Punching Above Your Weight
Digital Tools, Design Strategies and Organisational Structures for Expanding Design in Small Practice

Rory Hyde
Doctor of Philosophy (Architecture)

2010

RMIT
Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Rory Alexander Fitzwilliams Hyde

October, 2012
Abstract

The title of this work, ‘punching above your weight’, is a phrase native to boxing, where it is used to describe fighting at a level better than is expected of one’s division. It is used here in the context of architecture to describe a kind of practice that embodies these qualities, by delivering trim efficiency and power that would be expected of a larger organisation.

The hypothesis of this thesis is that with the aid of new digital media and design software the ability to ‘punch above one’s weight’ is now becoming increasingly possible, and is subsequently opening up new possibilities for the organisation of architectural practice. This research sets out to test this hypothesis by investigating the particular characteristics which may make up such a practice, by focusing in parallel on the two sides of this equation: digital design strategies and organisational structures.

While digital media is not new to architecture, its increasing pervasiveness, power and sophistication have led to the maturing of this media, fundamentally reshaping the way architecture is designed and practiced. This research identifies key opportunities for practice offered by this new media, including: the ability to repurpose information between stages of development, procedural design strategies, a return to craft, and the opportunity to connect directly to computer-controlled means of manufacturing.

These design strategies were tested on real projects within the context of the architectural practice BKK Architects, where the investigator was ‘embedded’ as a member of the design team. During the course of this study, BKK Architects was comprised of less than fifteen people, it is this context which gave the thesis its focus on small practice. This limitation is used constructively as a means to explore how new digital design strategies could be uniquely applied in the context of a small practice, and the limited resources that this implies.

Furthermore, this ‘smallness’ often extends throughout the delivery chain; small practices often work on smaller projects, with smaller builders and smaller budgets, subsequently requiring specific strategies for engaging with this context. Focussing on small, and the limited resources that this implies, has led to the development through this research of innovative design strategies that embody the small-practice spirit of the ‘grand gesture within limited means’.
As a way to foreground the insights and observations drawn from the project work, this thesis is focussed on the strategies that bring projects into being, not the outcomes of the projects themselves. By emphasising and focusing on the processes that lead to an end product, broader conclusions can be drawn that are relevant to practices and researchers beyond the specific context within which this work has been conducted.

A key contribution of this research is the development of design techniques employing parametric, computational, and manufacturing based approaches, that are specifically tailored to the small practice, with particular emphasis on those strategies that can aid in extending and enhancing the very early stages of designing.

This thesis also proposes ‘the new augmented practice’, a model for practice that combines the strengths of small practice as a collaborative and creative environment, with the new potentials offered by digital design tools to produce a practice structure that is specifically suited to the demands of our contemporary information age.
Biography

Rory Hyde completed a Bachelor of Architecture with Honours at RMIT University in 2005. He is highly engaged in all aspects of architectural culture, including research, practice, education and media.

Rory has published and presented his research locally and internationally. He has taught design, technology and communications in the School of Architecture and Design at RMIT. Rory is co-host and producer of The Architects, a weekly radio discussion show about architecture on Triple R, broadcast in Melbourne.

Upon commencing this research Rory had very recently completed his undergraduate professional degree in architecture and also had significant experience working in a small practice. These two interests combined give a unique perspective of the crossover between the research and experimentation that occurs in the academy and the realities of design and production in a small commercial studio.

The Embedded Practice PhD program offered the ideal opportunity to explore this crossover more thoroughly than would have been possible through either further education or further practice experience exclusively.
# Table of Contents

Declaration 2

Abstract 3

Biography 5

Table of Contents 6

## Chapter 1. Introduction 8

1.1 Research structure and context 9

1.2 Methodological approach 12

1.3 Definition of terms 14

1.4 Conceptual framework 19

## Chapter 2. Literature review: contemporary digital design strategies and their origins 21

2.1 Design as structured rational method 22

2.2 Design as informed by a set of components and geometric rules 28

2.3 Design as evolutionary process of trial and error 33

2.4 Enter the digital: Implications of a shift in media 40

2.5 Expanded tools 44

2.6 The implications of digital media in architecture 48

2.7 Practice engagement of emerging technology 50

2.8 Summary 55

## Chapter 3. Literature review: Organisational structures in architectural practice 56

3.1 Historical precedent: ‘from collaboration to division’ 57

3.2 Organisations in the network society 72

3.3 New opportunities for design practice 75

3.3.1 The information master builder 77

3.3.2 Flexible specialisation and personal fabrication: a return to craft 79

3.3.3 Design about production 81
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3.4 Small, networked practice</td>
<td>84</td>
</tr>
<tr>
<td>3.3.5 A dissolution of hierarchy</td>
<td>86</td>
</tr>
<tr>
<td>3.3.6 Innovation through increased risk and accountability</td>
<td>89</td>
</tr>
<tr>
<td>3.3.7 Practice as research</td>
<td>92</td>
</tr>
<tr>
<td>3.3.8 Design thinking</td>
<td>96</td>
</tr>
<tr>
<td>3.4 Summary</td>
<td>98</td>
</tr>
</tbody>
</table>

### Chapter 4. Case study projects: Strategies for expanding design

#### 4.1 Closing the loop

#### 4.2 Deferred decision designing

#### 4.3 Hand-made digital fabrication

#### 4.4 Design as a goal-oriented experiment

#### 4.5 Re-folding complexity

#### 4.6 Pleating as surface rationalisation

#### 4.7 Summary

### Chapter 5. Interview: Structures for expanding design

#### 5.1 Interview with partners of BKK Architects, November 2008

#### 5.2 Summary

### Chapter 6. Conclusion

### Chapter 7. Appendix

#### 7.1 Projective conclusion

#### 7.2 Transcript of interview with directors of BKK Architects, October 2006

#### 7.3 Full text of scripts

#### 7.4 Paper: ‘Punching Above Your Weight’

#### 7.5 List of abbreviations

### Bibliography

### Acknowledgements
Chapter 1. Introduction

The hypothesis of this thesis is that with the aid of new digital media and design software the ability to ‘punch above one’s weight’ is now becoming increasingly possible, and is subsequently opening up new possibilities for the organisation of architectural practice. This research sets out to test this hypothesis by investigating the particular characteristics which may make up such a practice, by focusing in parallel on the two sides of this equation: digital design strategies and organisational structures.

This research is positioned in response to a number of key issues that have converged to radically reposition contemporary architectural practice. The first is the ubiquity of technology, which has caused a dramatic shift in the way architecture is conceived, produced and practised. While the computer has been present in architecture for a number of decades, only recently has its role matured from that of a digital drafting board to be used as a design tool (Kieran and Timberlake 2004, p.59).

The second issue is the changing landscape of organisational structures of architectural practice and business more broadly. The economy is shifting from being characterised by mass production to that of flexible production, where the key competitive assets are the ability to create and manage knowledge (Castells 2000), (Berry 2003), (Bjerke and Hultman 2002).

These two key issues – technology and organisational structures – are inextricably linked, as Malcolm McCullough (2006, p.15) states, “information technology and organisational change are just two sides of the same coin.” By examining these two aspects in parallel, this research aims to articulate a practice model that responds to these radical changes in technology, design and organisational structures in a manner that is intrinsically relevant and viable to today’s information society.

This thesis contends that by developing new process-driven design strategies, managing complex information, increasing efficiency and enhancing collaboration, digital tools could enable smaller practices in particular to accomplish a greater amount within limited resources, or – to use a metaphor from boxing – to ‘punch above their weight.’

The reason for this constructive limitation on small practice is largely determined by the research structure and context.
1.1 Research structure and context

This research has been undertaken in collaboration between the Royal Melbourne Institute of Technology University’s (RMIT) Spatial Information Architecture Laboratory (SIAL) and the small practice Black Kosloff Knott Architects (BKK). This unique structure was initiated by the lead researchers (Mark Burry et al) as a means of integrating research undertaken in the university with pressing issues encountered in practice. An interdependent relationship is established between these parties whereby RMIT/SIAL offers a resource network of technical experts, equipment and training, and BKK brings real world projects with their associated real world issues to which this expertise can be applied [Figure 1]. Although this collaboration is not the subject of this research, a brief explanation is given here of how it was established and the roles of the various parties, as it has implications for the focus and findings of this work.

The practice partner, BKK Architects, is a Melbourne-based, design focussed architectural practice founded by Tim Black, Simon Knott and Julian Kosloff in 2002. The three directors came together after gaining significant experience and skills from working at a high level in other practices in Melbourne, and quickly built a reputation for quality houses, small public works and commercial
projects. In this relatively short existence, the work of BKK has been widely published and has garnered a number of local, state and national awards for design (Black, Knott et al. 2008).

What is particular about BKK is that the directors of this practice are intent on limiting the number of people in the practice as a way of remaining close to the designs, collaborators, staff and clients. In an interview with the partners, director Simon Knott stated “when we first started, we said ‘we want to be a big international practice’, and now we’re thinking maybe we don’t want that, maybe we want to be hands on, and keep it back to ten or fifteen people in the office” (Appendix 7.1). The partners also consider the practice’s high design quality to be their greatest interest and competitive strength – staying small is one strategy they are employing in an effort to ensure this will continue.
I started with BKK in 2003 as a part-time student designer. At that time the office was a very small practice, with three directors, two other part-time students and myself. In 2005 at the time of commencing this research, BKK had expanded slightly to have a total of seven staff including the three directors.

At the time of writing, BKK have recently undergone another phase of expansion, now employing ten staff, most full time, plus the original three directors. Figure 3 illustrates this line up and also indicates the key relationships beyond the practice to the key external collaborators, institutes and organisations. (This network is of primary importance to the practice, and will be returned to in more detail in Chapter 5.) BKK have also relocated to larger premises with a more structured and professional workspace. Despite this shift in scale, the practice aims to retain the quality and atmosphere of the original studio environment, with the practice statement on their website claiming that they merge "large-scale practice capabilities and experience with the adaptability, innovative culture and client focus of a smaller practice" (Black, Knott et al. 2008).

The university partner SIAL is a research unit based at RMIT specialising in the exploration and implementation of advanced digital design strategies across various spatial disciplines. As the host institution, it provides educational support, technical training in high-end software, resources such as rapid prototyping machines and workspaces [Figure 4], and academic supervision for a number of postgraduate candidates. SIAL can also draw upon a network of experienced researchers and designers who were sought for advice and feedback throughout the course of this research.

As the ‘embedded’ research candidate, I sit between the academy and practice, effectively as a member of both; a post-graduate researcher in the university and a working member of practice. In this case, being embedded in practice meant that I was working within the practice in a full-
time capacity. My role comprised of all the usual tasks demanded of staff in a small practice, including work on designs for commissioned projects and competitions; producing documentation, construction and presentation drawings; meeting with clients and conducting site visits. However each of these tasks was undertaken with an analytical approach, examining and reflecting upon the ways things would typically be done, and in many instances proposing and experimenting with new tactics or strategies for achieving them.

1.2 Methodological approach

As is noted in section 1.1, this research has been undertaken as part of a larger research project titled ‘Technology Transfer through Embedded Research within Architectural Practice: the creation of an Australian practice-based architectural research and development network’ led by the Chief Investigator Mark Burry and Research Associate Andrew Maher. (Burry, Maher 2005) The methodology for ‘Punching Above Your Weight’ has been determined by this larger program, and as such is documented thoroughly elsewhere (Maher, Nelson 2006) (Maher, Mewburn 2007) and is not the subject of this thesis. These researchers observed the embedded researchers in action, and have collated their findings on the effects of this on the host practices, the type of knowledge produced, and the opportunities offered by programs of this kind.

