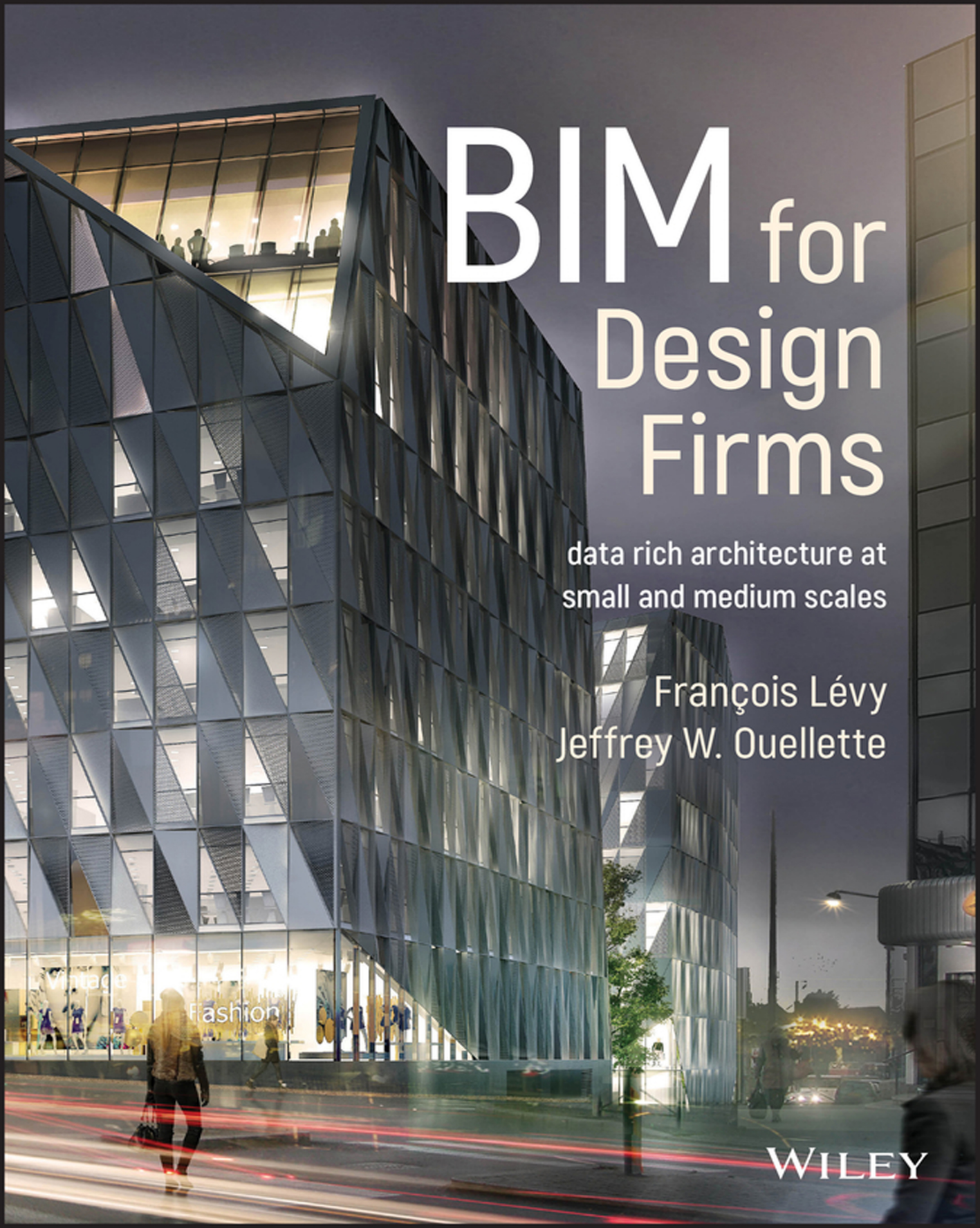
BIM for Design Firms
data rich architecture at small and medium scales
François Lévy
Jeffrey W. Ouellette
Fashion
WILEY

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For Julie

In the 1995 movie *Get Shorty*, Delroy Lindo, in the role of Bo Catlett, says, "You have an idea, you write down what you wanna say. Then you get somebody to add in the commas . . . if you aren't positive yourself . . . you come to the last page you write . . . The End." Would that writing were so simple or straightforward! This book has taken far longer than I had initially anticipated or hoped, in spite of it's not being my first rodeo. Any project of such a span has countless benefactors and supporters, some whose names appear in these pages, and many who have contributed less apparently. A heartfelt thanks and appreciation to the many architects, designers, educators, and photographers who contributed case studies, images, and ideas to this book, in particular Justin Dowhower and my co-author Jeffrey Ouellette, who made substantial contributions to the manuscript. To Mark Winford, thank you for your early partnership, for Mosaic, and our projects together. I'd also like to extend thanks to all my friends and colleagues at Vectorworks, and especially Robert Anderson, Sarah Barrett, and Rubina Siddiqui who contributed images or helped me think through certain ideas.

