

Tectonics, Economics and the Reconfiguration of Practice: The Case for Process Change by Digital Means

The current programming culture in architecture could all too easily be written off as a youthful, geeky obsession with the algorithmic and the parametric among nascent practitioners, who have had little if any opportunity to build. The activities of Gehry Technologies run counter to this stereotype. Building on 15 years of experience at Gehry and Partners, Gehry Technologies was founded in 2002 as an independent organisation dedicated to the business of technological innovation and the development of architectural software tools. Dennis R Shelden, chief technology officer, discusses the wider implications of a concentrated focus on technological tools and organisational processes for designers and the business of building.

Gehry Technologies is a relatively new organisation, representing a new organisational model in the spectrum of building practice. The organisation pursues an enquiry into the processes of building and the emerging practices and roles suggested by technological advances. The impact of this focus on process translates into architectural form through the tectonic aspects of design, and a view of building from the process of making back towards architectural design, rather than the prevailing view of making as design's outcome. There are several reasons for this focus on tectonics and process, not the least of which is that consideration of these aspects has been downplayed in the development of tools and methods in favour of the more obvious architectural drivers of schematic and planning-level thinking about building. At Gehry Technologies we perceive there to be a gap in the available tools sets and methodologies for these aspects of design, and great opportunity for the profession as it moves into these areas of interest.

The opportunities and potential value of retooling contemporary building practice are well documented, as are the potential pitfalls. There is great potential for design in expanding the set of forms available to architecture, along with a corresponding sense that the rules of engagement have to be different to realise this potential in built form. Capabilities for the geometric expression of form – enabled by

advances in digital media – have moved beyond the capacities of 'conventional' project descriptions to effectively capture and processes project intentions into building. Meanwhile, the contractually structured conventions of project team organisation and roles have inherent, deliberate limitations on communication, whose utility has now been exceeded.

Reconfigurations of Practice

Building has a history of a hierarchically structured organisational model and supply chain that stems from the 'limited bandwidth', or limited capabilities for the transmission and processing of information, of the pre-digital age, and suggests a preference for 'command and control' over collaboration.

Other businesses have advanced their organisations in light of recent technology. While the heavy manufacturing industries have optimised around such hierarchical command-and-control structures, others have developed around more decentralised, webbed business organisations, including light manufacturing, retail and the entertainment industry.