This section presents some of the positions occupied by others in the study of architectural practice, and makes a claim and justification for the relevance of the embedded practice model in approaching this research.

Of the few texts that focus explicitly on practice, as opposed to buildings, many (Kostof 1977) (Saint 1983) (Gutman 1988) (Addis 2007) assemble their findings largely from primary source documents such as photographs, plans of spaces and archives; and personal accounts from staff who worked in the practices studied. No new insights are drawn from immersive research in practices themselves, but they instead adopt a historical approach, which, especially in the case of Kostof and Addis whose scope stretches back to ancient Greece and Egypt, is naturally justified. While Chapter 3 relies heavily on these references in building an argument for the transformation of practice sizes and approaches throughout the 19th and 20th centuries, the key observations in this work are derived from my first hand experience as an ‘embedded’ researcher within BKK Architects.

Peter G. Rowe in his seminal book Design Thinking (1987, p.1) defines a number of ways of “viewing the design of buildings”. These include: from “the perspective of the historical record
of production—the lines, shapes and masses of past buildings and urban artefacts”; examining a building “for its conformity with theoretical prescriptions of what constitutes ‘proper’ architecture and ‘good’ design”; or by “observing what designers do and how they undertake their tasks.” Rowe adopts the third approach, focussing on the designer, as opposed to the designed outcome, as his exploration is aimed at a greater understanding of “those rather private moments of ‘seeking out’”. Rowe implies this is the closest that the design theorist can come to the mind of the designer.

From Rowe’s perspective as a design theorist – on the outside observing the process of other designers, not a designer himself – participating in the design process would be seen to interfere with the designer’s natural process, thus influencing the results of the study. In response to this, while it may run counter to accepted research practice, I would argue that this ability to influence the outcome is an integral part of the design process itself.

Maher, Nelson and Burry (2006, p.5) in their paper on this Embedded Practice program explain that the candidates “are simply everything that a regular worker might be in that practice, and more specifically a conscious and analytical participant and a potential agent of change.” They describe this role as a “participant-observer”, whereby ‘participation’ is what sets this position apart from the typical role of the researcher in practice who would observe others at work but not contribute to this work. This is a very important distinction as it offers a unique ‘inside’ perspective from which to explore the workings of the practice.

It is important to note that as a practising architect I am internal to the discipline, as opposed to being an ethnographer, sociologist or historian turning a lens upon the work of architects. In addition, before commencing this research I had been working in BKK for a number of years as a designer and had developed a nuanced understanding of the methods of the practice, the type of work produced, and where there was scope for expansion. This implicit knowledge of the practice proved to be a constructive basis for the research. As an active participant located within the practice enabled a greater influence on the directions it could explore. Indeed, BKK encouraged me to treat the practice as a laboratory of experimentation by testing new design strategies and examining the effects of organisational relationships. In this sense, I was more focused on what this practice could be, as opposed to what it was.

This represents a marked difference to other approaches to examining practice. Dana Cuff’s Architecture: The Story of Practice is arguably the most influential and widely cited in this small field. Cuff’s explicit focus is on “the culture of practice”, which as she states, “fosters a certain kind
of analysis, one that looks closely at people’s everyday lives, their situated actions, as well as what they say and the meanings they construct.” (1991 p.5) Her methodology stems from her training in social science, and draws upon the specialised fields of cultural and social analysis. Despite this approach, she does not occupy the position of the independent observer, but similarly gets her hands dirty: “I made myself useful … by doing some drafting, photography, proposal writing, and model making.” (Cuff 1991, p.9) However this involvement in the office is undertaken as a means to “gain access to the parts of the practice [she] needed to see” (Cuff 1991, p.9), rather than to interrogate the working methods themselves.

This captures the key difference in methodological approach. Cuff participates in order to examine the culture and the people of a practice as it is; I participate in order to examine a practice with the explicit intent to change it. The ability to propose new methods or systems of working is a critical aspect of this work, and a characteristic that is central to design as a process. It is therefore the opinion of the author that this agency for change represents a necessary capacity to ensure relevance.

1.3 Definition of terms

The title of this work, Punching Above Your Weight: Emerging Digital Tools, Design Strategies and Organisational Structures for Expanding Design in Small Practice, contains a number of terms referred to throughout this dissertation which have associated implied meaning held by the author. This section defines each of these terms and states their relevance to the topic.

‘Expanding’ operates on a number of levels in this work. At the level of the individual practice partner BKK Architects it describes the expansion of the practice’s design approaches through the contribution of new design strategies and reflection upon existing ones. While this will have an immediate and applicable outcome in BKK, it is also hoped that through documentation and explanation of these strategies they might be of use in architectural education and to a broader audience of practitioners. In this sense, the intention is to both expand design possibilities and its documentation.

The word ‘design’ is used as both a noun and a verb, it can refer both to a designed artefact and to the process by which this artefact is developed. The word is used in the title to describe action; the ‘design process’ or ‘design strategy’ that leads to a project. The term is also understood to include many broader, more qualitative aspects. Veteran American graphic designer Paul Rand (1993, p.3) defined the process of designing as “much more than simply to assemble, to order, or even to edit; it
is to add value and meaning, to illuminate, to simplify, to clarify, to modify, to dignify, to dramatise, to persuade, and perhaps even to amuse.”

‘Design’ also has another meaning in the context of architectural practice, referring to the ‘design stage’, the early exploratory step in the standard sequence of the production of a building. While this work is largely concerned with the open-ended and exploratory, it does not see ‘design’ as limited to a particular stage which can be correspondingly invoiced, but as an attitude or approach which pervades practice, stretching throughout a project cycle and even across multiple projects.

‘Digital design’ is a subset of ‘design’, referring to the use of technology in the design process. While the ubiquity of computers in contemporary architectural practice should make this distinction irrelevant, digital design methods have not superseded non-digital methods, but have rather contributed to the plurality of design approaches. Here ‘digital’ is used to highlight the emphasis on digital design methods in this research, and as a useful limit to the territory covered. The implications of the digital in architecture are explored more thoroughly through the literature in Chapter 3.

‘Emerging’ refers to the tools, strategies and organisational structures that are becoming more apparent, prominent or important to architectural practice. Hence, many of these approaches are not strictly new, but have been developed in other industries and have gained relevance throughout the course of this research. ‘Emerging’ is used here to distinguish the newer tools, strategies and organisational structures explored in this research from those that are commonly used in practice.

In the context of this research, ‘tools’, ‘strategies’ and ‘organisational structures’ each describe a different scale of operation and examination. ‘Tools’ are the finest scale of engagement, sitting as techniques or actions within particular ‘design strategies’, which are in turn deployed within the ‘organisational structure’ of the practice itself.

To expand on these individual terms further, the word ‘tool’ is used in two contexts throughout this work. Firstly in reference to specific tools for performing a task, most often software or hardware tools, and secondly in the sense of ‘tooling up’, or equipping an office with a set of instruments for production.

The term ‘strategies’ is used to describe a sequence of procedures – often employing tools – that can be repeated or reproducible to achieve the same or similar outcomes. It is used most commonly, prefaced by ‘design’, to describe a particular approach to developing an outcome or form.
'Organisational structures' refers to the operational context of an individual practice and the relationships this practice has with other companies or collaborators. While this term is often used to describe the hierarchical structure of management in a company or the type of business entity of that company, it is used here in a more generous way to include more informal relationships or associations within a practice.

The concept of ‘small practice’ forms a critical constraint in this research; before expanding upon what a small practice is, it is useful first to clarify why this distinction in size is made. Gutman (1988, p.4) promotes the use of size as a variable for distinguishing practice types, as “it is highly correlated with other critical features of an office and its work: the scale of projects, job complexity, the degree of specialisation of the firm, management structure, pay levels, commitment to professional values, and so on.” Perhaps because of these varied and interrelated features of an office, it is very difficult to accurately define a small practice, a difficulty which is compounded by the many conflicting quantitative measures of what can strictly be defined as ‘small’.

The Australian Bureau of Statistics classifies a small business as employing less than 20 people, with medium businesses employing greater than 20 but less than 200 people, and large businesses employing more than 200 people (ABS 2001). As architecture firms are generally smaller when compared to firms of other disciplines or industries, The Royal Australian Institute of Architects adopts a different scale when defining practice sizes. A small practice is considered to include up to 10 employees including directors or partners, a medium sized practice from 10 to 50 and a large sized practice with 50 or more employees including directors or partners (RAIA 2002).

Despite this reduced measure, the great majority of architecture practices in Australia are considered small, with 94.8% of practices containing less than 10 employees at the last time this metric was surveyed in 1993 [Figure 6]. Small practices also employ the greatest number of people, with 72.2% of people employed in a practice of 10 people or less [Figure 7]. Rather than small also implying marginal, small practices are in fact the dominant form of practice in Australia.

These figures are relatively consistent with Britain and the United States. Britain’s RIBA similarly reports a large proportion of people employed in the architecture industry engaged in small practice, with 58% employed in practices of 10 people or less (RIBA 2005). This dominance of small practices is pervasive across the construction industry as a whole. Norbert Young (2003, p.272) describing research into construction related practices in the US states, “we discovered that there are 1,250,000 [AEC] companies in the US alone. But when we went deeper, we discovered that 98%
of the companies had ten people or less! … we are fundamentally a very small business industry operating in local markets.”

Despite the quantitative distinctions listed above, the exact borderline of what differentiates a small practice from a medium or large sized one does not alter the discussions in this work. For this reason, Bjerke and Hultman (2002, p.7) in their study of small practices in general, simply define them as having “limitations in the number of employees and other physical resources.”
projects; building types that are typically dominated by consortium clients and the associated impersonal client relationships.

The value of working on smaller projects is supported by McDougall (2001, p.vi) – himself the director of a ‘large’ practice – who states that “unlike the larger project, which is constrained by various forms of joint will or consensus, the small project, and its patrons, often allow a proposition to be put, an experiment, an esquisse.” Similarly, McCullough (1996, p.264) proposes that “small businesses have a better chance to sense needs, adapt to new conditions, and respond to local variations.” These are qualities that are not only valuable in an economic sense, but which impact upon the employee’s quality of experience, whereby “mental agility and contribution of personal values become essential qualifications for work.” (McCullough 1996, p.264) This engagement with smaller more intimate projects and clients also has a qualitative benefit in how small practices are perceived. Gutman (1988, p.42) claims “a certain admiration has emerged in contemporary society for small-scale buildings that goes along with the growing preference for the reduced scale of houses, businesses, and communities.”

Indeed, as we enter fully into the ‘information age’, this ‘certain admiration’ seems to have developed into a legitimate economic position, with Bjerke and Hultman (2002, p.4) claiming that “in the new economic era we are increasingly moving in the direction of favouring small firms.” A sentiment echoed by prominent management thinker Peter Drucker (2001, p.259), who challenges the widely held assumption in business that ‘bigger is better’, claiming that “the characteristics of information imply that the smallest effective size will be best. ‘Bigger’ will be ‘better’ only if the task cannot be done otherwise”.

![Figure 8: Project types undertaken by small practices. RAIA Members Survey 2002](image-url)
These considerations identify another aspect of small practice that is difficult to quantify, that of an ‘economy of means’ or ‘grand gesture within limited resources’, which a number of critics (Hamann 2005) (McDougall 2001) have suggested is characteristic of Australian architecture more broadly. In summary, ‘small practice’ is defined here as being characterised both by the quantitative limitations of practices composed of a small number of people (of which there are a large number) and the qualitative characteristics this implies.