I owe a deep debt of thanks to Kimberly Kohlhaas, my design and business partner of several years, many of whose own contributions have influenced my design thinking and our firm's projects that appear here. To our staff, current and past, I am grateful for your hard work, intelligence, and heart: Sherri Woolley Ancipink, Christopher Balli, Charlton Lewis, and Barrett Webb. And while many project renderings are shown in the following pages, these are real projects for real clients, most of whom I have the privilege to call friends. Their genuine trust in our firm has been a source of professional satisfaction and personal joy. Thank you Adam, Megan, Marlon, Jennifer, Dan, Laura, Jörg, Nancy, Jana, Lex, Jake, Joy, Steve, Dave, Tim, Katie, Alice, Diane, Mike, Sanjay, Mandy, Jan, Stanley, Catherine, and Larry. I'd like to thank the dedicated, hardworking, and patient people at Wiley, particularly Helen Castle, Margaret Cummins, Vishnu Narayanan, Kalli Schultea, and Jayalakshmi Erkathil Thevarkandi.

Finally, this is a bittersweet opportunity to express my profound gratitude and appreciation for the late Constance Adams. While not a "BIM" architect, she was a brilliant visionary whose trust and confidence in me never flagged.

François Lévy

My contribution is only possible because of the collective kindness and knowledge of a great number of people—teachers, mentors, family, friends (and competitors!), employers, customers, and collaborators—inspiring me to be a conduit, an advocate, a champion, for their best ideas. I'd especially like to thank François for asking me to be a part of this endeavor. Over the years, he's been a peer, colleague, boss, customer, and most importantly, a friend. I really appreciate his confidence in me to be a part of another one of his illuminative projects.

Jeffrey Ouellette

This is a personal book. It is largely informed by my career in architecture to date, the lessons I have discovered about the process of design, the mistakes I have made, and the colleagues, clients, and students from whom I have learned. It is anecdotal, which is not to say that it is not factual nor accurate. It hopes to be conversational in tone, and perhaps entertaining. Certainly I have enjoyed sharing what I have come to know and believe about BIM (building information modeling). Before the term had been coined, I had begun to use a BIM process—albeit one higher on building modeling and lighter on information. In part this was motivated out of a sense of adventurousness, but primarily it seemed to be a promising methodology to explore design opportunities, from novel geometry to the quantitative analysis of thermal chimneys and rainwater harvesting. At the time much of the parametrization of BIM tools was yet to come, so many model elements had to be assembled from scratch from 3D primitives (extrusions, sweeps, Boolean additives, and so forth). Even then, it was clear that there were new designs possible that would not have been previously feasible to explore.

Through no virtue of mine, I have been fortunate in my timing. I happened to enter the profession of architecture at a time when computational power began to become ubiquitously available. In college I had written my senior thesis on a friend's TRS-80, and its great graphical upgrade consisted of an amber screen (easier on the eyes than white letters on a black background) and letter descenders (like the tail in the letter g) that could be displayed below the line, instead of g's, j's, and q's being vertically compressed and moved up, like this: mY qUIXOTIC gUEST IS AjUDge. By the time I was a graduate student in architecture school, CAD was available on desktop computers, rather than dedicated drafting stations that combined hardware and software in one inseparable package. By the time I was working in a firm, the earliest versions of what was to come to be called BIM were available. I've been very lucky to have seen the profession span from hand drafting to CAD to BIM, and having the first-hand experience of working across those technologies has been highly instructional.

Richard Dodge and the Virtual Making of Things

In 1992 I was a graduate student in the first design studio that was CADD-based (computer-aided design and drafting) at the University of Texas at Austin School of Architecture, taught by the late Richard Dodge. The story I heard was that Richard's father had been a builder in California, and the younger Dodge had been drafting (on a table of course, with a parallel bar and triangles) since his teens. By the time Richard was an architect he could draft like an angel with the speed of a bullet. So it may have seemed odd that he embraced CADD as he did, but he was like that: a frank and engaging professor, an accomplished and intellectually curious designer, a technically proficient architect who was no less talented for being so professionally grounded.