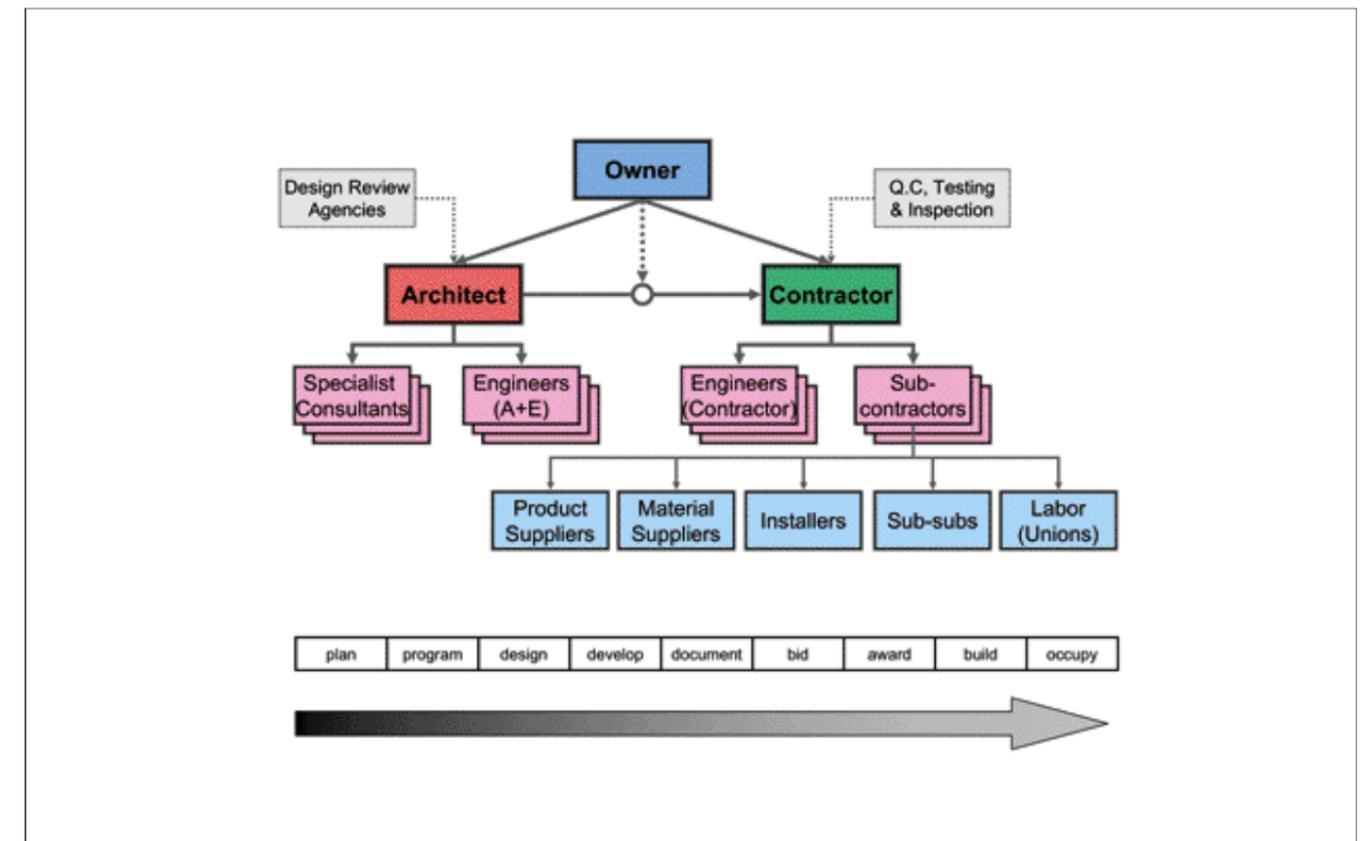
The business of building has yet to do either. It has been noted that building teams are constructed as networked organisations, but are contractually restricted from functioning in this manner. The process of building has remained – officially – hierarchically structured in control,

and linearly structured in time. Contract, finance, information and control flow-gates control the process and communications between players. These structures are legislatively defined, and there is considerable inertia in the current model, and risk in pursuing new models. There are many issues with the existing organisation, perhaps most notably that it has isolated architectural practice from the centre of value of construction. This has occurred nominally in the interests of protecting architects, the argument being that architects cannot be experts at everything, and construction processes – which have high risk (but also high value) – are too detailed or too complicated for generalists.

Digital practices offer the potential for expanding the reach of design deeper into the process of building, and the potential emergence of a new, digitally enabled, master-builder role for architecture is the topic of much discussion. Digital tools offer a catalyst for pursuing alternatives to traditional project controls, by reducing the risk of innovation below the level of current practice. We are now seeing new ways in which designers and builders provide new value by forming new project organisations that branch across the tree. This has the

appearance of the direct violation of the formal ways that information flows through projects. So the risks of making change are high, but firms are moving in these directions because of the inherent opportunities in doing so. Whether the architectural profession will take the lead in this industry reconfiguration remains to be seen, but under any circumstances, the opportunity of control through improved access to information does not seem to be a zero-sum game.

A key aspect of this catalytic force is the potential for directly repurposing information through various stages of project definition and execution, between specification and execution, and between form and economics. This is radically new, in that previously human intervention, and presumed quality control, was required to transfer intent across usages. Each division or reprocessing required an authority to be taken and documents to be stamped. The notion that project definition might flow freely and automatically between players without specific human action threatens to make the traditional ways of controlling responsibility obsolete. Yet it is in this streamlined connection of process that new opportunities are available.