1.4 Conceptual framework

If the design problems presented by society continue to transcend ‘normal’ practice to a significant degree, then leadership in decision-making can hardly be expected to be regained. A repositioning of practice, then, will necessarily require two things: advancements in design itself, and further collaboration and cross-disciplinary knowledge. (Rowe 1996, p.5)

In reflecting upon the declining status and responsibility of the architect, Peter G Rowe cites “advancements in design itself” and “further collaboration and cross-disciplinary knowledge” as the two requirements for the repositioning of practice. These two aspects of practice establish the dual focus adopted in this research, namely design strategies on the one hand, and organisational structures on the other.

The structure of the chapters reflects this dual focus, with one literature review (Chapter 2) and one projects chapter (Chapter 4) dedicated to examining design strategies, and one literature review (Chapter 3) and an interview (Chapter 5) dedicated to organisational structures. Thus, both design and organisations are each examined from the perspective of theory and practice.

Chapter 2 is the first of two literature reviews, titled Contemporary digital design strategies and their origins, it explores the development of design thinking and design strategies that have contributed to the articulation of contemporary digital design. Three key categories of design strategies are identified; design as a structured rational method, design as informed by a set of components and geometric rules, and design as an evolutionary process of trial and error. Each of these categories of design strategies are explored through examples in the literature, examined for their role in forming contemporary digital techniques and their associated impact on design. Importantly, they are all procedural in structure, anticipating the need to explicitly declare design procedures in a digital design environment.
The second literature review, Chapter 3: *Organisational structures in architectural practice*, forms a parallel investigation into practice models and practice sizes, tracing the roots of collaboration in the ateliers of the Ecole des Beaux-Arts, and maps the subsequent overshadowing of small firms in the rise of corporate practice in the mid to late twentieth century. The emergence of digital technology and the ‘network society’ (Castells, 2000) is identified as offering the potential to reverse this trend of corporate dominance through enhanced connectivity and an increased emphasis on knowledge work. This chapter also profiles several new forms of practice, identified as having risen out of these economic conditions. These practices are networked, digitally augmented, have a re-engaged attitude to construction (as opposed to theory) and an interest in collaboration and research.

Chapter 4: *Strategies for expanding design*, presents a number of design strategies developed for specific case study projects in BKK Architects. Each employs digital techniques that build upon the research of precedents in procedural design identified in Chapter 2. They describe new processes for drawing together construction techniques, the means of communication and design testing that lead to expanded design. They are directed at working within a small practice context and the various constraints that this implies.

Chapter 5: Structures for Expanding Design expands upon the nature of this small practice context through an interview with the directors of BKK Architects, exploring their attitudes to the key themes of this research: new technologies, practice structures, staff autonomy, research, creative networks and collaboration both within the practice and with other practices and consultants.

The conclusion of Chapter 6 draws together the various threads addressed throughout the thesis, particularly regarding firm size, new technologies specific to small practice adoption and identifies the characteristics of a practice that is specifically relevant to the economic context of today and in the future. This chapter also attempts to go beyond the specific findings of this research by locating them within a broader context of recent events such as the threat of global warming and the global financial crisis, to offer a ‘projective conclusion’.
Chapter 2. Literature review: Contemporary digital design strategies and their origins

All designers have design strategies. They are the explicit or implicit methods that a designer employs in the act of designing and are the professional and conceptual procedures that inform and generate the designed outcome. To focus on design strategies is a means to understanding and exploring architecture. However, as has often been argued (Kostof 1977, p.vii) (Steele 1994, p.6) (Ferris 1996, p.8) (Murray 2004, p.7), architectural discourse typically focuses on the final product: buildings. What is less often communicated are the particular strategies that take place in the lead-up to the completed artefact.

Murray (2004, p.7) argues, “In the discourse surrounding architectural production over the previous twenty years it is difficult to find credible descriptions of the way in which architects actually execute their role.” Similarly, Ferris (1996, p.8) claims architects suffer from a “contagious reluctance to explain what it is they really do, preferring instead to let their buildings speak for themselves.” Ferris divides the output of architectural discourse into two categories: architectural monographs and directive ‘how-to’ books. The monographs “attempt to showcase buildings, incorporating the most seductive of photographs, yet are devoid of any significant narrative outlining the evolution of the projects.” While the ‘how-to’ books of practice “attempt to define specific organisational and managerial methods, but often overlook the totality of the architectural process.”

This research seeks to respond to the apparent lack of coverage of design methodology, by presenting a detailed explanation of the evolution of key design strategies and the thinking that underpins them, and also – in the following chapter – by linking this analysis back to the organisational structures that frame the context in which this work has been produced.

The examination of design strategies in this chapter focuses on those explicitly declared examples, where a designer describes an individual process, or where new rigorous models for designing are proposed. This is a sub-set of a larger world of design strategies, encompassing the full spectrum from intuition to spatial syntax. In this sense, this chapter does not attempt to be all encompassing, but instead looks for key examples that have contributed to forming the structure of and assumptions underpinning our contemporary digital design processes and thinking. These examples form the following categories: design as a structured rational method; design as informed by a set of components and geometric rules; and design as an evolutionary process of trial and error. What
ties these strategies and examples together is that they are all explicitly *procedural*. Procedural design has been identified (Frazer 1995, p.18) (Benjamin 2004, p.54) (Aish 2005, p.62) (Shelden 2007, p.83) as a key characteristic of digital design strategies, and while not all of the precedent examples examined employ computers, they all form the foundations of our contemporary design software and processes.

### 2.1 Design as structured rational method

There are many descriptions of the design process that seek to reduce it to a series of clearly defined rational steps, to the extent that this line of thinking has largely been embedded into the procedures of practice. A clear example of this is the chart published by the Royal Australian Institute of Architects (2001) as part of their Professional Practice Notes that specifies the series of stages of the development of a project and the typical percentage fee applied to each stage [Figure 9]. This chart implies that each stage be completed in order and specifies the amount of time that can justifiably be spent on each stage. It is not so much a strategy, but a sequence of steps that need to take place for a design to be developed, around which contemporary architectural practice and the associated construction industry is structured.

<table>
<thead>
<tr>
<th>Service stage</th>
<th>Examples:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Percentage proportion of fee to be charged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schematic design</td>
<td>15</td>
<td>17.5</td>
<td>15</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design development</td>
<td>15</td>
<td>12.5</td>
<td>15</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract documentation</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tendering and negotiating</td>
<td>2.5</td>
<td>2.5</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contract administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Construction</td>
<td>25</td>
<td>25</td>
<td>30</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Post construction</td>
<td>2.5</td>
<td>2.5</td>
<td>5</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The definitive clarity of this chart of specific percentages belies the blurry and overlapping reality of practice, which is rarely neatly divided between phases. It is useful as an introduction however, as it offers an idealised version of the pragmatic and economic context within which the more specific and project-related design strategies take place.

Extending this sequential and rational approach, Bryan Lawson (1990), referring to the comparable staging of projects in the UK, offers a number of ‘maps’ which attempt to describe the design process. Unlike the RAIA chart, his ‘generalised map of the design process’ [Figure 10] importantly includes feedback loops, acknowledging the iterative cycle that design often follows. These feedback loops also operate at different scales, and interface with the context beyond via undefined input and output arrows.
Following a discussion of various diagrams, almost exclusively dismissed by Lawson himself for their limited linear structure, he concludes with a diagram representing the design process as a pyramid composed of interrelated processes in dialogue with each other defining a zone between a problem and a solution [Figure 11].

While this diagram captures the non-linear reality of the design process – by using volumes instead of arrows – Lawson is concerned primarily with the hidden thought processes of designing, of which these diagrams, and the many others he presents, add little insight. He acknowledges these shortfalls by stating “knowing that design consists of analysis, synthesis and evaluation linked in an iterative cycle will no more enable you to design than knowing the movements of breaststroke will prevent you from sinking in a swimming pool” (p.38).

If the previous examples attempt to describe a generic design process through diagram, Louis Sullivan’s (1896) dictum “form follows function” is more readily defined as a specific design strategy. Adapted from the original “form ever follows function”, Sullivan calls for the formal expression of a building to be determined by its requirements with an implied scientific clarity. Unlike Mies van der Rohe’s similarly often quoted Modernist mantra “less is more”, which describes an aesthetic result, Sullivan’s could be used to guide a design process. However the specifics of putting it into practice are ambiguous at best. Mitchell (1990, p.ix) argues that Sullivan’s statement “provides little practical
guidance since he failed to specify precisely what he meant by ‘form’ or ‘function’ or (for that
matter) ‘follows.’” Similarly, Brawne (1992, p.51) states that Sullivan’s dictum “presumes a logical,
almost scientific translation of the brief into a building – yet it completely undervalues the decisions
made between the brief and the outcome.”

Despite these ambiguities, ‘form follows function’ has become inseparable from rationalist and
functionalist style and rhetoric. However, in the same essay where he coined “form ever follows
function” even Sullivan (1896) himself dismisses a purely rational approach, calling for the designer
to “heed the imperative voice of emotion.” Sullivan advocates a return to first principles, to
“follow our natural instincts without thought of books, rules, precedents, or any such educational
impedimenta to a spontaneous and sensible result.” This quote captures the tension between
rationality and intuition that is ever-present in architects’ descriptions of the design process;
rarely are their positions straightforward and they are often easily challenged by contradiction or
competing views.

In a more explicitly scientific application of ‘form follows function’, Christopher Alexander in Notes
on the Synthesis of Form (1964) proposed a new method of design synthesis as a highly rationalised
act of problem solving. Alexander’s method involves listing the functional requirements and
parameters of a design problem and graphically identifying potential conflicts by “writing a minus
sign beside a line for conflict, and a plus beside a line for positive agreement.” [Figure 12]

![Figure 12: Typical example of Alexander's diagram of constraints (Alexander 1964)](image)

This scientific approach sought to quantify the parameters that design decisions are based upon,
endorsing logical structures over intuition. Alexander (1964, p.8) argued it “brings with it the loss
of innocence,” as “a logical picture is easier to criticise than a vague picture since the assumptions
it is based on are brought out into the open.” For all its seeming scientific accuracy and efficiency,
Alexander’s method is questionable in its application in practice. The highly structured approach
requires the designer to accurately list all the potential parameters at the outset of a problem, a step
which Brawne (1992, p.38) challenges, as “there can be no certainty that all the necessary criteria

CHAPTER 2  24  DESIGN STRATEGIES
and only those necessary have been listed.” This separation of establishing the design parameters from the design process, also dismisses the potential of design as a form of exploration, whereby new information and knowledge about the design problem is discovered along the way.

Again, Alexander’s method overly simplifies the designer’s task, misrepresenting the design process in practice. This simplification becomes almost condescending as Alexander (1964, p.6) is also critical of designers’ abilities by claiming that his system is “a way of reducing the gap between the designer’s small capacity and the great size of his task.” Despite this questionable reflection of the design process in practice, Alexander’s method is useful precisely because of its rigorous structure. The need to explicitly declare design parameters prefigures the contemporary need to similarly declare parameters when working with parametric software.

Another useful idea explored by Alexander (1964, p.4) is the potential for the design process to substitute the evolution of vernacular forms over time. He states,

> Since cultural pressures change so fast, any slow development of form becomes impossible. Bewildered, the form-maker stands alone. He has to make clearly conceived forms without the possibility of trial and error over time.

This idea is picked up later in the context of generative digital design by Frazer (1995, p.66), who proposes that the prototyping and feedback expressed in vernacular architecture by actual construction be replaced by computer modelling. Despite this similarity, by needing to declare these parameters at the outset, Alexander’s system limits its potential for feedback – a critical factor in evolutionary design. This concept of generative design will be revisited in section 2.3 of this chapter.