I remember one day in studio a conversation about the connection between drawing and making. Richard suggested that the day was already here when our architectural drawings could directly drive machines to manufacture custom building components that would otherwise be cost-prohibitive to fabricate by hand. Numerically controlled (NC) milling machines had been around in the manufacturing world since the 1950s, computer numerically controlled (CNC) routers were already in use. But it hadn't occurred to us that the technology of mass manufacturing could literally be at our fingertips. The limitation wasn't the milling machines, of course. The bottleneck was the architect not having a ready medium to communicate with the CNC router—until ubiquitous CADD (Figure I.1). Even then, my imagination was limited to structurally expressive wood truss gusset plates, or heroic steel clevises that one might find on Lloyd's of London or the Centre Pompidou (what my grandfather like many Parisians called *Notre-Dame-des-Tuyaux*—Our Lady of the Tubes). Additive manufacturing machines (3D printers) were obscure enough to still be science fiction to most of us.

Yet in that far-ranging conversation, sprawling from the charcoal pencil drawing technology of the Baroque to the precision mechanical drafting of the modernists, we could see the outlines of virtual buildings through the fog of the future. We imagined what it might mean once we were given license to draw not just a select few plans, sections, and elevations, but model an entire building virtually. We could not predict what was to come, but we did see that the nature of the tools that we used to design and document our buildings would change the very expression of those buildings. Just as the Baroque could not be Baroque without charcoal, nor modernism without technical drafting pens, so too our coming architecture would be an expression of our digital tools. We knew that the tools we would come to use would shape that which they wrought, and all we had was a choice: be open-eyed about that relationship, or stick our heads in the sand.

FIGURE I.1 An early CADD drawing. The truss design is predicated on the assumption that that the plywood gusset plates would be fabricated with a CNC machine, laid out on a sheet to minimize material waste.

BIM for Studios

Most of my professional experience is in small firms, and as a consequence the BIM design praxis that I have learned and developed evolved around smaller projects with fewer designers. So there's a certain logic for the title of this book to reference that perspective. "Architecture" is of course my profession. Let's not forget that there are many other disciplines that employ BIM and that architects were hardly the first to embrace it, putting it mildly. "Data-rich" suggests that BIM is employed for analytical computational design and simulation. That is, there is a performative implication to the use of BIM for design.

Since its inception, BIM has been assumed to primarily be the sandbox of large firms and their large-scale projects. That's understandable. First, the extent and complexity of large projects has made them low-hanging fruit, ripe for a new way of drawing and collaborating to help manage the considerable human capital and information required to design and document them. Moreover, software, hardware, and training costs associated with the revolutionary new

technology to support BIM can arguably be more easily absorbed by large firms than small ones. One of BIM's important features is its ability to foster interoperability between various design and building professions; large projects tend to have more players at the design table, so to speak, than smaller ones.

BIM has long been touted for benefits to documentation and coordination. As a digital artifact, the building information model is developed by one or more design disciplines—architectural, structural, mechanical, and so forth—each contributing assemblies or components to (a) federated model(s). As a process, building information model*ing* assumes an exchange of information in order to establish the geometry and characteristics of a proposed project based on each design stakeholder's respective contribution. The process requires defined and delineated roles, interoperable data exchange formats, coordination, and communication. The model may evolve through late-stage design processes through these exchange procedures, but it is presupposed that there is already a design to begin with. That is, the BIM process is the social and technological protocol by which the BIM artifact progresses as a concerted digital response to an established architectural design.

As a practitioner, while some of my experiences are congruent with the above, on the whole my BIM life has been swimming against the general current. With some exceptions, most of my design collaborators do not use BIM, so projects tend to involve a single model rather than a federated one from multiple professional stakeholders. Even then, there are opportunities for BIM coordination with collaborators (see case studies from Chapters 5 and 6). Over the past two decades, my professional experience has been in firms of one to five, well within the bounds of the definition of "small firms" (years ago, the Boston Society of Architects reported perhaps anecdotally that 80% of architects worked in firms of six or fewer; see Figure I.2). And while I enjoy BIM's significant productivity gains in all phases of design including construction documents, BIM has not been relegated to merely documentation and coordination. Indeed, it is in large part this inversion of the typical BIM use case that has led to this book. BIM for design and BIM for a small firm is almost the antithesis of BIM as it is frequently deployed for documentation and coordination of large projects.

