic and sustainability imperatives and cultural preoccupations of the early twenty-first century.

Before long, architects will learn to think in BIM and when they do, the results are likely to be at least as fresh and as surprising as those that have followed, over the twenty-year era that is now coming to an end, from the introduction of curved-surface modeling techniques and digitally controlled fabrication devices.