Working within parameters and constraints need not be a limiting factor to design in practice. While the constraints listed as examples by Alexander are exclusively functional, the hugely influential and prolific designers Ray and Charles Eames adopted a broader definition of what constitutes a constraint. Charles Eames (1972, 2005) when asked what constraints are used to inform a design, replied:

> The sum of all constraints. Here is one of the few effective keys to the design problem: the ability of the designer to recognize as many of the constraints as possible; willingness and enthusiasm for working within these constraints; constraints of price; of size; of strength; of balance; of time and so-forth. Each problem has it’s own peculiar list.
The response was paired with an image of toys produced by the Eames studio [Figure 13], implying subtly through editing that these constraints may also be social or fun, and not just pragmatic or functional.

This reflection on the Eames’ design process reveals an optimistic openness to the use of constraints in design. While design is still seen as a structured and rational problem solving exercise, the constraints informing this process can be both qualitative as well as quantitative. In this sense, they are not a limiting factor, but a source of invention and further understanding of the complete design task.

Indeed, design that responds to constraints need not necessarily be derived from a rigorous system but, as Chris Wilkinson of British architecture firm Wilkinson Eyre describes, a rational approach can feed an intuitive process. Explaining the design process of their Gateshead Millennium Bridge of 2001, Wilkinson (Hyde, Harrison et al. 2008) lists the design constraints of structure, accessibility, and clearances:

> We weren’t allowed to put any structure on the bank… it also had to be fully accessible for wheelchairs which means there’s a restriction on gradients, and there’s also a requirement for clearance for boats when it’s in the closed position, and when it’s in its open position we had two clearances to meet. There’s a conflict there, which means you actually couldn’t have a bridge that crossed straight from bank to bank.

Combined together, these constraints “seemed to make the design impossible.”
At this point, a rational methodical approach to resolving these conflicting constraints — like that of Alexander’s — assumedly could not have produced a solution, because the method cannot innovate beyond the sum of its parameters. Instead, Wilkinson describes his partner Jim Eyre’s “eureka moment” to curve the deck of the bridge in plan, allowing a longer deck for wheelchair ramping requirements and which when tilted achieved the clearances required for boats, thus accommodating all of the conflicting constraints of the project in one single gesture, which as Wilkinson says, “proved to be a very good idea.” This eureka moment does not happen every time, referring to the usual means of arriving at a design solution Wilkinson states “I can’t explain why, but after a while it seems to settle down and the design concept just emerges and becomes obvious.” Rather than placing limitations on a project, Wilkinson views constraints as fundamental to a good project, put simply, “when you don’t have constraints, it’s much more complicated.” (Hyde, Harrison et al. 2008)

However, the trouble with quantifying architecture with parameters and constraints, and subjecting these to a rigorous process, is that it preferences the practical and quantifiable aspects of design. The Bauhaus painter Wassily Kandinsky (1926, 1979, p.30) expressed an early concern for these limitations, warning that:

> the numerical expression may lag behind the sensory perception and that it may, thereby, inhibit it. A formula is very much like glue. It is also akin to flypaper to which the foolish fall victims. It is like an overstuffed chair which embraces one in its warm arms.
Architecture is both a practical and a ‘felt’ medium, which cannot easily be described or quantified using criteria. To Kandinsky, the pitfalls of the scientific, rational approach are that it may be relied upon for evaluation and judgement in what ought to be an intuitive medium.

This doesn’t mean we should abandon attempts to quantify architecture altogether, alternatively, the ability to measure and collate requirements and constraints is likely to become an increasingly important skill required of the designer. As I have experienced through this research, contemporary parametric design software requires the functional and formal relationships of a design to be explicitly defined. Similarly, collaborators from other disciplines – including engineers, quantity surveyors, environmental consultants and planners – require highly accurate design information in order to calculate a proposed building’s cost or performance. The approaches for achieving this, described above, offer a conceptual background to the issues encountered by designers as this technology is introduced into practice.

2.2 Design as informed by a set of components and geometric rules

While it could be argued that all architecture is the accumulation and arrangement of separate components or elements, what distinguishes the examples described here is the foregrounding and thorough exploration of this combinatorial aspect of the discipline to form explicit theories and design strategies.

Contemporary procedural design techniques have a lineage that extends well beyond the development of computation in the mid 20th century. Addis (2007, p.3) attributes the codification of design procedures to Greek engineers of the 6th century B.C.E. Roman architect-engineer Vitruvius drew heavily on this tradition in his De Architectura of 25 B.C.E. which contains procedural design systems for the description and evaluation of ideal classical Roman temples. For Vitruvius (cited by Addis 2007, p.30) the act of designing is inherently about communication to others, he states “Designing is the ability to convey the scheme for the finished object to others and to provide a rational explanation of the scheme using engineering knowledge and scientific principles”. Thus his procedures do not distinguish between design generation and communication, but communicate all aspects of the building, including its visual appearance, structural duty, material properties, method of construction, which “made it possible to generate, before
construction began, the dimensions of the entire building and its components, which could then be communicated to the workforce” (Addis 2007, p.31).

As Figure 15 by Addis illustrates, Vitruvius’ process begins by selecting a number of starting parameters, including the width of the proposed temple, the number of columns, and the column ratio from a limited number of predefined options. These parameters are then used in various mathematical and proportional calculations to determine the rest of the details and dimensions of the temple. Such procedures of over 2000 years ago embody two of the key marketing features of contemporary CAD software: associative geometry and attribute data. And while one must be cautious in drawing comparisons between such an ancient method of design and the contemporary digital strategies of design today, if parametric design can be described as integrated, calculable, procedural and flexible, then the work of Vitruvius in all its mathematical rigour and predictable certainty, could be seen as a very distant precursor to the Building Information Modelling (BIM) software of today.

![Flowchart showing design procedures for a temple in the Doric style, based on a description by Vitruvius circa 25 B.C.E (Addis 2007)](image-url)
Furthermore, as Addis (2007, p.31) explains, the application of this approach is also the same, as “such tools allow one to predict the consequences of design decisions and to explore the possible occurrence of problems further along in the design process, and so avoid them.”

A procedural design approach to Classical architecture, was brought into the recent present by William J. Mitchell in *The Logic of Architecture* (1990), where the classical rules of proportion and composition are used as examples for the fundamentals of computer programming in architectural design. In one example (p.9), Mitchell declares the properties of the Parthenon using the rigid programming syntax of “white(Parthenon)” [Figure 15] as an alternative to the conventional phrase “the Parthenon is white”, thus highlighting the potential to describe buildings using software conventions.

While Mitchell (Hyde 2007) explains that the purpose of using Classical architecture as the basis of his book was to provide the reader with an understanding “that [computers] weren’t just commercial products, but there was some kind of underlying logic and connection to traditions of thinking.” The appropriateness of this example is no coincidence, as Vitruvius’ procedures reveal, this approach was similarly used to design the actual temples thousands of years ago.

A proportional approach to controlling the design of buildings was most famously employed by Le Corbusier in his ‘Modulor’ human-scaled proportional design system of 1954 [Figure 16]. It is generated by pinning “down the human body at the essential points of its occupation of space,” (Le
Corbusier 1954, p.50) which produces a series of finite dimensions, related to each other in simple, harmonic proportions.

Le Corbusier admired the direct and un-adorned architecture produced by the quantifiable approach of the engineer, stating, “they employ a mathematical calculation which derives from natural law, and their works give us a feeling of HARMONY.” (1923, 1986, p.15) The Modulor system adapts this quantifiable approach of the engineer to determine proportional regulating lines for architecture, from the scale of furniture to the entire building.

Rather than being just a tool used internally in the architect’s office, Le Corbusier (1954, p.37) saw this system as being set up on the building site as

a grid of proportions, drawn on the wall or made of strip iron, which will serve as a rule for the whole project, a norm offering an endless series of combinations and proportions; the mason, the carpenter, the joiner will all consult it whenever they have to choose the measures for their work; and all the things they make, different and varied as they are, will be united in harmony.

This proposed approach to the implementation of the Modulor in practice could be described as one that is both bottom-up and top-down. Bottom-up in that it is distributed to allow consultation by those actually producing the work, and top down in that it is imposed on the building sites by the ‘educated’ architect.

Le Corbusier (1954, p.35) insists that the Modulor is not a system for creativity, but merely ordering. “The regulating lines do not bring in any poetic or lyrical ideas; they do not inspire the theme of the work; they are not creative; they merely establish a balance.” However, this claim is disputed by Jencks (2000, p.300), who argues “just as one speaks with ready-made words, the architect builds with preexisting elements, and in both cases, language and architecture, this traditional repertoire actually allows invention.”

Despite the rhetoric of rigorously structured design systems, it has been argued that Le Corbusier’s method as applied in practice was very different from that which he projected through his writing. Summerson (1957) argues “that architectural theory and architectural style are things apart—each with its autonomous life, and this is nowhere more obvious than in the case of the author of Vers Une Architecture.” Which is not surprising, as if the Modulor is “not creative”, as Le Corbusier claims, what is driving these projects? Jencks (2000, p.302) suggests it was much more intuitive, arguing Le Corbusier’s method “was based equally on control, accident, and sudden juxtaposition.
Thus in general, he worked out the scheme rationally, left it to ferment, reached a creative synthesis, and then responded with visual solutions that had been stored in his memory.”

In this sense, Le Corbusier’s Modulor informed only one part of the process, that of structuring and ordering the larger design ideas, not a sufficient design idea in and of itself. American architects and researchers Stephen Kieran and James Timberlake (2004, p.51) reference the Modulor as a means of comparison with their contemporary approach for managing the design and construction process. In their view, the standardised, disparate, industrial-era system of building components which Le Corbusier claimed would revolutionise the building industry has become it’s very problem, as the issue now lies in the coordination of these components on site. As a solution, they propose architects should embrace recent developments in manufacturing technology and information management in order to reach deeper into the construction process. In order to do this, architects require systems which control not only the geometric descriptions of their buildings – such as the regulating lines established by the Modulor – but systems that also control the flow of components throughout the process, stating, “supply chains and organisational structures are how we control our buildings, not regulating lines.” [Figure 17]

In summary, design approaches that employ components and geometric rules engage issues of hierarchy, information management and relational structures that are fundamental to emerging software techniques today. And while these precedents are crucially different as they are largely pre-digital, they nevertheless offer examples of the encoding of design intention and procedure within the structure of the design itself, and provide a critical position, unburdened by techno-determinism, from which to view the logical and hierarchical structures that are now built into architects contemporary digital software.
2.3 Design as an evolutionary process of trial and error

Donald Schön (1983, 1991, p.79) described the design process as a “reflective conversation with the situation”, whereby the situation “talks back” and the designer responds to the situation’s back-talk. This recursive process of proposition and reflection promotes continual refinement, importantly driven by feedback, a characteristic of evolutionary systems. Schön suggests this is a typical approach adopted by designers, although as Downton (2003, p.100) argues “this kind of constant testing is rarely made explicit or elaborated and enumerated in any way by designers; it is simply part of the larger activity labelled as designing.” The following examples examine explicitly declared design strategies involving evolutionary feedback.

While not strictly a formula for design generation, but for the analysis of existing architectural products, Gottfried Semper’s ‘formula explaining architecture’ is a curious example of the application of mathematical logic to constructed form. As described by Brawne (1992, p.12), it is an attempt from the mid 19th century to establish a correspondence between the evolution of species and the existence of building types:

\[ Y = F(x,y,z,\ldots) \]

where \( Y \) is the end result, \( x,y,z \) are the different agents, forces which act together or separately and which are modified by the coefficient \( F \)

Brawne states that Semper “is looking for a rational, scientific explanation for the differences between buildings.” And while the formula itself is static – in that it is not recursive – the “forces” and “agents”, which presumably represent the cultural and environmental factors forming the background to a developing architecture, are in constant flux, thus resulting in a constantly evolving result.