And in spite of that, I would contend that BIM for design and in small teams is not antithetical to large firms. True, interoperability is especially critical on large projects to automate the coordination of architecture with site, civil, structural, mechanical, electrical, and plumbing engineering disciplines. Yet the design benefits of a broader, data-rich 3D design process—as distinct from that subset of design comprised of coordination and construction documentation—can be reaped by studios within larger firms. Even large architecture firms create manageable team sizes to design and develop architectural projects. Fueled in part

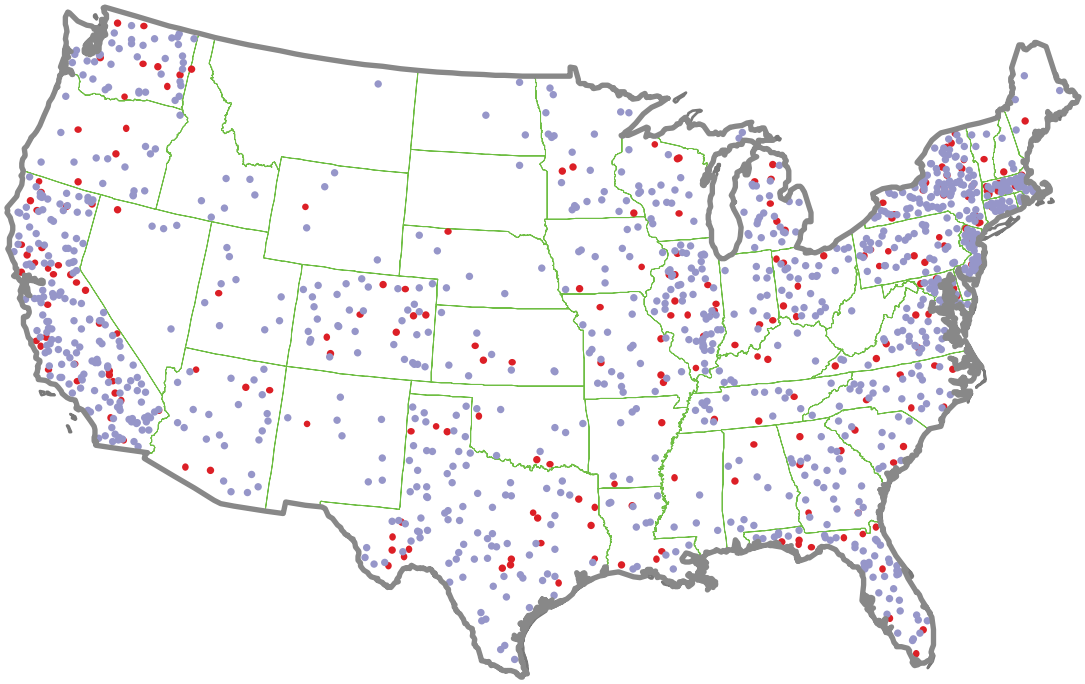

FIGURE I.2 As of 2010, there were just under 104,000 registered architects in the continental United States, according to NCARB. Each blue dot represents about 100 US architects; each red dot roughly represents 100 architects in firms of more than 6. Dot distribution is entirely random within each state, and red dot distribution is approximate.

by technological advances and increased personal productivity, the trend for creating formal or informal small design studios within larger firms is palpable. This book is for them, too.

A Horse of a Different Color

Here's a common story about design; tell me if it sounds familiar. After a flurry of parti diagrams and inspired sketches, and on the heels of code research and programming, a project is conceptually developed using sketch modeling software. It gets refined, perhaps exported to rendering software for initial client meetings, postprocessed by a Photoshop wunderkind. Eventually the schematic design matures, and it's time to get serious about building systems and preliminary structural coordination. So the model is rebuilt using BIM authoring software, and rolls along in design development. Then the deadline looms, and half the project is hurriedly drafted in 2D CADD while some of the BIM model limps gamely across the finish line. At each step of the way, of course, data is lost as the project is exported from one software platform to another, with frequent

redoing of completed work. And if there were significant design changes in design development or construction documents, backtracking created more inefficiencies.