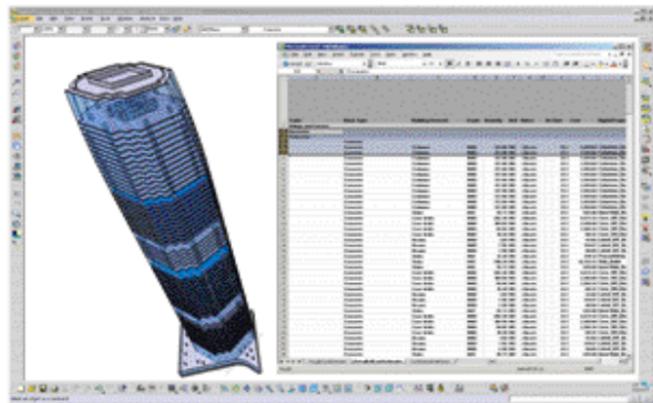
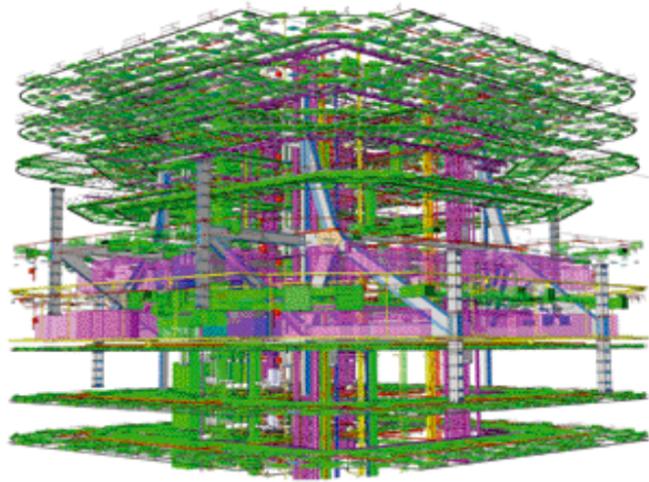


Conventional building delivery is structured hierarchically in terms of control, and linear in time. Digital tools are providing a catalyst for rethinking the structures of project delivery, presenting opportunities for firms to expand their roles, offer new services, and change the sequencing of how and when design information is developed and consumed.

The third dimension has so far been the locus of this new communication. One of the drivers of information integration is the understanding that miscoordination occurs at connections and interfaces, precisely where the inherent gaps of contemporary process are defined.

One of the hallmarks of emerging design tools is the ability to expose cost-benefit analysis as an aspect of iterative design. This requires exposing information developed late in the game and hidden internally in specific delivery roles, upstream and into the mix of high-level project decision making.

The 'single building model' has been an attempt to coordinate project knowledge around a framework for the integration of spatial occupancy. This view of the net result of specification as geometric location is an obvious one, and substantial efficiencies are being realised by digitally simulating the spatial configuration of building elements prior to construction.



Swire Properties supported the development of a digitally integrated building delivery team for the One Island East Project (Hong Kong, 2004-). The project database was used to produce detailed quantity extractions and cost estimates, which were provided to bidders as part of tendering phase documents. The 'single building model' is, in fact, an integrated view of numerous trade- and discipline-specific design documents.

Yet even as this view of the spatially integrated building model begins to take hold in practice, there is the sense that technology – and opportunity – have already moved beyond. The reason is simple: much more is known internally about the nature of products than can be exposed to the process simply as occupancy of space. The notion is that design or engineering intent *generates* occupancy of space in a given building configuration, and that this intent can be coordinated in a much more direct manner. Parametric modelling is the technological basis for this expression of intent. The opportunity of parametric modelling is that we can express design, engineering and fabrication intentions independent of geometry, such that these intentions persist over geometric variation. It is this capability that allows the conventional notions of the linearity of process to be reversed, that late-stage decisions can be potentially back-propagated upstream into design iteration without the inherent cost of the conventional generate-test-discard model.

