4

INFORMATION
MASTER
BUILDERS

BRANKO KOLAREVIC
The challenges of constructability left designers of new formal complexities with little choice but to become closely engaged in fabrication and construction, if they were to see their projects realized. Building contractors, used to the current “analog” norms of practice and prevalent orthogonal geometries, were reluctant to take on projects they saw as apparently unbuildable or, at best, with unmanageable complexities. The “experimental” architects had to find contractors and fabricators capable of digitally-driven production, who were often not in building but in shipbuilding. They had to provide, and often generate directly, the digital information needed to manufacture and construct the buildings. So, out of sheer necessity, the designers of the digitally-generated “blobby” architecture became closely involved in the digital making of buildings.

In the process, these architects discovered they have the digital information that could be used in fabrication and construction to directly drive the computer-controlled machinery, making the time-consuming and error-prone production of drawings unnecessary. In addition, the introduction and integration of digital fabrication into the design of buildings enabled architects to almost instantaneously produce scale models of their designs using processes and techniques identical to those used in the industry. Thus, a valuable feedback mechanism between conception and production was established.

This newfound ability to generate construction information directly from design information, and not the complex curving forms, is what defines the most profound aspect of much of the contemporary architecture. The close relationship that once existed between architecture and construction (what was once the very nature of architectural practice) could potentially reemerge as an unintended but fortunate outcome of the new digital processes of production. In the future, being an architect will also mean being a builder, not literally, of course, but by digitally generating the information to manufacture and construct buildings in ways that render present inefficient hierarchies of intermediation unnecessary.

The new processes of design and production, born out of the pragmatic ramifications of new formal complexities, are providing unprecedented opportunities for architects to regain the authority they once had over the building process, not only in design, but also in construction. The new relationships between the design and the built work place more control, and, therefore, more responsibility and more power into the hands of architects.

By integrating the design, analysis, manufacture and assembly of buildings around digital technologies, architects, engineers and builders have an opportunity to fundamentally redefine the relationships between conception and production. By reinventing the role of a “master builder,” the currently separate disciplines of architecture, engineering and construction can be integrated into a relatively seamless digital collaborative enterprise, thus bridging “the gap between designing and producing that opened up when designers began to make drawings,” as observed by Mitchell and McCullough.1

**HISTORY OF DISASSOCIATION**

For centuries, being an architect also meant being a builder. Architects were not only the masters of spatial effects, but were also closely involved in the construction of buildings. The knowledge of building techniques was implicit in architectural production; inventing the building’s form implied inventing its means of construction, and vice versa. The design information was the construction information – one implied the other.

The master builders, from the Greek tekton (builder), to the master masons of the Middle Ages were in charge of all aspects of buildings, from their form to the production techniques used in their construction. They had the central, most powerful position in the production of buildings, stemming from their mastery of the material (stone in most cases) and its means of production. As the palette of materials broadened and the construction techniques became more elaborate, the medieval master masons evolved into master builders (or architects) who would integrate increasingly multiplying trades into an increasingly more complex production process.

The tradition of master builders, however, did not survive the cultural, societal and economic shifts of the Renaissance. Leon Battista Alberti wrote that architecture was separate from construction, differentiating architects and artists from master builders and craftsmen by their superior intellectual training. The theory was to provide the essence of architecture, and not the practical knowledge of construction.

Paradoxically, the history of architecture’s disassociation from building started in the late Renaissance with one of its most celebrated inventions – the use of perspective representation and orthographic drawings as a medium of communicating the information about buildings. The medieval master builder (architect) used very few models and drawings to test or communicate ideas, and relied instead on direct verbal communication with craftsmen, which,
in turn, required continuous presence on site, but provided for a seamless exchange of information at all phases of building. With Alberti’s elevation of architects over master builders came the need to externalize information (so it could be communicated to tradesmen) and the introduction of orthographic abstractions, such as plan, section and elevation, into the currency of building. Architects no longer had to be present on site to supervise the construction of the buildings they designed.

The rifts between architecture and construction started to widen dramatically in the mid-nineteenth century when “drawings” of the earlier period became “contract documents.” Other critical developments occurred, such as the appearance of a general contractor and a professional engineer (first in England), which were particularly significant for the development of architectural practice as we know it today. The relationships between architects and other parties in the building process became defined contractually, with the aim of clearly articulating the responsibilities and potential liabilities. The consequences were profound. The relationship between an architect (as a designer of a building) and a general contractor (as an executor of the design) became solely financial, leading to what was to become, and remain to this day, an adversarial, highly legalistic and rigidly codified process. It is the biggest obstacle to change today.

The late-nineteenth century New York firm McKim, Mead and White is often cited as another example of the power architects once had over the building process. As described by Howard Davis, this architectural firm, in its quest for total control over the construction of each of their buildings, produced not only hundreds of drawings, but also had a final say over every detail, the quality of materials and workmanship, and over every payment to contractors and subcontractors. But this high degree of control was not without consequences. As architects placed more and more layers beneath themselves, the distance between them and the construction site increased. As Davis observes, “As the system evolved further, the role of the general contractor grew at the same time as the architect’s connection to craftspeople lessened.” Although architects were at the apex of hierarchical control structure, increasingly the desired outcome had to be explicitly and precisely described in various contract documents. The architect’s role on the construction site, instead of shaping the building (as master builders once did), became the contractual administration, i.e., the verification of the contractor’s compliance with the given contractual construction documents. The design was split from the construction, conceptually and legally. Architects detached themselves fully from the act of building, unintentionally giving up the power they once had, pushing the design to a sideline, and setting the profession on a path of increasing irrelevance in the twentieth century.