So even in those firms that have arrogated BIM, that adoption may not be with as much depth as might be expected. Indeed, large firms that adopt BIM may be more prone to a cobbled approach to design and production software tools. Not that there's a moral virtue to a "full BIM" ethic, nor is there any particular value in being dogmatic for dogmatism's sake (indeed I tend to find the opposite). Rather, the pressure to get work produced and meet deadlines can place short-term expediency at odds with best practices, and as a result there are missed opportunities for exploring and resolving alternative design possibilities.

It is beyond question in my experience that BIM is a more efficient way to work. That is, less effort (as measured in time devoted to delivering architectural

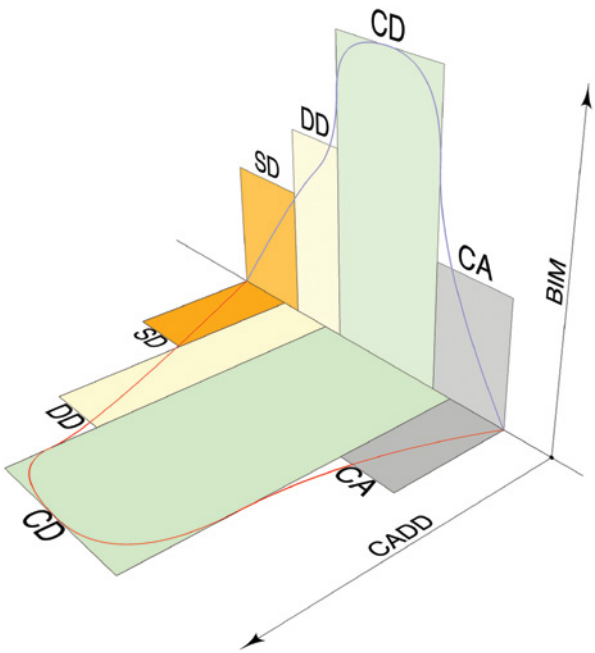

FIGURE I.3 The BIM gap: CADD versus BIM. In CADD (and manual drafting), less time can be devoted to earlier design phases since construction documentation (CD) comprises around 40% of architectural services (graphed on ground plane). In BIM (upright), not only are CDs a smaller portion of overall services, but throughout design and documentation architectural services are more efficient with BIM (blue curve) than CADD (red curve). One possible benefit of this *efficiency* windfall is to devote more design effort to architectural *effectiveness*.

services) is required with BIM to produce an equivalent instrument of service (i.e., set of architectural documents) as would be produced with CADD (see Figure I.3). But efficiency only expresses the ratio of effort to output. It says nothing about effectiveness—the degree to which the output produces desirable results. Effectiveness is a measure of success.

At its most orthodox, BIM is about efficiency. Perhaps a question worth asking is, "To what end?" I propose that we reinvest those efficiency gains in effective architecture. In other words, let's design more: design more deeply, design more thoughtfully, design more courageously. *BIM for Design Studios Firms* is intended to help unearth alternative design possibilities and point to new opportunities for architects and designers to exploit BIM for far more than executing designs whose conclusions are already baked in. This book is not about "faster, better CADD." It's not a software manual, nor a handbook of tips and tricks to improve efficiency, nor a primer for BIM managers. It is a guide to investigate something new about design, suggesting that technique and methodology are intimately bound to architecture.

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Austin, Texas

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Chapter 1

Digital Design

What is design? Is there a particular quality to digital design processes?

A question asked with the objective of obtaining a definitive answer is not a very interesting question. A question asked in an open-ended, indeterminate process of perpetual inquiry becomes a way of being. So when one thoughtfully asks "What is design?" what is really meant is, "How can I keep testing my assumptions about architecture and what it means to design?" Or, "How shall I keep questioning how and why I design what I design?"

Swimming in the waters of this type of inquiry will always be hard. For the young designer—looking for his voice, unsure about how to proceed, feeling the pressure of solving a design problem, and wandering away from a theory of design process—inexperience clouds the question. For the experienced designer—confident in her abilities, mature in her practice, technically knowledgeable, and sure-footed—the quick and possibly glib solution arises so quickly, seemingly magical in its effortlessness, that there's no time and certainly no incentive to question it.

Then there's the question of the cognitive quality of designing "by hand" as distinct from designing "digitally" ("computationally" would be more apt, as "digital design" has little to do with fingers). How does the modality of design affect the design outcome? Is an architect exploring a design solution by sketching with pencil and paper favoring a different design outcome than one immersed in a BIM workflow, by virtue of the haptic or cognitive nature of the design process? Does BIM lead to a particular architectural outcome?