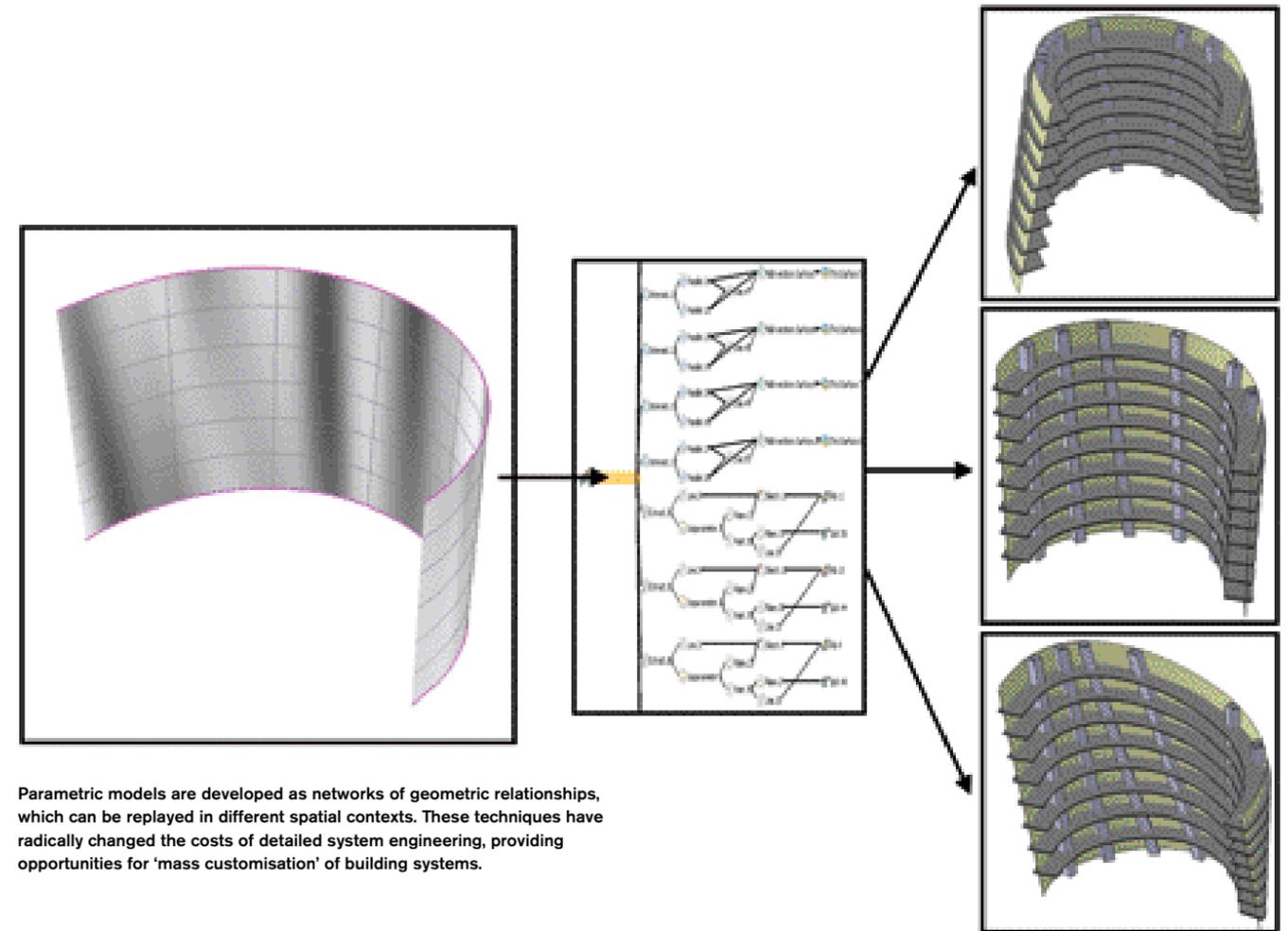
Digital Tectonics

One net affect of algorithmic design on practice has been a new emphasis on tectonics as a key driver of architectural expression. The trajectory of tectonic intentions towards a central role in design has occurred independent of digital processes, but expansions of formal possibility through digital media have necessitated increased attention to these practical aspects of building.