The twentieth century brought increasing complexity to building design and construction, as numerous new materials, technologies and processes were invented. With increased complexity came increased specialization, and the emergence of various design and engineering consultants for different building systems, code compliance, etc. At the same time, the amount of time allotted for design and construction was shrinking. As the complexity of building increased and the design “time” decreased, the architects sought the need to limit their liability exposure. While the legal definition of their role was becoming progressively more defined, architects were, at the same time, increasingly losing control and the decision-making power over the building process, thereby formally dissolving the authority they once had and knowingly disassociating themselves from the rest of the building industry.

In the United States today, architects are prohibited from taking part in construction by the codes of practice established by the professional association, the American Institute of Architects (AIA). The standard contracts in use by the AIA state explicitly that “the architects will not have control over or charge of and will not be responsible for construction means, methods, techniques, sequences, or procedures.” This aversion to risk has, unsurprisingly, led to the further marginalization of architectural design, further contraction in services offered by the design firms, and further reduction in fees.

The outcome of this progressive disassociation of architecture from the rest of the building industry is a profession unsure of its role in contemporary society and its economy, and a profession unable to respond to the challenges and opportunities of the Information Age. Only by taking the lead in the inevitable digitally-driven restructuring of the building industry will architects avoid becoming irrelevant.

THE DIGITAL CONTINUUM

It is debatable whether the drawings emerged in the building industry because of the need to separate design and construction or whether their introduction produced the present separation. The lasting legacy is the legal framework within which building industry professionals operate today, requiring drawings, often tens of thousands of them, for a project of medium size and complexity.
Only the present divisions of responsibility make this production of drawings necessary. In other industries, such as shipbuilding, the designer and the builder are often one legal entity, so there is little or no need to produce drawings, i.e. to externalize design information. Many shipyards and boatyards have eliminated drawings by working directly with a comprehensive three-dimensional digital model from design to construction. The digital geometric data extracted from the model are used to drive the automated fabrication and assembly equipment.

Fortunately, the digital revolution that radically restructured the shipbuilding and other industries did not go unnoticed in architecture. Some architects were quick to exploit the design and construction opportunities that were opened up by the newfound ability to digitally generate and supply the manufacturing information to fabricators and contractors, and, in turn, their ability to reciprocate by providing accurate material and cost estimates. In these newly discovered mutually-beneficial processes of direct information exchange, the digital design information became the construction information, and vice versa, without the intermediate time-consuming and error-prone steps of drawing production. These digital processes, pioneered by Frank Gehry’s office, represent a radical departure from the normative practices – they eliminate, rather than automate, the production of various construction documents as paper drawings. The digital data are passed on directly, i.e. in paperless fashion, to fabricators for cost estimation and fabrication.

The ability to digitally generate and analyze the design information, and then use it directly to manufacture and construct buildings, fundamentally redefines the relationships between conception and production – it provides for an informational continuum from design to construction. New synergies in architecture, engineering and construction start to emerge because of the use of digital technologies across the boundaries of various professions. As communication among various parties increasingly involves the direct digital exchange of information, the legacy of the twentieth century in the form of drawing sets, shop drawings and specifications, will be inevitably relegated to the dustbin of history. The need to externalize representations of design, i.e. produce drawings, will lessen as a direct consequence of the new digital possibilities for producing and processing information.

As production of the drawings declines, i.e. as digital data are increasingly passed directly from an architect to an engineer or a fabricator, and vice versa, so will the building design and construction processes become more efficient. By some estimates, there is a potential for building construction to become 28–40% more efficient through better (digital) information and coordination. But for that process to begin, the legal framework of the building industry, in which the drawings establish the grounds of liability, would have to change. In other words, the nineteenth century building practices would have to change for architects to work directly with fabricators, i.e. subcontractors. This “disintermediation” should bring new efficiencies. According to James Cramer, Chairman and CEO of Greenway Consulting, architects will find themselves “moving from linear to non-linear changes – from information that is shared by teams, rather than individuals, and communication that is continuous, rather than formal and fragmented.”

In this scenario, the digital model becomes the single source of design and production information that is generated, controlled and managed by the designer. It encodes all the information needed to manufacture and construct the building. Layers of information are added, abstracted and extracted as needed throughout the design and construction, as architects, engineers, contractors and fabricators work in a collaborative fashion using a single digital model from the earliest stages of design.

Such a model of production requires that all tools for design, analysis, simulation, fabrication and construction be integrated into a single, cohesive digital environment that can provide information about any qualitative or quantitative aspect of building under design or construction. The challenge is (and has been for more than three decades of computer-aided design) how to develop an information model that facilitates all stages of building, from conceptual design to construction (and beyond, for facilities management), and provides for a seamless digital collaborative environment among all parties in the building process.