Introduction

As a fruitful premise for inquiry (what Socrates in Plato's dialogues calls εικωσ μγθοσ—a "likely story"), let's consider that architecture (as a profession, though perhaps too as a human artifact) has been experiencing an evolving crisis for well over a century. And while we're in Greece, let's also ponder that "architect" is from άρχι and τέκτων: "master builder," or chief craftsman. While some architects may be capable builders, for a very long time the process of design has

been divorced from the direct process of making. To be sure, in Europe some architects serve as *maître d'ouvrage* (master of the work), and their professional function is distinct from design architects. Even in the United States, many architects function as project managers. And as with *maîtres d'ouvrage*, their bailiwick encompasses project objectives, scheduling, sequencing, and budgets; they are not builders or craftsmen *per se*. Perhaps not coincidentally, very few architects come up through the profession with a background in building. For better or worse, ours is a profession rooted in the academy.

Arguably, the Viennese Secession, Franco-Belgian Art Nouveau, the British and American Arts and Crafts Movement, and their contemporary localized counterparts were a reformation against mechanized and industrialized fabrication methods coming online over a century ago. (Ironically, nowadays of course one can order Arts and Crafts furniture online, made in a factory overseas and delivered with two-day free shipping. I have no objections to such a convenience, but it does reduce an architectural and artistic movement to a mere style or fetish.) Mechanization has so pervaded our social expression of work that the handcrafted has lost the moral superiority assigned to it by the Arts and Crafts Movement, and is now commodified or fetishized. A century ago windows were produced by hand like custom millwork; now they are mass produced—and with good reason, too, as modern windows assembled with modern materials and manufacturing vastly outperform their historical counterparts.

So on the one hand we have master builders who do not build, and on the other we have building processes that are farther and farther removed from craft (Figure 1.1). In a philosophical context, it may not be a problem that architects do not build anything; it may merely be a needless obsession with an archaic etymology that would suggest that as a profession we should be builders. I for one am not trained in the act of building, nor do I have the urge to exercise it. Except that as the distance from design to execution lengthens, the constructibility of the design may suffer. Moreover, design can be instructed by construction. An architectural detail may be intricately drawn, but what if it cannot be achieved due to the dimensional tolerances required, or if the sequencing of its components would be impossible?

If anything, the abstract nature of architectural design processes only contributes to this gap between the design idea and its physical manifestation. The more abstract the design artifact, the greater the gap. The architect loves the hand-drawn line in part *because* it is so abstract: bearing almost no intrinsic information, an entire story may be inferred from a few accidental details. Is it perfectly straight (a firm decision has been made) or wavering (it describes a vague impulse, or perhaps a natural feature)? Is it ink (confident, authoritative), or soft pencil (tentative, or evocative)? Is it drawn on vellum (final) or trace (exploratory), or on a scrap of napkin (extemporaneous)? Note that all these

FIGURE 1.1 Automated construction of an architectural wall. If the craft isn't in the assembly in the field, where does it lie? In the programming of the automation?

Image courtesy Construction Robotics.

meanings are subjective: they are supplied by the observer, using certain cultural visual cues as a context for assembling a narrative out of a mere line drawn between two points. In other words, the observer infers the meaning (Figure 1.2).

By training moreover, for many architects and designers drawing is much more than merely a means of clearly communicating a comprehensive idea. The act of drawing itself is a cognitive process, an act of uncovering, an exploration. Just as the traveler may not fully see the building he is drawing until he actually draws it, so the architect may not fully realize a design idea *except by drawing it*.

Now consider a BIM assembly. With contemporary BIM-authoring software, it can of course readily be rendered in a hard line; in a sketch style with variable parameters to control wobble, overstrike, and so on; as a cartoon color rendering with graphic qualities reminiscent of Francis D.K. Ching; as a white rendering almost indistinguishable from a museum-board model; as a photorealistic rendering with depth of field, blur, and complex lighting; and so on (Figure 1.3).