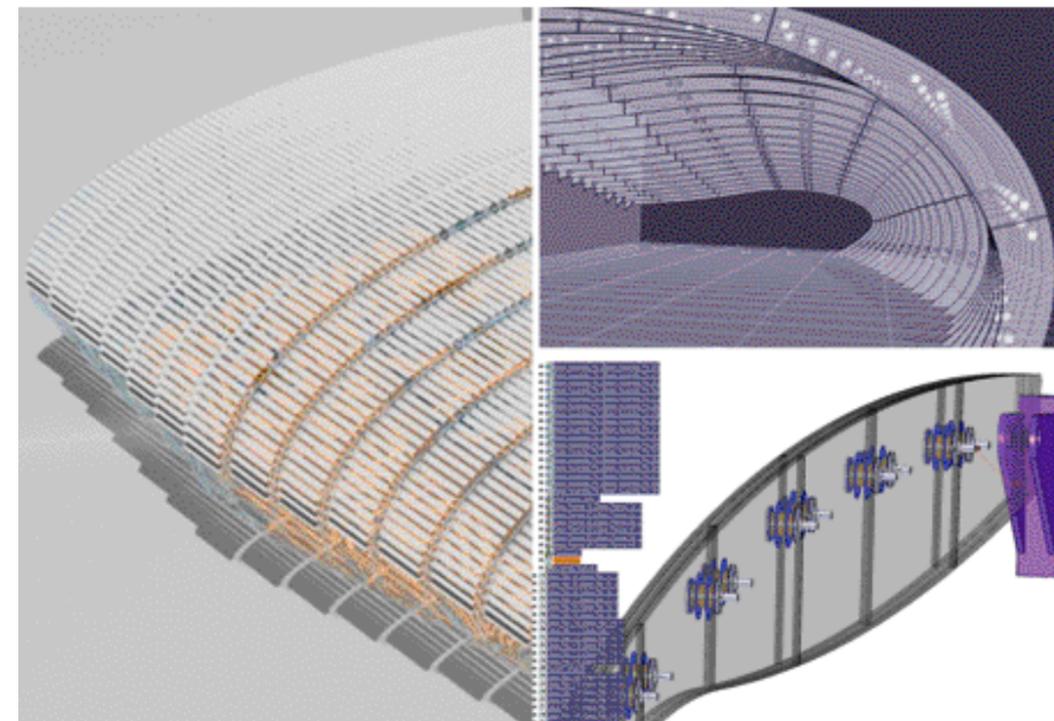
There was a sense in 20th-century practice that what was critical was to get the more 'architectural' aspects right – aesthetic intentions and the relationship between form and programme – and that these intentions could be abstracted from project execution. Modernist forms allowed for the abstraction of form from materials, and for a primacy of geometry over materials. Tectonic specifics were at best second-order drivers of form, and were 'hot swappable': one material could be substituted for another late in the process as part of 'value engineering' without requiring substantial revisitation of higher-level project intentions. The move away from tectonics and process is expressed in the contractual distinction between the roles of architects and builders, and corresponding distinctions between specification and execution.

Of all the unanticipated trends that the digital has produced, none is more surprising than its role in the re-emergence of craft and increased intentions towards materiality as important design themes. We might question whether these arose as first-order drivers in themselves, or emerged as necessary topics with design's move beyond the forms of Euclidean geometry, a development in which digital media certainly have played a profound role.

The expanded potential of architectural forms has mandated a consideration of material and tectonics as first-order drivers, key enablers or constraints that impact the potential realisation of form as building. The limits of our



Parametric models are developed as networks of geometric relationships, which can be replayed in different spatial contexts. These techniques have radically changed the costs of detailed system engineering, providing opportunities for 'mass customisation' of building systems.



Front Inc adopted a parametric approach to the design of the Yatala Glass Showroom (Brisbane, Australia, 2004-). The firm provides design, engineering and detailing services, and is expanding into self performing the delivery of building envelope systems. Front's practice demonstrates the potential of new technologies to support innovative business models and opportunities for practice.

capacities to express or control the *descriptions* of form are no longer the main barriers to exploration: digital media have taken care of that. Rather, the limits are economic, and are resolved by bringing the efficiencies of fabrication processes into the sphere of formal design considerations.