For Gehry’s office, a digital model created in CATIA – the design and manufacturing software used mainly in the aerospace industry – is the single source of design and construction information. In a remarkable departure from the current norms of practice, the three-dimensional digital model is actually a key part of the contract documents, from which all dimensional information is to be extracted during the fabrication and construction of the building. In other words, the digital model takes precedence over any other construction document, legally and in practice, on the construction site. This is a radical, revolutionary change in building practice, for which Gehry’s office will probably be remembered in future history books (and not only for the sinuous, curving geometries of the Guggenheim Museum in Bilbao, Spain).
The single, unified digital model, as envisioned by Jim Gymph, one of Gehry's partners, places the architect in the role of a "coordinator of information" between the various participants in the design and construction of a building. The principal idea is to unify, i.e. to bring together in a single digital information environment, the hundreds of different parties involved in a typical building production, with the aim of overcoming the inefficiencies, resource-wise and information-wise, that result from the conventional divisions of responsibility and modes of production in the various professions.

Gehry's office first experimented with the "paperless" process of digital production in the late 1980s in the design and construction of the large fish-shaped pavilion at the entrance of a retail complex on Barceloneta's waterfront (1992, figure 3.1). It was a watershed project for the office. As was the case with all of Gehry's projects later on, a physical design model was first generated and then translated into a corresponding digital surface model. The digital model was further refined; the wireframe model was extracted and used by structural engineers to develop the supporting structural frame. A physical scale model was machined from the digital version for comparison with the initial conceptual model. The digital model was then used in the full-scale construction to directly control the production and assembly of the components. For the first time, the construction drawings were not needed to erect the building. This process of project development and production, with some variations, was used by Gehry's office on a number of projects. Particularly notable among recent projects are the Experience Music Project (2000) in Seattle (figures 3.9a–b), and the Walt Disney Concert Hall (2003) in Los Angeles (figure 8.1), whose design and construction represents the most complete use of digital technology by Gehry's office so far.

According to Gehry, particularly appealing is the newfound ability "to get closer to the craft" by engaging the digital technology directly in the production and thus eliminating the many layers that exist between the architect and the act of building. To Gehry, that means one thing — "it's the old image of the architect as master builder," who now has control over the building process from beginning to end. Thus, the basic idea of the Bauhaus (of the unity of the craftsman and the artist) from the early twentieth century is reactualized at the beginning of the twenty-first century.

**CHALLENGES**

In the new digitally-driven processes of production, design and construction are no longer separate realms but are, instead, fluidly amalgamated. Builders and fabricators become involved in the earliest phases of design, and architects actively participate in all phases of construction. The fission of the past is giving way to the digital fusion.

This model of a digitally-facilitated collaborative continuum from design to construction, while opening up unprecedented opportunities for the building industry, faces a number of difficult, multifaceted challenges, which must be overcome for this new digital continuum to become a reality. The principal obstacles stem from the long-established social and legal practices in the industry. Its highly fragmented and differentiated structure, which facilitates a clear definition of the responsibilities, does stand in the way of new collaborative synergies emerging in the industry.

The sharing of digital data among various parties in the building process is, in fact, discouraged by the current legal codes of practice. Under the current definitions of professional liability, if an architect transmits a digital model or a drawing to a contractor or a fabricator, he or she becomes liable for any work resulting from the given digital data. The consequence is that each participating party in design and construction creates its digital data from scratch, i.e. from paper documents reproduced from the previously digitally-generated information. Needless to say, this process is not only highly redundant and utterly inefficient, but it also compounds any errors that could occur in interpreting the information exchanged on paper.

While uniting all the participants through a single modeling system, as discussed earlier, does hold a promise of a remedy for the present redundancies and inefficiencies, it makes the responsibilities of different parties far less distinct than is presently the case. If the building industry were to adopt this new modus operandi of shared responsibilities, it needs to clearly assess the legal repercussions and embark on a fundamental redefinition of relationships among various parties in the building industry, with the help of legal and insurance experts. A radical restructuring of the industry, while technologically possible today, is an enormously difficult task because of the tremendous social and cultural inertia of the firmly entrenched traditions, developed slowly over several centuries.

The transition then is likely to be evolutionary rather than revolutionary. Gehry's office, for example, relies on a "hybrid" system in which an owner-contracted consulting firm (called C-cubed, and led by Rick Smith) provides digital modeling services in CATIA to all members of the design and construction team, effectively
coordinating the production of the shared digital model. Each team member extracts and adds information to the shared model as mandated by their expertise without crossing the traditional lines of responsibility and thus staying within the limits of liability established by the legal and insurance rules. Had Gehry’s office assumed the responsibility for the development and data coordination of the digital model, they could have been liable legally as a professional architectural firm for the information provided by other members of the team.

While this solution protects the architect and creates an elegant legal “umbrella” for the rest of the design and construction team under the existing rules, it places significant responsibility on the owner-contracted consulting firm as a “data manager.” This is an emerging role that needs a full and clear definition as challenges of accurate and integrative production of information become more and more demanding. It is this role – the information master builder – that represents the greatest opportunity for architects to return to their master-builder roots. The architectural profession will seal its fate if it abandons the overall process and information integration and management to construction and engineering firms, some of which have already realized that the emerging dynamic, geographically distributed, digital networks of design and production expertise are the future mode of operation for the building industry.