As Semper merely used his formula to speculate on the existence of vernacular styles not as a means to generate designs, it is not strictly a design strategy. Nevertheless, it stands as an important precursor to the formula-driven digital experiments of today, especially as it is combining multiple factors or inputs, similar to the multiple-aim optimisation of the contemporary work of OCEAN explored later in this chapter.

A more useful formula attempting to describe the evolutionary nature of the design process is Karl Popper’s ‘Tetradic Schema’, or ‘Schema for the Growth of Theories’ (Popper 1963, p.548).
Figure 18: Author’s diagram of Popper’s spiralling process

\[ P1 \rightarrow TT \rightarrow EE \rightarrow P2 \]

Where \( P \) stands for ‘problem’, \( TT \) stands for ‘tentative theory’, and \( EE \) stands for ‘(attempted) error elimination’, especially by way of critical discussion.

This formula reflects the common design process of trial and error. As applied to the practice of architecture, it results in a spiralling sequence of design proposals, whereby each iteration is subjected to an evaluation of its merits against the previous cycle [Figure 18].

Brawne (1992, p.59) is interested in Popper’s scientific approach to trial and error as it enables a more objective means to divide the good from the bad. When producing numerous versions of a design, evaluating these versions becomes increasingly important. Interestingly, considering the scientific appearance of the formula, these evaluations are made by “critical discussion”—a rather ‘un-scientific’ means of assessment. While this process can potentially produce a large number of options or iterations as the cycle is repeated, Downton (2003, p.75) argues that Popper’s schema is limited as a means to generate new possibilities, arguing that the application of to design “does not address one common activity of the sciences – exploration.”

By contrast, the trial and error approach when implemented by Eero Saarinen becomes a highly generative design technique through the hybridising of design options, as is recounted by Charles Eames while working in Saarinen’s office on the competition entry for the Smithsonian Institute Gallery in Washington in 1939 (Merkel 2005, p.48):
First Eero thought out the whole thing carefully, and then told us the first thing to do would be to make a hundred studies of each element that went into the building. We would pick the best, and never let our standards fall below that. Then we would make a hundred studies of the combinations of combinations. When the whole thing was finished, Eero was almost in tears, because it was so simple. And then of course, we won the competition.

This testimony expresses the high design ideals and unparalleled work ethic of Saarinen and his office. It could be argued that the high quality of the few buildings produced by Saarinen comes down to this drive for continuous design evolution through trial and error.

The critical difference between Brawne’s looping interpretation of Popper’s schema for the growth of theories, is that Saarinen’s version of trial and error marries the best combinations with other best combinations, producing the opportunity for the unexpected, not merely a self-reinforcing loop. Trial and error in itself is not a design strategy, in that it does not account for new design ideas, but only refines them, accounting for only half of the process. Without Saarinen’s initial concept or his astute judgement to select the best from the multitude of studies, trial and error alone cannot produce innovation.
An interesting question for today to extract from Saarinen’s exhaustive analogue approach to trial and error is “how could new technology simulate this extraordinary ability and work ethic?” The following design strategies each explore equivalent digital methods for achieving these ends, using the generative and selection powers of evolution in nature as a metaphor and model.

John Frazer’s _An Evolutionary Architecture_ (1995) addresses this idea of design as an evolutionary process most directly, both from a conceptual standpoint and through practical examples. Frazer (p.9) proposes “the model of nature as the generating force for architectural form”, and that “architecture be considered as a form of artificial life, subject, like the natural world, to principles of morphogenesis, genetic coding, replication and selection.” In practice, computer programming is employed to simulate the environmental context of a potential building, to which the requirements of the building are added, which subsequently emerges and evolves toward a final design over successive generations.

Frazer’s evolutionary method is important in the way the computer is employed not as a tool for extending the efficiency of the designer, but as a collaborative partner. Alexander (1967) dismissed this role of the computer, describing it as merely an “army of clerks, equipped with rule books, pencil and paper, all stupid and entirely without initiative, but able to follow exactly millions of precisely defined operations”. Frazer (1995, p.18) accepts Alexander’s claim, only he is not discouraged by it, stating, “our evolutionary approach is exactly the sort of problem that could be given to an army of clerks – the difficulty lies in handing over the rule book.” This emphasis on the ‘rule book’ fundamentally recasts the role of the designer in the design process, as the subject of operation is shifted from the _artefact_ to the _context_. Instead of operating on the designed artefact itself, the designer now operates on the context in which the artefact will evolve, with the intention that the designed outcome can be justified rationally and scientifically as a natural product of this context.

By liberating the designer from manually constructing each option or proposal, Frazer (1995, p.100) argues it becomes possible to “seed far more generations of new designs than could be individually supervised, and to achieve a level of sophistication and complexity far beyond the economics of normal office practice.” For this to occur it also requires the designer to be far more explicit in the decisions made, in order for “a concept to be expressed in genetic code.” This efficient production of options is put to use to develop more natural and responsive forms, as Frazer (1995, p.66) proposes “the prototyping and feedback expressed in vernacular architecture by actual
construction [to] be replaced by computer modelling and construction.” This may be possible in an idealised and simplified world, but again, “the difficulty lies in handing over the rule book.” To

return to Brawne’s (1992, p.38) criticism of Alexander’s graphical approach to responsive design – “there can be no certainty that all the necessary criteria and only those necessary have been listed” – the same criticism could be applied to this evolutionary approach. The complexity of declaring and quantifying all of the contextual factors impacting on any potential building or design is virtually impossible, not least because in reality these factors are constantly in flux.

Although fascinating for its outlook and foresight, the projects illustrated as examples in An Evolutionary Architecture no doubt suffered from primitive technology and do not fully deliver on the claims made throughout the book. Frazer continues to address this area through research, and has recently championed BIM as a version of a building’s “genetic seed” (Frazer 2006, p.138). Even still, projects that have adopted this approach, such as the One Island East residential tower in Hong Kong designed by Wong & Ouyang – endorsed by Frazer as the first building to be entirely designed and documented using the parametric software Digital Project (Frazer 2006, p.138) – seem to have exploited the efficiencies offered by this software, but have neglected to explore the potential for design innovation as proposed in An Evolutionary Architecture.

More recently, Foreign Office Architects’ (FOA) use of the biological concept of ‘phylogenesis’ as a means to classify their projects expresses a continued interest in evolution as a means for design generation. Adopting terms native to evolutionary biology, their collection of past projects is treated as a “genetic pool”, their method of production is a “phylogenetic process”, and their resulting projects are “differentiated organisms” (Zaera-Polo and Moussavi 2003, p.8). Similar to Frazer’s evolutionary proposition, Zaera-Polo and Moussavi (2003, p.10) describe their projects as “not something designed, but a breed of a particular species.” This interest in evolution is clearly
expressed in their ‘phylogenetic project classification diagram’ [Figure 21], which represents their projects in a tree structure indicating shared formal characteristics.


*has now been transformed into (some would say degraded down to) the equivalent of a prize-dog or racehorse breeder. There clearly is an aesthetic component in the latter two activities, one is in a way, ‘sculpting’ dogs or horses, but hardly the kind of creativity that one identifies with the development of a personal artistic style.*

While De Landa (Zaera-Polo and Moussavi 2003, p.520) implies this approach is somehow less ‘creative’, that “evolutionary simulations replace design, since artists can use this software to breed new forms rather than specifically design them”, FOA (Zaera-Polo and Moussavi 2003, p.11) appear
proud of this association, claiming to be interested in the “knowledge used to produce wines, horses or bulls: out of genetic pools and environments purposefully manipulated.”

Despite FOA’s frequent use of complex evolutionary and biological language to classify their projects, there is little evidence of the use of evolutionary techniques within the descriptions of their design processes or projects (Zaera-Polo and Moussavi 2003). It appears that this interest in evolution is deployed only as a post-rational metaphor to describe a collection of projects that were – perhaps disappointingly – designed and produced using traditional means.

The editorial partnership of Michael Hensel, Achim Menges and Michael Weinstock – collectively operating under the banner of “The Emergence and Design Group” – has contributed substantially to research in the field of evolutionary design systems through the Architectural Design (AD) issues Emergence: Morphogenetic Design Strategies (2004); Techniques and Technologies in Morphogenetic Design (2006); and Versatility and Vicissitude: Performance in Morpho-Ecological Design (2008). The group’s research interests are roughly clustered around the theme of morphogenesis, a concept again borrowed from the field of evolutionary biology. Menges (2006, p.79) defines morphogenesis as “the process of evolutionary development and growth, [which] generates polymorphic systems that obtain their complex organisation and shape from the interaction of system-intrinsic material capacities and external environmental influences and forces.”

It is an approach explored in architecture for its capacity to integrate the means of formation with materialisation; to generate architectural form from its requirements. The separation between these two aspects in contemporary architecture is criticised by Menges (2006, p.79) as “prioritis[ing] the

Figure 22: OCEAN, Structural analysis model of Prague Library competition
generation of form over its subsequent materialisation”, with no opportunity for the material system to influence the overall shape of the building. Alternatively, a morphogenetic design approach “[understands] material systems not as derivatives of standardised building systems and elements facilitating the construction of pre-established design schemes, but rather as generative drivers in the design concept” (Menges 2006, p.79).

This design generation system responds, not unlike other evolutionary processes, to environmental criteria, but also to the logics and constraints of the manufacturing process. In this sense, the biological model is pursued to a more relevant outcome, one that responds both to the ‘natural’ environmental context, but also to the culturally determined pragmatics of available construction technologies. Where FOA adopt the concepts of evolutionary biology as a reflective means of categorising projects, Hensel, Menges and Weinstock actually deploy them as a generative process within projects through their practice OCEAN, which itself is structured as a collaborative network capable of evolving (OCEAN 2007).

Collectively, the precedent design strategies and explanations of the design process explored in this section form the background to the subsequent development of new design strategies explored through the case study projects in Chapter 4. Although the majority are pre-digital, they form important foundations for concepts underlying contemporary digital techniques. Although each of these approaches – design as a structured rational method, design as informed by a set of components and geometric rules, and design as an evolutionary process of trial and error – vary in the degree to which they are explicit or intuitive, they are all fundamentally procedural. It is this procedural nature that offers a direct connection with contemporary digital techniques, and offers clues as to how this new media can be most effectively used in the service of design creation. This next section explores the nature of this media, and the implications it has on working processes and the architectural discipline more broadly.

2.4 Enter the digital: Implications of a shift in media

The term “post-digital” is often used to describe our current era’s engagement with technology. It is a peculiar title, as like all things ‘post’, it describes not what it is, but what it succeeds. Burry (2004, p.64) defines it as the state whereby “as practitioners, researchers and educators we have comfortably accommodated the computer in all our creative and practical undertakings.” Although we may be comfortable, this pervasive use of the computer in practice, and a maturing in the way it is used,
necessitates a revaluation of its potential. Particularly as much of the exploration so far has focussed on efficiencies, not design. Burry (2005, p.9) argues, “…investigations into the extent to which the computer actually assists in the design process have been secondary to more pragmatic goals in most schools and practices.” The second half of this chapter explores the fundamental structure of the computer as a way of addressing how it can best be applied to the tasks of designers today.

The ubiquitous adoption of digital technology in architectural practice has brought with it fundamental shifts in design strategies. These shifts stem from the critical philosophical difference between the analogue and the digital. Frichot (2004, p.90) in reflecting on the nature of this difference, asks us to

compare, for instance, a clock face, across which we can observe the passage of time by its sweeping hands, and the glow of a digital clock, which instead displays time through the flicker of discrete digits, zero through nine… Where analogue is more akin to the quality of a felt thought, a digital code is a quantity demarcated with exactitude, and with no allowance for ambiguity.