I assert that the modality of a BIM rendering, unlike that of the hand drawing, is a function of the communication of the completed design thought. As typically used, BIM is not as a rule an exploratory device. It may be that this fact contributes to experienced designers' contending that BIM is not a design tool, but only suitable to the refinement, coordination, or documentation of a

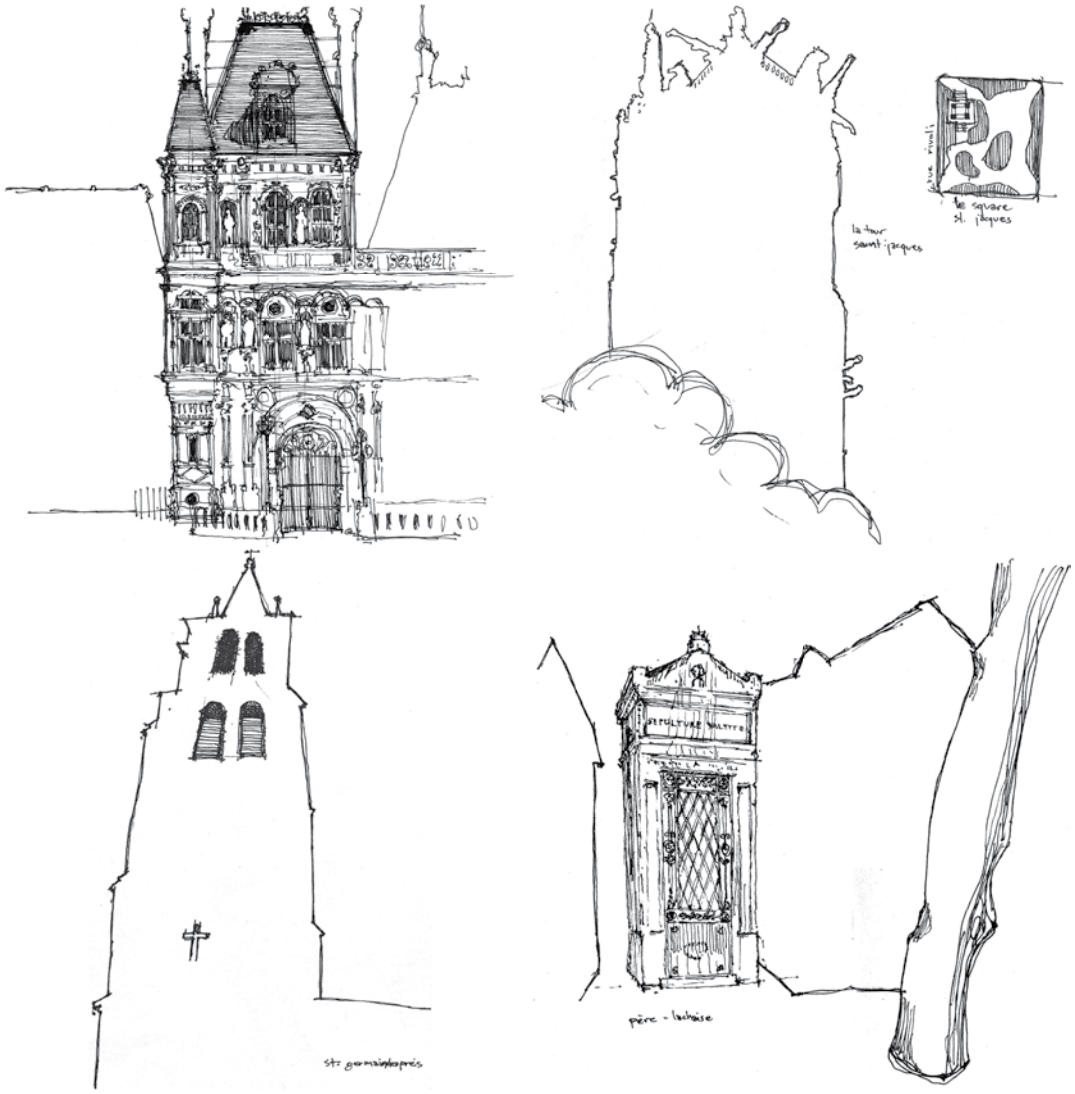

FIGURE 1.2 These travel sketches communicate as much with what they omit as by what is explicit. Moreover, the architectural elements of the drawing require that the user interpret the intended representation.

design derived by other means (Figure 1.4). This is a serious error, due perhaps to judging digital processes by analog standards and analog experiences. For the paradigm of the line is not the appropriate one for BIM. Rather, BIM inhabits the world of data, whether abstract or geometric, and should therefore be evaluated performatively and formally, rather than graphically.