With greater responsibility comes increased liability, i.e. a greater assumption of risk, but also greater rewards. According to Jim Glymph, “both money and time can be eliminated from the construction process by shifting the design responsibility forward.” Glymph offers, as an example, the cost of producing the shop drawings, which far exceeds the architectural and engineering fees for a typical large-scale project. But if architects were to provide the information for the benefit of other members of the design and construction team, they ought to be compensated for that new role. The restructuring of the industry therefore requires not only professional and organizational adjustments, but also a rethinking of how various members of the team are compensated.

In the State Center for Computer, Information, and Intelligence Sciences (2003) at MIT, Gehry’s office is breaking new ground by sharing the overall responsibility for the project with other members of the building team. The concept of shared liability is a remarkable departure from the current distributed liability of building practice. It is, perhaps, the most difficult challenge to overcome, as it represents a complete reversal of the present position by architectural professional organizations and insurance companies of minimizing the liability of architects in the building process. If they are to remain relevant as a profession, architects will have to learn to share responsibility with other members of the building team, as they once did.

Some architects have responded to the opportunities and challenges that come with shared responsibility by teaming up with contractors to create design-build firms, which serve as both architect and contractor to the owner, thus representing a single legal entity and a single point of responsibility. This change in the structure of building practices, and the resultant redefined legal framework that provides for shared decision-making, is one possible logical remedy for the present inefficiencies of a highly fragmented building industry. By some estimates, one-quarter of all construction projects in England and one-tenth in the United States are now done as design-build.31

Design-build, however, is only one way of actualizing the emerging professional synergies of digitally-driven modes of production. A more interesting possibility is the structuring of building teams as dynamic, geographically-distributed digital networks of design and production expertise, which change fluidly as the circumstances of the project or practice require. Architects will increasingly find themselves working in an environment of multidirectional digitally-mediated exchange of knowledge among various members of design and construction teams. In the emerging fluid, heterogeneous processes of production, the digital data, software and various manufacturing devices will be used in different ways by different members of the building team, who will often operate in different places and in different time zones.

As architects shift their attention from drawing production to digital information authoring, the software industry has a very important role to play in the transition to emerging digital modes of practice. Instead of adopting a conservative stance, which calls for providing technologies based on prevalent modes of practice, it has to actively engage in developing the tools that support new modes of production. In partnership with the building industry, it must overcome existing social and cultural barriers to technological innovation and must aggressively promote a new culture of use based on a single building model.

Educational institutions are the ones who have the power (and, hopefully, the foresight) to prepare future generations of professionals for the emerging practices of the digital age. We need to start training architects to be master builders again, to understand and re-engage the processes of building through digital technologies.
THE INEVITABLE
As architects find themselves increasingly working across other disciplines, such as material science and computer-aided manufacturing, the historic relationships between architecture and its means of production are increasingly being challenged by the emerging digitally-driven processes of design, fabrication and construction. The amalgamation of what were, until recently, separate enterprises has already transformed other industries, such as aerospace, automotive and shipbuilding, but there has yet to be a similarly significant and industry-wide impact in the world of building design and construction. That change, however, has already started, and is inevitable and unavoidable. The obstacles are numerous but the rewards are compelling if architects can manage to liberate the profession from the anachronistic practices of the twentieth century.

If nothing else, eventually the sheer number of digitally-produced projects will bring about a new way of thinking about architecture and its proper place within the building industry. Many of the strategies and techniques of production, which are pioneered today by Frank Gehry and his numerous less-known but more adventurous, younger colleagues, will be commonplace tomorrow, just as the material and technological innovations of the nineteenth century eventually became mainstream in the twentieth century.

NOTES
3 Ibid.
4 AIA Document A201: General Conditions of the Contract for Construction; the AIA's oldest contract document in circulation.
6 Ibid.
7 Ibid.
5

DIGITAL MASTER BUILDERS?

MARK BURRY
BERNARD CACHE
BERNHARD FRANKEN
JAMES GLYMPH
MARK GOULTHORPE
BRENDAN MACFARLANE
WILLIAM MITCHELL
BRANKO KOLAREVIC
DIGITAL MASTERBUILDERS?

MARK BURRY
BERNARD CACHE
BERNHARD FRANKEN
JAMES GLYMPH
MARK GOULTHORPE
BRENDAN MACFARLANE
WILLIAM MITCHELL
BRANKO KOLAREVIC
KOLAREVIC: This panel discussion will focus on the reemergence of the master builder paradigm. In contemporary circumstances, the master builder is someone who is fully involved in the making of the buildings, where the making means design, production and construction in an almost medieval fashion. As mentioned in the introductory remarks, the complexity of the blob-like forms is drawing architects back into being fully involved in the making of the buildings, that is, into assuming the role of the master builders. Most of the panelists did find themselves in that new role, perhaps out of sheer necessity to see their designs built for reasonable budgets. I would like to ask each of the panelists to provide their own views of that master builder reality in which they find themselves: is that something they are intentionally seeking out, or is that a necessity to have their work built?