Where Frichot’s definition captures the essential difference, Negroponte (1996, p.11), explains the implications, suggesting “the best way to appreciate the merits and consequences of being digital is to reflect on the difference between bits and atoms.” The fundamental difference being the ephemerality of bits and the ability to repurpose them compared with the physicality of atoms. “Bits commingle effortlessly. They start to get mixed up and can be used and reused together or separately.” This is a difference in media. Referring to McLuhan’s (1967, 1996) (pre-digital) statement, Negroponte argues, “The medium is not the message in a digital world. It is an embodiment of it.” Information is no longer tied to it’s means of presentation, but can be chopped, changed and recontextualised freely.

This shift in media, or rather the expansion of potential media, is critically important in a discipline that is so powerfully inflected by mediation. Evans (1986, 1997, p.156) describes the “peculiar disadvantage under which architects labour, never working directly with the object of their thought, always working at it through some intervening medium.” Changes in this intervening media throughout history have played a critical role in the changing nature of practice. Mark Wigley (2001, p.38) traces the influence of freely available paper in the Renaissance in transforming drawing in art. “By the end of the 15th century, paper production had reached such a level that artists had developed whole new techniques of experimentation with it. The new support had fostered an entirely different attitude toward art. Paper was established as the unique site
for confirming mastery.” This impact was also felt in architecture, where it erodes the intimate connection of the architect with the building site, “it was the status of drawing that made it possible to elevate architecture from the status of a guild practice to that of a liberal art, an art liberated from the constraints of the material world […] Architecture’s status as a discipline turned on its connection to paper […] Paper became the real building site.” (Wigley 2001, p.38)

This relocation of the architect to the studio, “from rough hands to smooth hands” (Kvan 2004, p.83), freed the architect from working at 1:1 on the building site and also brought a new intellectual plane of engagement to design. The associated drafting instruments of set square and linen remained relatively unchanged until the introduction of graphical computer-aided drafting software in the 1970s. While these two-dimensional systems merely digitised the drafting boards that preceded them, the real breakthrough came with the introduction of three-dimensional modelling software in the 1990s. These newfound capabilities spawned a fascination with virtual space, posing “a threat to one of architecture’s essential dimensions: the concrete aspects of construction and building technologies, in a word, its materiality” (Picon 2005, p.114). The absence of physical properties like weight, thrust and resistance in three-dimensional virtual space would suggest that the discipline’s fascination with these tools would continue to erode architecture’s connection to the heavy reality of building. However, the increased sophistication of contemporary digital systems paradoxically seems poised to reconnect architects with the ‘object of their thought’. Commentators claim we are in “a particular moment in the history of architecture when the old opposition between the digital and the tectonic has begun to collapse, and the digital is increasingly being used in the service of the tectonic.” (Leach, Williams et al. 2004, p.4)

One outcome of this engagement with the tectonic via the digital is the paradoxical re-emergence of a ‘crafted’ aesthetic. The economic and time advantages of mass-production and volume repetition have been radically challenged by the appearance of computer controlled manufacturing machines that can produce individually customised building elements components with apparently comparable efficiency to the production of identical ones. Architects have enthusiastically exploited the opportunities presented by this technology as it offers a connection between digital explorations and architecture’s continued dependence on the physical realm. A dependence in part due to professional relevance, as Leach (2002, p.6) argues “operations in the digital realm…will have no value unless they impact directly upon the material world”. Instead of the intervening media being a “peculiar disadvantage” (Evans 1986, 1997, p.156), new technologies for communicating designs now offer the potential for a direct connection between designers and construction.
Although arguably still on the horizon of the mainstream construction industry, Mark Goulthorpe (2006) views the future of building as a confluence of technological precision and post-industrial craft-based production. The standardisation of industrial components is targeted as the source of the current inefficiencies within contemporary construction, as “when it’s brought back to site, that’s where the intolerant mess is.” Goulthorpe (2006) proposes a reintegration of architect and builder/fabricator that is more akin to the manufacturing industry than the traditional relationship between architect and builder:

*If you can start producing composite function in elements – like a skin that is a composite honeycomb panel that is structural, it’s insulating, it’s everything – and you put it under one roof and it’s built to zero tolerance by a very competent fabricator with a very sophisticated machine, potentially you can undercut the logic of industrial production.*

Goulthorpe (2006) sees this as a defining watershed in architecture’s relationship to materiality and making. “At that moment the world tears open, because you’ve got formal liberty, economic validity and an utterly changed politic of the whole profession and construction industry.”

This ‘return to craft’ need not be limited to the use of manufacturing machines; a ‘crafted’ approach to our engagement with technology is also gaining momentum as digital information itself is crafted through design. Kvan (2004, p.83) describes designing digitally as “not simply the casting of data into form…the data is selected, crafted and its representation directed”. The most
significant contribution to this field of thinking, and a key reference in this research, is Malcolm McCullough’s Abstracting Craft (1996, p.185) in which he advocates a “reunion of intellectual and mechanical activities enabled by design computing”, creating “a condition that combines some of the individuality and responsiveness of craft with the process control of industry to create something new.”

### 2.5 Expanded tools

Beyond these broader distinctions between analogue and digital technology and means of working, it is necessary to explore the particular qualities of software and the techniques it enables.

The simplest, but arguably most fundamental difference between analogue and digital means of working is the ability to ‘undo’. This tool, now available in almost all software, enables the user to click back in time, allowing digitally produced artefacts to be edited and improved incrementally, instead of discarded and redrawn. Maeda (2006, p.79) suggests “that the feature makes people more creative by allowing them to take more risks”, but also adds that it may make others “less creative because they don’t think through ideas but rather create by happenstance.” Either way, the inherently editable nature of digital media forms the foundation of many of these other creative digital tools discussed here.

![Figure 24: Screen grab of the Rhinoscript code editor for the 3D modelling software Rhinoceros, by author](image)
The second digital software tool discussed here is ‘scripting’. While not strictly a software tool itself, scripting enables the extension of the functionality of software using text-based code, or scripts, that execute program commands within a logical structure. Scripting is like ‘looking under the hood’ at the underlying structures of an existing program to automate particular tasks, as an alternative to creating new software from scratch. In architecture, scripts written for CAD software can be used to develop project-specific design tools that may generate a detailed model or study with the input of just a few key parameters.

Automation and efficiency are important aspects of scripting, but as McCullough (2006, p.12) states, “the amazing part of scripting is how it adds a whole extra level to design thinking.” The key to this is the ability to explore options easily by tweaking input parameters. Hugh Whitehead of Foster and Partner’s Specialist Modelling Group (SMG) describes the scripted tools they produce for the practices’ design teams as “option generators”, which “help designers to express programmatic thoughts without having to program” (Loukissas 2003, p.23).

While Whitehead’s SMG produce scripted tools that are implemented by others, for Casey Reas, personally exploring and rewriting scripted code is the design process itself. Reas (2007, p.174) describes exploring an idea by evolving a code over months to produce various outcomes in various media. Reas also acknowledges that this approach may not be for everyone, due to the unforgiving nature of programming syntax, “For artists and designers used to working directly and visually with their materials, the strict constraints of programming notation can be a barrier to the flow of ideas. This barrier begins to erode with experience, but never disappears altogether.” In summary, scripting is a terse, quantitative and often unintuitive medium for designers to operate, but ultimately a potentially powerful means tool for design generation and refinement. Scripting forms the basis of a large number of the case study projects discussed in Chapter 4.

The third tool discussed here is ‘parametric design’. ‘Parametric’ is the collective title given to software that enables the designer to build relationships between geometry and/or design parameters. Often called associative design, it is the relationships that set it apart from conventional computer modelling packages that require the designer to declare explicit dimensions of objects. This subtle distinction has powerful effects, as modifications of a design can occur by tweaking the parameters, used correctly and with foresight, it negates the need for erasure and redrawing as a means for revision. This enables modifications to a model often to be made in real time, keeping up with the pace of a conversation. It also opens up further design possibilities through exploring the
zones between two states, as McCullough (1996, p.172) states, “instead of having to imagine each state before you model it, you might discover a state while you continuously manipulate a particular design variable.”

Like scripting, ‘parametric design’ requires a fundamental shift in how design is understood. Decisions that may have been made intuitively in an analogue process similarly need to be explicitly declared as relationships in a parametric environment. Aish (2005, p.62) summarises this shift as one “from intuition to precision”, which he sees as necessary if designers want to retain control of their process. Parametric design is arguably more attractive to the designer as it does not require knowledge of programming that can present an associated “barrier to the flow of ideas” as described by Reas. Although Mitchell (Kolarevic 2003, p.71) also suggests that designing parametrically should be considered a form of programming, as

> 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. It is a very different style from what people think of as coding, but nonetheless it is programming.

Both scripting and parametric design can be used to generate digital design data for digital manufacturing. ‘CAD/CAM’, an acronym for Computer Aided Design / Computer Aided Manufacturing, is a term used to describe the various incarnations of digitally controlled manufacturing techniques, including rapid prototyping, direct manufacture and mass
customisation. If scripting and parametric design are the key digital design developments internal to the designer’s process – internal in that they occur within the computer – then CAD/CAM represents the key development of translating this digitally generated information into physical form.

The advances afforded by the integrated relationship of CAD and CAM allow the architect to “expand the opportunities of buildable form, [and] extend the reach of design intent deeper into the building delivery process” (Shelden 2006, p.87). By integrating design with construction through manufacturing techniques, and by feeding the fabrication parameters or constraints back into the design generation stage, the shift from “intuition to precision” can occur in an informed manner throughout the entire design and project delivery process.

However, it should be noted that the advocates of this technology, many of whom are quoted here (Shelden, Kolarevic, Aish), have a tendency to be hyperbolic when it comes to the revolutionary possibilities offered by these tools. Reas’ earlier quoted concern regarding the flow of ideas should be taken seriously. The requirement of explicitly determining parameters and relationships in both scripting and parametric design presents a major challenge to a practice which also demands intuition, common sense and strong judgement.
2.6 The implications of digital media in architecture

These tools and technologies enabled by digital media have important implications in the practice and design of architecture. The first of these discussed here is the potential to repurpose information between stages. The effortless commingling of bits, as Negroponte describes, allows a fundamental shift in architectural practice when compared to pre-digital process. As these bits – or components of a three-dimensional model, for example – acquire attributes about their function, weight, cost or staging requirements, the digital model can become an integrated project database, not just a collection of A1 sheets. McCullough (1996, p.179) draws the distinction between industrial production as being about the flow of material, and contemporary CAD/CAM production as being about the flow of information, where data is translated seamlessly between the various stages of a project, “design prototypes become design specifications, then process modules, then machine instructions.” Further to this, Shelden (2006, p.83) views this ability as the key to integrating form with economics, a “radically new [approach], in that previously human intervention was required to transfer intent across usages.”

Repurposing information between stages of a project can increase efficiency and decrease the chance for errors, both valuable benefits to an office, but is not likely to ‘expand design’. When one zooms in to the scale of the design process, the same fundamental difference of working digitally that enables the re-purposing of data between project stages, can also be used to define procedural design strategies. Designs can now be the result of a complex sequence of procedures or geometric operations, each automatically building upon the outcome of the previous step. In this instance, the designer employs the computer as a design partner, not a drafting tool. The designer no longer ‘constructs’ a design by drawing objects or lines, but ‘curates’ the procedures and rules for an instance of a design to be generated by the computer.