Part of this trend may be transitory, due to the current limitations of the economics of spatial control. For while digital media have afforded an almost unlimited availability of information at continued reductions in cost, the same is not (yet) true of our ability to project this information into the spatial environment. This limitation has been breached in schematic-phase design activities, where prototyping capabilities provide low-cost, high-fidelity translations from digital to physical. However, such technologies are not yet scalable to building size objects of singular configuration, at unit costs competitive with that of traditional construction. It might be argued that digital design media have produced an excessive production of information, beyond our capacity to consume or control, and that manual intervention has found a new role as a bridge between information and material. The

process of realising digital form at the building scale has been based on a deliberately reduced pipeline between the digital and the physical, with a heightened authority bestowed upon the craftsman as the interpreter.

The same can be said of the resurgence of interest in the behaviours of materials. The initial exuberance of the ability to project digital forms into the physical has given way to a new-found respect for materials as important voices in this process, and developments are now concerned with back-propagating materiality – or at least its geometrified interpretations – into the digital tool set.

The value of generative design on the architectural side, and mass customisation, its closely related fabrication counterpart, does not seem to be particularly in the efficiencies afforded to the architects' studio, nor the ability to produce interesting patterns of form. These benefits could presumably be achieved through other means, with considerably more directness, freedom and tactility. The benefit is to project execution – to provide economies in fabrication, allow tradeoffs between economies of information and component generation. To the

extent that this phenomenon is of concern to design, it is to expand the opportunities of buildable form, to extend the reach of design intent deeper into the building delivery process, and bring economies of making within the set of formal tradeoffs available within the scope of parameters available for design synthesis.

Predicting and Building the Future

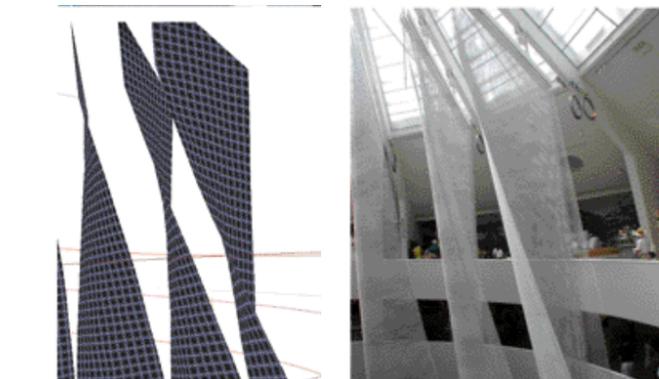
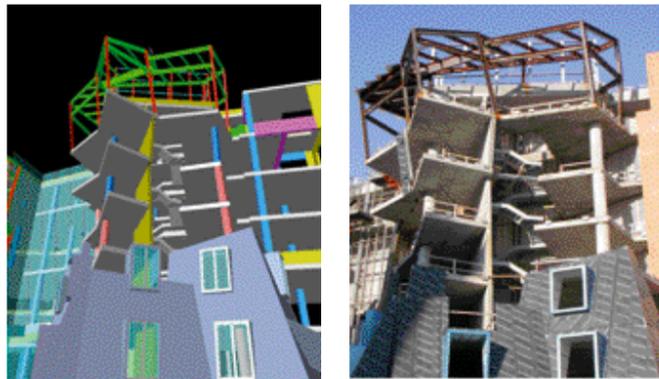
Gehry Technologies has staked a somewhat unusual position in the spectrum of emerging building practice. We have found ourselves in the position of toolmakers, in order to fill tactical gaps necessary for new models of practice. Our experience suggests that there is a viable role for practitioners to engage directly in the business of technology innovation. The availability of computationally sophisticated talent in practice, and the increasing number of firms – both small and large – whose work is pushing the envelope of 'conventional practice' through digital means, suggests that other firms have much to contribute, and much to gain, in advancing the common pool of technology available to practice. To date, this course of action has been limited by the high barriers to entry into the technology and innovation market, combined with a perception that opening a firm's internally developed expertise

to the larger audience represents a leak of intellectual property and technological differentiation to competitors. In short, the business case that will incentivise firms to share innovation with the wider community is missing. Our ambitions for the near future include developing business models for the productisation and distribution of technologies that lower the barriers to entry and incentivise a wider range of firms to contribute to the network of available technologies.