GLYMPH: In our case, it is both. With what we do, which is really based on not taking the rationalizations steps described by Hugh Whitehead, we wind up with many highly-shaped, sculptural forms. That was a pursuit I think Frank Gehry wanted as a means of expression in his architecture, which was constrained by the cost and complexity of dealing with the geometric problems without computing. In the advanced computing world at the time we began doing this, it meant that you had to collaborate very, very closely with fabricators who were just beginning to enter the same world. This made it a necessity in order to execute that type of architecture, to establish a very strong bridge between us and the fabricators, the craftsmen, and the people executing the work, who are just being introduced to information technology. So, it was a necessity in that regard.

There is also deliberateness to it, because there is a philosophical stance in our firm that the architect needs to be able to deal with the tactile and sensual and the less easily quantifiable aspects of his art. To do that, he needs to get very close to the craftsmen, or to the fabricators, so that they become extensions of the gestural strokes that Frank Gehry will make on a model and collaborators in it.

Philosophically, I think we are driven toward the notion that the barriers that have been established, particularly in North America, between subcontractors, craftsmen, and people working in the field and the architect himself need to be torn down. Architecture needs to return to a more direct association between the material, craft, the physical reality of the building and its own design process.

MACFARLANE: We started with ideas, not intending to get into the complexity of fabrication. We were not that interested in the fabrication of the project; it is about being more interested in the ideas than the concepts. My passion today is close to that of a “mason,” working with the fabricator, taking that as a generating way back towards the idea, and reworking the idea. I never thought I would be in that position. It is exciting and very, very interesting. It is a subject that interests me a lot.

CACHE: In our case, it was very deliberate to be involved in fabrication. We would like to concentrate all the complexity in the software, so that building architecture can be just a gesture – as simple as putting a dowel into a hole. I think that building software is also part of the business in this field.

FRANKEN: We had a team of 75 people working on the last BMW project we did. It is not that the master is somewhere at the top and controlling everything; it is more like the role of a movie director. The movie director is a decision-making machine; he has to make sure he makes the right decisions as many times as possible. We are working with people whom we respect but, on the other hand, it is our position to control them, which makes the process difficult. We have to come up with control systems like the ones we saw at Foster’s, having lists and seeing tolerances, etc. We need the possibility to remove people if they are not performing their part, often on the basis that isn’t regulated by law. The whole question of liability when it comes to digital data exchanges is open. It is all new territory.
KOLAREVIC: I think what was just mentioned – the issue of control – actually uproots the existing hierarchies, in which architects give up the control of the project as soon as they pass the construction documents to the contractors. So how do you deal with risks, with the liabilities in these new modes of operations? We heard from Hugh Whitehead that they actually pass their models to the fabricators and say, well, it is your model now, you are making it, so therefore you are liable for it. So how do you in your practices deal with the issues of risks and liabilities?

MITCHELL: There are a number of interconnected issues. Technologically, we have a very fluid situation with developments happening in two domains that are being tied together. First, there is an amazing transformation happening in fabrication technology – the whole technology of computer-controlled machines, essentially robotic devices that make things. That technology is transforming amazingly fast at every scale, from the nano-scale at which we are assembling atoms directly, up through product-design scale to the upper end of the scale spectrum where architecture is. So, there are these amazing transformations happening in machines that make things together, with machines and processes for artificially positioning and assembling complicated things. Then there is considerable degree of innovation in what we tend to think of as CAD software – but it is really broader than that. It is the domain of computational support systems you use for exploring design ideas.

You end up with the situation where you have to marry these two worlds. As there isn’t a standard way of marrying these worlds, you have to invent it. That is what makes it so exciting now – this constant process of inventing it, trying to fit these things together in ways that are not given, not locked in place. I would hope that it does not rigidify, that the kind of inventiveness and fluidity continues.

Then there is a question about risks. Architects have spent a long time backing away from liability and backed themselves into smaller and smaller corners in the process. This is very different from the way other professionals have behaved in the twenty-first century and the twentieth century, where you say you try to develop your competence to the point where you can take more risks. That is what defines you as a professional – the ability to move into situations where you can confidently deal with the risk factors that are involved. I really think this is what architects have to do – get away from this position of constantly backing away from liability and develop enough competence to responsibly manage risks in situations of high innovation and high uncertainty. That is what real professions do. I think it means a change in the way we think about education. It means a change in general professional attitude. I think it is very fundamental.

GLYMPH: In the Disney Concert Hall project, the risks were vastly increased by the process we used – the risks to the architect. In most cases, we look at the process as a risk reduction for everyone. We do hand off models and have people share data and continuously build on the same database. There are lines of responsibility that are drawn; because of the way you deal with computing systems, those can be extremely complex lines of responsibilities.