This seamless space of digital information exchange is central to emerging contemporary parametric and computational design strategies, although the desire for machines to automate complex or repetitive tasks is not new. Vannevar Bush (1945) held a similar desire over sixty years ago in the description of his Memex; a machine designed to lighten the burden of information on the researcher, claiming
Relief must be secured from laborious detailed manipulation of higher mathematics… if the users of it are to free their brains for something more than repetitive detailed transformations in accordance with established rules.

This inherent requirement for the computer to follow rules could pose an issue for the designer. While Burry (1999, p.79) advocates a more explicitly declared approach to design as a means to being more ambitious and able to pursue specific aims, he also acknowledges the risk that “design becomes formulaic.” But has not practice always been formulaic? Projects follow a clear series of steps through an office, from sketch design to construction documentation, which are correspondingly signed off by the client. Why should it matter if design were to be constrained to follow a similar path? This may be already be the case with some designers, but as argued earlier in this chapter; the actual route design travels is often inevitably a more non-linear, recursive one.

This is not to dismiss curating the process altogether, setting rules for design is a common approach. Architects often describe working within a ‘design world’ defined by media, strategies or approaches. McCullough (1996, p.229) suggests the design process “really occurs in two stages: composing a structure, and then exploring the consequences of that structure.” Similarly Mitchell (1990, p.81) describes design as a “complex game [of] exploration of formal possibilities in some world”, which occurs within a “meta-game” in which the rules and conventions for negotiating this world are declared. This approach is not limited to designing with the computer; alternatively, the structure of a design world is largely determined by the choice of media and instruments. A project designed using a pencil would assumedly have a very different set of rules from one designed in the three-dimensional space of the computer. Furthermore, these choices in media can have direct consequences in the final built outcome, as “the design of how we go about designing, and ultimately making, circumscribes what we make” (Kieran and Timberlake 2004, p.7). However when using the computer it becomes possible to explicitly codify a design world. Frazer (1995, p.65) views the recognisable styles of various architects to be evidence for the potential to do this, claiming “all that is required is that this generic approach is explicit and sufficiently rigorous to be coded.”

But can design be quantified in this way? Schön (1988, p.181) defines design rules as “largely implicit, overlapping, diverse, variously applied, contextually dependent, and subject to exceptions and critical modification.” How could a computer successfully replicate such complexity? Even Frazer (1995, p.100) concedes that automating this process would require “some changes in
architects’ working methods.” This need not adversely affect the designed outcomes, alternatively, with the introduction of quantifiable constraints and objectives into the design process, it could improve them. We may finally see the benefits hoped for by Vannevar Bush in the 1940’s, as rigorously defined design processes hand over routine procedures to the software, freeing up designers’ minds to consider other issues.

2.7 Practice engagement of emerging technology

Unfortunately, this future may remain as science fiction, as the reality of practice often demands routine procedures that stubbornly resist innovation and change. In his introductory essay to the Archilab catalogue of collected projects by various ‘digital’ practices, Ole Bouman (2001, p.15) declares his disappointment with the way the computer has been employed so far in practice, asking “what other options are there apart from cost-cutting and streamlining?”

As an illustration of this point, Bouman defines three categories of practices’ engagement with computers. First is the “Unabashed Surrender” approach, where “the design identity of these architects is synonymous with their use of the computer… However versatile their designs, it is above all their use of the computer that attracts attention.” Second is the “Pragmatic Attitude”, where “even if the entire office is computerised, the benefits of the new technology are barely if at all conceptualised and as such taken into account in the designs. Media remain what they are: means. Nothing more.” And thirdly, the “Negative Attitude”, whereby practices “stubbornly stick to the old familiar way of working and simply ignore the cultural significance of the new media. At the very best… they will employ someone to take care of this side of the business. The architecture continues to look the same as ever.”

In the years since Bouman’s classifications, computers used in architecture have extended their reach into every facet of practice, but arguably these distinctions between digital evangelists and those maintaining an analogue approach to design still persist today, as evidenced by the technical and conceptual gulf between Zaha Hadid and Peter Zumthor for instance. This section seeks to understand the causes for this condition described by Bouman, and attempts to compile criteria for the useful adoption of the computer in design.

The existence of Bouman’s so-called ‘unabashed surrender’ group of practices may be attributed to aesthetic agendas driving the implementation of computers in design. Shane Murray (2004, p.8) is highly critical of this aspect of contemporary digital practice. Citing the ‘Non-Standard
Architecture’ exhibition held at the Pompidou Centre in 2003, he claims this stream of practice “appears to be directed to avoiding all precedent and promoting architectural designs that engage in new geometries and formal solutions that celebrate the new technologies.”

The emphasis on form and geometry by these practices is hardly surprising, as these are precisely the qualities that three-dimensional digital design space has revealed to the designer. However, this concern predates the introduction of computers in architecture. Eero Saarinen cautioned the design of aesthetically driven formal architecture in 1957, stating “technology has made plastic form more easily possible for us. But it is the aesthetic reasons which are the driving forces behind its use… Plastic form for its own sake, even when very virile, does not seem to come off” (Saarinen 1968, cited by Kolarevic 2003, p.5). This concern is echoed today by Bernard Cache, who’s practice Objectile was included in the Pompidou exhibition Murray criticises. Cache (2003, p.25) states

*we very much question contemporary free forms when they become a cliché and sacrifice the past to the advantage of an absolute present. Marketing strategies are the new form of tyranny, and information technology can appear only as a dues ex machina if these strategies succeed in making us forget our own history.*

Cache’s concern for history is perhaps driven by a tendency of these practices who unabashedly surrender to the technology to depend upon this technology as a substitute for an ‘idea’. Melbourne-based practice Ashton Raggatt McDougall have consistently explored the potential of emerging technology in design, yet make it clear that this is not what motivates their projects, emphasising “it’s how we do it, not why we do it” (Raggatt 2008).

While Bouman’s ‘unabashed surrender’ architects would appear to be intentionally pursuing the formal capabilities of the computer, those architects deemed to hold a ‘pragmatic attitude’ may be motivated by the particular systems offered by the software industry which do little more than automate pre-existing forms of practice. Kieran and Timberlake (2004, p.59) describe the architecture industry’s move from T-square and linen to the computer as a means of documentation as “only a switch in media”, adding that “architects still use the computer for 2D drafting and ‘movie-set’ 3D representations.” Mitchell (2003b, p.354) similarly views the early incarnations of architectural CAD software as “mostly employed as accurate and efficient replacements for traditional drafting instruments in the production of construction documents.” This role is problematic, as by enhancing the efficiency of traditional techniques, Mitchell argues, “these systems further marginalised alternative practices.” Kieran and Timberlake (2004, p.59) propose
architecture’s engagement with the computer should move from “representation to simulation”, citing the automotive and aerospace industries as examples where every component is modelled as a 3D digital prototype of the final built product.

Bouman’s criticism of the ‘negative’ group, who “stubbornly stick to the old familiar way of working”, for their architecture “continu[ing] to look the same as ever”, is a peculiar comment, as it has often been argued that it is computers that cause resistance to change. In the pre-digital age, media had less impact on the design process, but as the practice of architecture becomes digitised, it is becoming increasingly dependent on a small number of software applications for design and production purposes. This has an effect on design outcome as software selection and the internal logic of the software can influence design decisions, leading to “families of designs with formal commonalities” (Serriano 2003, p.85). These commonalities can be attributed to the rules embedded in the programs themselves, some having more than others. Mitchell (2003a) identifies a “trade-off between efficiency and design freedom” in the structure of different CAD applications which are pitched at beginners or advanced users respectively. The danger here is that by dictating the structure of software, the software industry is to a certain extent dictating design (Kvan 2004, p.82).

Robert Aish (2003, p.245) – a designer of architectural software himself – describes the influence that software has in design as “a very conservative force”. He argues that “the widespread use of commercial software institutionalises the underlying abstractions on which that software is based. If these abstractions encode existing or fixed conventions, then software (which is inherently adaptable) ends up being unnecessarily conservative” (2003, p.252). This ‘conservative’ software is problematic not only because it stifles design exploration, it also has an effect downstream in the communication of these exploratory proposals for construction. As Aish (2005, p.63) again argues, the emphasis of this software on “the generation of graphic notation based on drafting conventions… does not address the new requirements to digitally communicate unconventional forms directly to fabricators or contractors.” As long as two-dimensional drafting conventions are reinforced through software, it will be a long time before architecture and the associated engineering and construction industries can make the shift to a fully integrated digital design and manufacturing system like that of the automotive or aerospace industries.

In reference to the topic of this research, if digital design is to be ‘expanded’, the available stock of architectural software is arguably too prescriptive for the exploration of new design procedures
due to the conservative encoding of the procedures of standard practice. One way practices are attempting to overcome their dependence on this ‘very conservative force’ is by effectively becoming software developers themselves. By designing custom applications, plugins or scripts, practices are able to regain control over the digital design and production process that is otherwise dictated by software companies. Particularly those practices who are experimenting with the capabilities of the computer are in a curious situation where not only is the building the subject of design, but also the software used to design it.

Cache (Kolarevic 2003, p.65) views “building software [as] part of the business of this field.” A position reflected by Michael Speaks (2007, p.214), who views the production output of an office not only as the final built artefact, but also the “array of specialised techniques” that are generated throughout the process of development as contributing to the office’s accumulated “design intelligence”. McCullough (1996, p.153) proposes this accumulated intelligence could play a role in the differentiation of customised software, claiming “no two personal practices built on computing tools need be alike. More than the technologies themselves, accumulations of personal knowledge will influence what we do with the new digital tools, and how well we do it.” In addition, McCullough (1996, p.253) views the rise of social computing as an important factor in the democratisation of software use, claiming, “the emergence of more widespread authorship suggests new possibilities for practice.”

As architects are beginning to focus their attention on software design, a field typically outside the established discipline of architectural practice, it is worth speculating on what new perspective they could offer which is more relevant to the design of buildings. If contemporary CAD software was founded on digitising traditional architectural notation (Mitchell 2003b, p.354), an alternative approach would be to begin with the underlying structure of the computer itself. Just as Louis Kahn famously asked brick “what it wants and what it can do” (to which brick replied “I like an arch”) (Brownlee and Long 1997, p.163), one could ask CAD software the same question. In order to answer this question, a basic understanding of the underlying structure of software is required. While this may sound like an exercise likely to produce a result that is incompatible with the physicality of architecture, McCullough (1996, p.95) identifies similarities between the structure of the design process and the structure of computation. “The nature of notation might invite us to employ iterations and conditionals, which together with variables and their relations would turn scripts and scores into true programs. In sum, symbolic processing may assist compositional explorations. We make rules, and we can identify structure.” However, aside from the shared use of
the word ‘composition’, I would argue these two practices have little in common. Aesthetic decisions are often intentionally ambiguous and underdetermined, whereas a computer program will most likely crash if it is not entirely logically sound.

If in the above the designer begins by asking the CAD what it wants to be, Nigel Cross, (2001, p.46) in Masters thesis of 1967, proposed that the computer ask questions of the designer. Cross describes this theoretical relationship as one where “the computer should be…seeking from [the designer] those decisions which it is not competent to handle itself.” Giving the following example:

_The computer could be doing all the drawing work, with the designer instructing amendments. Drawings presented by the computer on a graphic interface would be gradually completed as the designer made more decisions … Programmed to proceed as far as possible without human intervention at each step, the computer would ask for decisions as required._

Fundamental to this proposal are the respective abilities of designer and computer, with each playing to their strengths. Just as Alexander (1967) defined the computer as an “army of clerks”, Cross assigns the computer the role of production machine, thereby liberating “the designer from routine procedures and to enhance his decision-making role.”