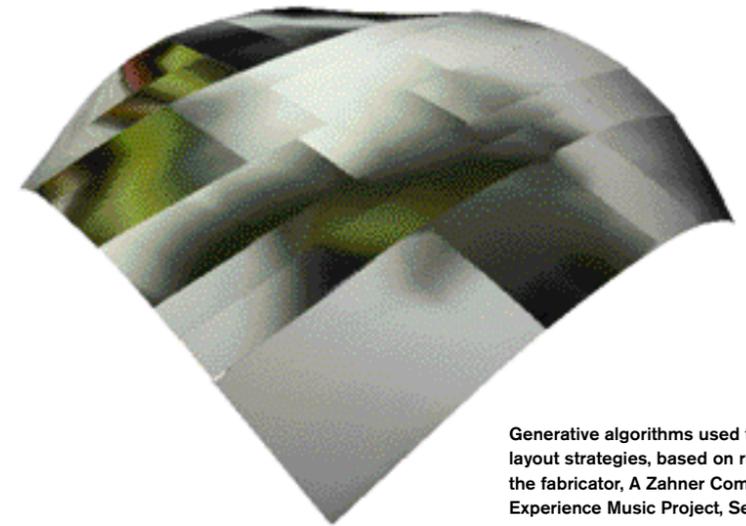
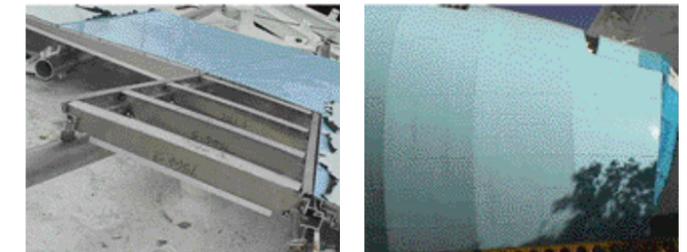
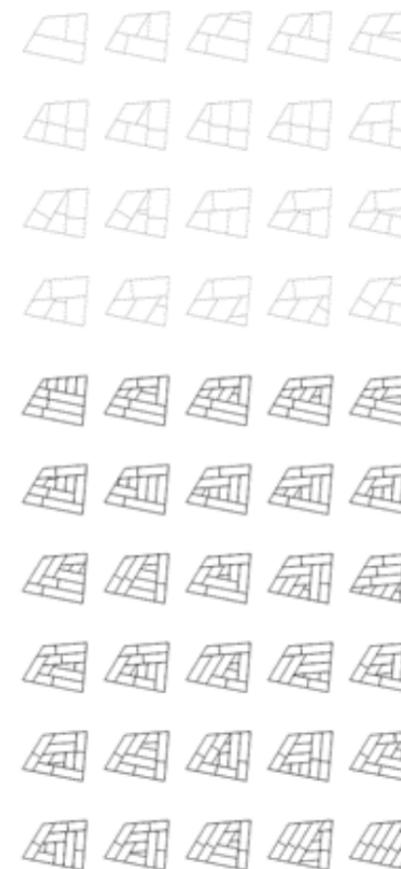
The forces of technology and economics have as of yet by no means been universally favourable to architecture as a profession, nor necessarily to builders, owners or consumers of design. Yet there is a resurgence of interest in design as an economic differentiator, which has unfolded parallel to the evolution of design technologies, that appears as a counterforce to the ongoing commoditisation of both tools and practice. The questions of reach, opportunity and responsibility for participants that engage around projects is very much in play, and the economic pressures of differentiation and efficiency are sounding a mandate for innovation that digital methods are available to serve. The potential of process reconfiguration to reposition design as again central to building is large, and the opportunity for designers in taking on this challenge squarely seems open ended. **Δ**

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Digital models are increasingly incorporating materials simulation and aspects of process to provide effective tools for predicting system behaviours during installation. Top: digital contract model with overlaid shop drawing submittals, mit Stata Center (Gehry, Cambridge, Massachusetts, 2004). Bottom: a custom mesh simulation tool used in the design of the Gehry Retrospective installation, Guggenheim Museum (2000).



Generative algorithms used to develop panel-layout strategies, based on rules provided by the fabricator, A Zahner Company (Gehry Experience Music Project, Seattle, 2000).