A better situation, which has occurred on most of our European projects, is to look at the whole problem in another way and collaborate very early with the team that will build the building. In that environment, we thought of ourselves as a bridge between those who have the real, direct responsibility to build the job (which isn’t the general contractor) and the designers. To make that collaborative environment work, you have to take into consideration early in the design process the nature of the material, the craft, and the capability of the actual hands that will build the building – and forget about risk. You have to design a model that is not concerned with the legal structure; you have to see what the technology can do to bring those two groups together. If a project is established from that point of view, you normally find out that there are many devices everybody is willing to put on the table to manage the risk. It is pure problem-solving with the tool that allows new possibilities to designers on one side but also serves the people on the shop floor or in the field at the other end of the spectrum. Simply looking at the most efficient way to put
together the system, I think is the key to what we should be doing. And then we change the law.

GOULTHORPE: The fascinating thing with technology is once you have a sense of what it can do it fills the imagination. I am a sort of hopeless case of being like a monkey with a stick poking into an anthill. But one realizes that the essence of technology is not in the stick – the stick is just a stick – it is in the desire for ants that it propitiates! This is the real point at issue for a cultural discourse. And the curious thing is that another monkey without a stick who sits watching the first monkey can also become ant mad – this is the proliferation of the effect of technology. And that seems to me is what is happening at present.

Offices like mine, which obviously can’t invest in expensive software, are still ant mad. We are investing a lot of time in creating liaisons with people who do have those skills, which is creating a whole new type of practice. I think of dÉCÔi really as three or four people in a traditional office structure in France, but then there is a network of affiliates – mathematicians, programmers, robotic engineers – who are globally dispersed and whom we call upon for their specialist skills.

That said, I think there are fascinating potentials for new spatial possibilities and new material possibilities; I am particularly fascinated by the new tactileities that one might begin to arrive at a geological rather than geographical potential of form.

Currently we are working on an apartment project where we are machining and casting every basin, every door handle, every light switch – an entirely non-standard production. We are casting in bronze and aluminum, so I had a crash course in nineteenth century founding technologies! I have spent about 30% of my time finding sufficiently skilled people to help us begin to realize new material possibilities in this realm. That extended beyond bronze-casting sculptors and aluminum welders to robotic engineers in Australia. If I spend 30% of my time finding them, and 30% understanding them and the constraints of a kiln in a particular factory (and how you cast a half ton chimney piece in bronze and what really are the constraints of that), it really is coming back to trying to be some sort of master builder, but with a digital communication possibility. In such work a vast network of different skills are called into play, which is fascinating – which is actually terrifying! (If the fireplace cracks, it is going to be my fault!)

If architects want to realize the potentials which seem to be in the offing with this fabulous new technology, I think we have to move back into a realm of taking responsibility and reinvesting in understanding fully every aspect of digital praxis, from bronze casting all the way through to robotic engineering. I think that probably does demand a shift in education and a huge shift in apprenticeship, in the manner in which people are coming through practice.

BURY: The real innovation required where I live, in Australia, is social innovation, in the sense of how the process is driven. The architect seems to be able to garner all the resources required to do the kinds of things we have been talking about. In the environment where I live, however, the population is not specifically asking for this kind of innovation, but will accept it begrudgingly if it appears not to cost too much of the taxpayers’ money.

In my view, the real enemy for the architects who attempt to innovate are the contracting organizations. It seems to me the more the architect and the team innovate and decrease the risk of going over cost, the more they risk going over cost because the contractor decides it is an innovation which might be risky and prices accordingly. So, we seem to have a paradox.

I think the most exciting thing about the idea of the master builder is the whole issue of authorship. I think that sole authorship – the designer being the master builder – is no longer relevant. It is not synonymous with the way we might have been encouraged to think, particularly in the 1990s.

KOLAREVIC: What would it take for these practices to enter the mainstream of the building industry in this century? I think the obstacles are very difficult and I think it would take quite a bit of time – perhaps a few generations – to actually make a serious change in our industry.
GLYMPH: Technically, it could be done overnight. Socially, which I think is Mark Burry's point, it could take a few decades. That is because you are really going back to when there wasn't even an architect and the gothic master builder worked with the craftsman (which is sort of the master builder reference that resonates). That is realizable technically, but it will take down a set of processes and procedures, roles and responsibilities, and laws and standards that have been in place and have developed for over at least a century, if not more. It will take some time to take that down. It will only come down if benefits can be shown early – and there is the conundrum, because the process is expensive now and it is not proving anything unless you are trying to do something extraordinary. It is not proving things to the ordinary yet.

We have to come up with completely different ways of contracting, building and relating to each other. We have to have a different attitude about liability, responsibility and risk, and how it is shared. But it is possible. We are doing a project at MIT that has a project liability policy which includes fabricators, their engineers, and architects under one umbrella. So, you can make progress... Those kinds of environments create whole new possibilities.

MITCHELL: I totally agree with all those things Jim just said. How do you do it as a matter of practical strategy? How do you get started? I think there are a couple of basic things. One is energetic innovative research and education. Just producing a generation of people who are good and committed at doing some of these things – that is how you make a change. You begin with people. I think it is a major responsibility of the schools to provide an environment where this sort of thing can happen. It is difficult to do, but I think that is fundamental.

The other thing is that it is very important to have brave models of innovative practices. You can't change the whole industry overnight. It is a massive, complicated thing, but you can make enormous amounts of progress by showing alternative models, by just doing it. Getting the concrete alternative models up, making the wonderful projects, is what in the end, I think, catalyzed change.

If you look at the difference between the construction industry and the computer industry, you see a very interesting thing. Take something like the World Wide Web, which was an invention that swept over the world in the blink of an eye. It happened because there wasn't a big established structure in place it had to fight with – it was just this new thing that could take over. What we have with the construction industry is a huge, rigidified established structure. We can't expect the kind of instant takeover as with the World Wide Web, but we can do it in education, producing the people. We can do it with alternative practice. I have lots of faith that we will eventually accomplish very radical change.

CACHE: We are a very small practice, two designers plus the back office of programmers and other people, but we want to be small and to remain small. I am glad to hear that much bigger offices are facing the same type of problems we have. A couple of months ago I had to go to one of our contractors and prove to him – on the machine – that the origin of the machine was not where he believed it was. As a result, we decided to buy machines. We have our own workshop, because it is very difficult to find a collaborative combination that works.

We develop software, we make every effort to produce the same products more efficiently each time, but the manufacturers keep their margins unchanged. That was becoming comical... We tried for ten years to establish a relationship by which we measure the time of production for each new piece we do, and we never succeeded. That is why we are about to set up our own production unit.

KOLAREVIC: I don't think that will be the model for offices like Gehry's and Foster's, where they would actually engage in the making of buildings themselves.

GLYMPH: Sure we would... One of the things that gives us the hope of actually pushing a lot of change right now is the Design Build Association of America, which is looking at these same issues and does not have the constraints architects
have. They have decided to take full responsibility. They are going to take off with this technology. And they are going to put architects who are not working in design-build out of business.

The construction industry is messy, dirty, unruly... It is the last place where you can go to have an adventure of high risk. The risk is unavoidable, but the industry is aware of its problems. In the last decade or two, while the overall productivity in the economy has been going up because of the impact of technology and different business practices, it has dropped 15% in the construction industry. They know they have a problem. There are many people searching for solutions. There are many owners and major clients who are searching for solutions to get out of this messy “Wild West” environment of building buildings. They are open to new ideas, so we do have an opportunity to advance. If we advance the technology quickly, we have an opportunity to lay out examples that work better, that have better results, that can create momentum towards making social, legal and business changes. Many people will be put out of business. Certain roles will disappear; others will be created. This is a major upheaval for an industry, and it has to be motivated. And I think it can be motivated because it is the only industry going in the wrong direction.

JERZY WOJTOWICZ (from audience): What are the implications of this curious condition for architectural education today? We witness certain preferences for certain modes of working – you call it master builder, but maybe it is a digital craftsman – but schools seem to operate largely along conventions developed over generations. We see introduction of non-rational geometries to design that are frequently uncritically endorsed by students who do not have the grounding of the people who sit across this table (and who certainly don’t have a grounding of Gaudi).

GLYMPH: I think you have to make a distinction of process and imitating Frank Gehry or others who have highly developed eyes, in a strong sculptural sense, and took 45 or 50 years to get there. Students can’t be there. Designing on the computer with blob generators doesn’t produce architecture. It is even more important now that the critical side of design be imposed on students. The quality of design from an aesthetic standpoint is even more important now, I think. At the same time, I think we need to bring back what I think most schools have moved away from, which is the training in how things are built and engineered and how they work. The architect is supposed to have both of those. I think the schools have abandoned the responsibility for one of them.

BURY: Just one question that I have never had a satisfactory answer to... When I studied, it was the late 1970s, we spent a lot of time hatching – I remember spending at least several days hatching on my final project! There has been an incredible productivity gain through CAD, but what are we doing instead with the time we have saved in studio? I am sure there is a deeper and richer body of theory including technology that could be added to the syllabus. But at the schools I have taught at, the syllabus is effectively still the same. Subjects like communication have changed to become some sort of CAD thing; there might be some business studies that might not have been as prominent in my course. There must be a lot of room for a completely renovated architectural education.

MITCHELL: I agree with that completely. I really think we have to loosen up a great deal and realize that in a moment of rapid transformation that kind of authoritarian mode of education is never a good idea. It is particularly a bad idea in this kind of context. We have to create environments that allow exploration, innovation, and finding of directions in ways that I think really good, research-based universities can do. They involve putting together new combinations of things that allow critical exploration of ideas to develop.

A number of us at the table are involved this term in a studio operated jointly at MIT. There is a group of students and faculty at MIT, a group of Mark Burry’s students at RMIT in Melbourne, and then Jim Glymph and a number of talented people in Gehry’s office. It is all tied together electronically,
with traveling back and forth, and so on. The reason we are doing that is not because we want to demonstrate the capabilities of video conferencing – far from it. To create the kind of experimental, critical environment that we want, it is just necessary to put together that sort of mixture, which is essentially outside of traditional education and research structures. You have to put together a collection of intellectual resources that you need to do real serious experimental work. I think you only get a critical work by doing experimental work, not by sitting around and talking in a seminar room, but by actually doing the design work and being really rigorous about it, getting into the critical discussions that arise out of doing the work. I think that has to be the strategy – a difficult one, but the right one.

MACFARLANE: I have a sense of concern when I hear a lot of people talking about fabrication techniques, and I think to myself, where did the concept go? Where did the critical discussion go? For myself, I am not worried, because I think we are interested in that – we come from that. I think I see in the schools right now a push towards this territory of both representation and fabrication from representation. That is where the energy really is, where the discussion really is, and that is partially why we are here today. Have we lost critical analysis along the way or have we lost an architectural culture along the way? I don’t think so at all.

GOULTHORPE: I think in our office we are facing a couple of problems. Finding people capable of doing the work is always an issue. I have been very fortunate to have a stream of Mark Burry’s students coming through, so I think I have benefited enormously from the rigor of Gaudí’s work and Mark Burry’s work – I hope they benefit from coming into our practice and get a thorough apprenticeship. Generally, students are coming with programmatic skills or parametric skills and they are teaching us something.

I think the university does have an incredible role to play in allowing the necessary accumulation of skills to come into offices. Students after five years of university education should be coming out as useful. One would hope.

We always face the problem of losing students. People come to the office for six months with a skill in 3D Studio MAX or Maya. Somehow, there seems to be a sense among the generation of school leavers that because they have mastered a software, they are sufficient as architects, and they almost immediately seem to be leaving to set up their own practice, which usually turns into a graphics company for websites very quickly. There seems to be an enormous problem in convincing this generation of digital talent that there is a deeper and more profound body of knowledge to acquire, which they will only get through apprenticeship. Perhaps there is some link between university and practice that needs to be reinforced somehow.

I want to point out that the people whose work I mentioned, many of them here, are philosophers, and this technological change is properly speaking a philosophical one: Bernard Cache, Greg Lynn, Lars Spuybroek… They are all thinkers from other fields or have had deep exposure to other fields. They are actually thinking the technology, rather than simply using it. I think we should be encouraging a properly philosophical reflection on the nature of this transition, which again I don’t find in many schools. It is almost a training program for technicians. I don’t think it is adequate – I think there is a much profounder reflection that needs to take place.

PAUL SELETSKY (from audience): How do the panelists view the implications of technology on the future role of the “architect of record?”

GLYMPSH: Sometimes referred to as the “executive architect?” In projects where we work with executive architects in foreign situations, where we cannot be the architect of record, they have to ride into the process with us, and that has the same implications for them. But what has been interesting about that is that it depends on where you are in the world. There are great models in the world for doing it differently. How it is done in North America is by no means even close to the right way of doing it. So, I would
suggest you look at executive architects working in Germany and in some cases in Spain. We have a couple of organizations we are working with. They are actually moving even closer to the role of being construction manager as well.

Once you have this technology and you master the database, the role of the contractor becomes logistics. Management can almost be done as a continuous process, as part of the design process. I think executive architects have evolved towards a design-build role or at least a project management role. We have a number of firms we worked with that have actually made that transition by adopting our process and seeing an opportunity. That is a hole people aren’t willing to step into. Contractors in the US have pulled away from that role as well. What is interesting is they don’t do coordination anymore either. So, there is a gap, there is an opportunity. I think there is technology out there that can give you the edge. I think a few are looking at that and having some success with it.

KEVIN KLINGER (from audience): There has been a lot of talk today about the necessity to enter into programming to achieve the things that you want to achieve, particularly with Mark Burry’s work and Bernard Cache’s work. Back to the issue of the master builder, could you address what you see as the role of the software developer as a part of that relationship?

MITCHELL: First, the issue of what software really is and who makes software... It used to be in the early days of computation (in the way Microsoft likes to think about these things) that the software is a packaged up, standardized product that somebody sells to you and then you are a user. The terminology tells you – it is really just horrifying as a way of thinking about it – it is like something you do in a back alley with a syringe. But in fact what is happening, of course, it is like learning that you were speaking prose all your life.

When you make a parametric model, in fact, you are programming. You are doing a sophisticated piece of programming. You are declaring entities that are going to be part of what happens, you are establishing relationships, you are assigning values to parameters, you are doing all the things that programmers do. Now, it is in a very different style from what people think of as coding, but nonetheless it is programming. I think there is no alternative if you really want to have your hands on what is important, if you really want to innovate, if you really want to do the sorts of things that were shown so beautifully today, you just have to learn to do them. I think it is fundamental to anybody who wants to seriously think about design or technology today to have those sorts of programming capabilities. What I don’t mean is knowing the syntax of some esoteric programming language – that is trivial – you can pick that up very quickly. What I think is crucial, is to have the intellectual skills of abstraction, definition of relationship, all of these sorts of things that parametric modeling demonstrates.

ROBERT AISH (from audience): On the issue of software I think the problem is that the software engineers producing the initial CAD software looked at what they thought real designers were doing, and made the incorrect assumption that the process of design was all done through the direct manipulation of geometry. The software engineers got into the typical Microsoft approach of creating an application which was a metaphor of what was previously done. In fact, in a deeper analysis of the architectural design process, we find that it has both an intuitive and a formal component. These can be more effectively combined in a computational design tool that allows the designer to be progressively more programmatic if he wants to be and as the design problem requires. I think that Bill Mitchell is absolutely right. My view is that a CAD application is in fact more like a visual programming environment.