Reflecting upon this extreme shift in roles proposed by Cross in the very first years of computer-aided design illustrates the fundamentally different route architectural design and the software developed for it has taken. As has been argued, contemporary CAD software has only very recently begun to question its foundations as digitising the pre-existing paper media. This section has explored that there are valuable lessons both in pre-digital design strategies and the more radical digital design experiments that can aid in articulating the structure of the next generation of architectural software and its relationship to the designer. More importantly, the direction that this next generation of software will take is no longer the exclusive domain of software developers, but as architects become increasingly engaged in the development of their own software and the tools to achieve this become more accessible, the future will be comprised of a plurality of approaches specifically tailored to individual designers’ needs.
2.8 Summary

This chapter has located a number of key design strategies concerning architects' engagement with technology and new forms of media. It forms the critical context and concepts that underpin the design strategies that are discussed in the case study projects in Chapter 4. It identifies the emerging tools and design strategies that are having a fundamental impact on architectural practice today, and the various critical perspectives in relation to them. More specifically, this chapter identifies the great potential of procedural design strategies when implemented in digital design systems, but argues for a broader definition of what constitutes ‘constraints’ or ‘parameters’ that are used to inform these design strategies.

In reference to the title of this research, while little distinction is made between existing design strategies that stand to benefit small practices more than large, it is an underlying focus of this research that by managing complex information, increasing efficiency and enhancing collaboration, digital tools are a democratising and empowering force in design, enabling smaller practices to ‘punch above their weight’ and accomplish a greater amount with limited resources. This democratisation is part of a broader shift from an industrial paradigm characterised by mass production to one of flexible production and niche markets. This shift will be explored further in the following chapter that charts the parallel developments in the organisational structures of architectural practices.
Chapter 3. Literature review: Organisational structures in architectural practice

The design of buildings is intimately tied to the organisation of the practices that produce them, and this organisation is in turn tied to broader economic trends and business thinking. As the thesis is concerned with identifying design strategies and organisational structures that are conducive to expanding design in the small architectural practice, this chapter provides the conceptual background to the organisational component of this aim.

The small practice, as defined in the introduction, is characterised by the small number of people involved, which by virtue of its size can often lead to a more collaborative, creative and intimate practice environment. This creative intimacy of the small practice is increasingly relevant in the ‘Network Society’ (Castells 2000), where – despite their scale, as the chief business assets from the twentieth century such as production capacity and financial strength, are replaced by more intangible skills of constructing and using information and knowledge – even large practices are striving to recast themselves as comprised of fast moving small units (Bjerke and Hultman 2002, p.1).

This chapter focuses on examples in practice that exhibit these qualities and therefore offer constructive precedent for the small practice of today. It begins by tracing the historical development of practice structures, followed by the examination of a number of emerging practices that propose innovative ways of engaging with our contemporary network society. It does not aspire to be comprehensive, but provides a narrative through the 20th century illustrated by key representative practices. As such, the range of sources is limited to focus on these particular practices, at the expense of breadth.

Interestingly, the creative and intimate qualities were of central importance in early forms of professional practice in the late nineteenth century, but were diluted as practices became larger and introduced intervening layers of management. This chapter then traces a return to more collaborative and creative forms of practice through a direct engagement with the technological means of production and building, through the formation of small practices coalitions, an emphasis on worker autonomy in practice, and a renewed interest in research and development as drivers of innovation.
3.1 Historical precedent: ‘from collaboration to division’

A key reference in this summary of the heritage of organisational structures in the architectural firm is Bernard Michael Boyle’s excellent chapter ‘Architectural Practice in America: 1865-1965’ in Spiro Kostof’s *The Architect* (1977). Boyle traces the evolution of practice from H.H Richardson’s importation of the French Beaux-Arts ‘atelier’ model in the late nineteenth century through to the development of the large corporate practice Skidmore Owings & Merrill (SOM) in the late-Modernist era. Boyle (p.330) characterises this 100-year period of architectural practice as a shift in organisational attitudes “from collaboration to division.” He cites the increasing size of practices due to the introduction of more and more specialists in response to the increasing complexity of buildings and building technology as the core reason for this. Increasing size necessitated a new level of management to coordinate this newly expanded workforce, further severing collaboration between architects and isolating the staff from the partners.

This section draws upon Boyle’s examples from America of H.H Richardson, McKim Mead and White, The Architects’ Collective and SOM, and is contextualised with descriptions of the parallel development in practice models in Australia as revealed by the practices of Bates Smart McCutcheon and Grounds Romberg and Boyd, drawing largely upon the work of Hamann (1981) and Goad (2004).

Although architectural practice has become largely dominated by the large firm, it is interesting to note that at one point it had more in common with the artist’s studio than the corporate office. The

![Figure 28: Photo of Ecole des Beaux-Arts atelier, c.1900 (Chafee 1977)](image)
The office of H.H Richardson best represented the French atelier practice model in America, as adapted from the École des Beaux-Arts model under which Richardson trained from 1859 to 1865. It is worth first briefly exploring the structure of the Ecole des Beaux-Arts programme as a precedent to the establishment of Richardson’s practice upon returning from Paris.

The structure of the Ecole des Beaux-Arts was a model of top-down hierarchy combined with self-organisation and collaboration. Architectural training was divided into two distinct aspects; the formal program offered by the school itself, which included the teaching of design, lectures and judging of competitions, and the ateliers; studio spaces shared by the students and guided by a master architect. It was the atelier that distinguished the school, and to which “architectural students at the Ecole des Beaux-Arts owe the greater part of their detailed instruction and criticism… [and where] they spend the greater part of their time” (Hitchcock 1936, 1961, p.40). Chafee (1977, p.91) emphasises the “remarkable” organisation of these ateliers:

> each was governed not by the architect whose name it carried but by the students themselves. They elected one of the group, usually a long-time member, to be their massier. He administrated the atelier, collecting modest dues from each member and paying the atelier’s costs.

This informal, self-organising structure of the ateliers was also extended to the atmosphere of the ateliers themselves. Chafee (1977, p.91) refers to a description of this atmosphere by an architect who completed his studies in 1903:

> The air of the room is close, for there is no ventilation. Silence never prevails. Jokes fly back and forth, snatches of songs, excerpts from operas, at times even a mass may be sung, yet amid the confusion and the babble—strange as it may seem—work proceeds.

This description, perhaps without the “excerpts from operas”, could be of any contemporary university studio; the criteria for an engaging and collaborative work environment has arguably changed very little.

A contributing factor to this atmosphere was the small size of the ateliers. Chafee (1977, p.89) reproduces an 1852 statistical study of the number of students in each of the ateliers. The 112 students of that year were placed in 37 ateliers, the largest of which contained 25 students, with over half in ateliers of 5 students or less. Although the average size of the ateliers was to grow by the turn of the century, it is likely that the atelier Richardson trained in was of a comparably intimate scale.
This experience as a student in Paris was used as a model for the structure of Richardson's practice, which he established in 1866 upon returning from the Paris Ecole the previous year. Richardson “strove not only to introduce French methods into his office, but to make it as well a source of training and education for younger men.” (Boyle 1977, p.310) In this sense, Richardson had expanded upon the French system – where the atelier and the master's office were usually separate in location as well as function – by combining the educational atelier with his commercial office. It was no doubt the combining of these roles that fostered the collaborative environment that Richardson's office would become known for, and which would have “a great effect on the development of architectural training and practice in America from that time forward.” (Boyle 1977, p.311)

One practice in particular that was directly influenced by Richardson's importation of the Beaux-Arts atelier model was McKim, Mead and White. Charles McKim had also studied at the Beaux-Arts before training at Richardson's office with Stanford White, and together they established their practice with William Mead in 1879. They made a clear effort to run “the office along the lines of an atelier where ‘art’ was of uppermost importance…and close collaboration between the partners and employees existed.” (Wilson 1983, p.14)
Despite the strong atelier atmosphere and sense of participation instilled in this practice during the early years, as the practice expanded in size, this quality seems to have been lost. Lawrence Wodehouse (1988, p.257) presents a summary of the number of employees in McKim, Mead and White, which reveals a sharp increase to “well over seventy” after 12 years of practice in 1891. While the “idea” of the atelier was a continuing inspiration to the partners, the reality in practice was only ensured “as long as their practices remained relatively small” (Boyle 1977, p.312).

The very large number of staff (by standards of the time) at McKim, Mead and White necessitated the introduction of a structured hierarchy, and with it, the loss of the atelier atmosphere that the practice was founded upon. The partners divided their responsibilities into the three typical roles held by practices of three partners, commonly known today as finders, minders and grinders (Allinson 1997, p.149). “McKim came to be most involved with large planning projects and with client relationships… while Mead took responsibility for management and production and White for detailed design.” In addition, “it became necessary for the principals not only to divide the responsibility for various areas of work among themselves, but to delegate authority extensively as well” (Boyle 1977, p.314). The firm moved into a larger office space, which “tended to isolate the partners from the drafting room and from each other.” (Wilson 1983, p.14) This isolation between the partners and the studio is clearly evident in the plan of the office circa 1891. It shows the large drafting room on the right, separated from the partners’ offices located on the left, by the general
office spaces, toilets, waiting room, mail room, elevator core, a number of doors and finally a ‘private corridor’ [Figure 30, 31].

This new organisational structure and the associated configuration, took its toll not only on the atmosphere of the office, but it also affected the quality of the designed output. Wilson (1983, p.14) writes that the shift in scale inevitably meant that some of the designs of this period “betrayed a certain blandness,” also noting “an impersonal office style” appearing in some of the buildings of McKim, Mead and White. Even Richardson’s office, which had in large part influenced the popularity of the atelier style of practice in America initially, succumbed to an organisational hierarchy and the issues this entails. Boyle (1977, p.316) claims that the “declining level of artistic achievement of the office under Richardson’s successors, [was] at least in part, due to the organisational changes that followed Richardson’s death.” Again, the connection is made here between the drop in quality of the design work and the concurrent organisational restructuring.

Thus in only two short decades since Richardson’s return from Paris, from where he brought his experiences in the Beaux-Arts ateliers, practices in America had expanded and restructured to the point that this influential model of practice was all but lost. It would take at least another half century of practice characterised by separation of responsibility and division of labour before architects began to explore new models that would allow a return to the collaborative and creative environment of the atelier atmosphere that had preceded.

A key example of this return to collaborative modes of practice was The Architects Collaborative (TAC), established by Walter Gropius and seven younger partners in 1945 [Figure 32]. The ideas behind this endeavour were first formulated a few years earlier by Gropius in the *Scope of Total Architecture* (1943, p.74). With echoes of the Bauhaus’ integrated attitude to the artistic, design and technical disciplines, Gropius states, “If [the architect] will build up a closely co-operating team together with the engineer, the scientist and the builder, then design, construction and economy may again become an entity—a fusion of art, science and business.” While this larger aim may have been to integrate all of these construction-related disciplines – of which architecture is just one – in a statement at the time of founding TAC, Gropius emphasises the need for the architect first to set an example of this co-operative practice in his own office. The essence of Gropius’ methods of
achieving this were “to emphasise individual freedom of initiative instead of authoritative direction by a boss” (Harkness 1980, p.11). This non-hierarchical practice model was specifically positioned in response to the early-Modernist image of the sole genius architect. Gropius dismissed the idea that the “self-sufficient operator who, with the help of a good staff and competent engineers, can solve any problem” as being “isolationist in character and will be unable to stem the tide of uncontrolled disorder” (Gropius, Fletcher et al. 1966, p.24).

These aims were manifest in day-to-day practice through a small number of key distinctions. The first of these were the regular weekly design review sessions that were instituted from the start [Figure 33]. TAC partner John Harkness (1980, p.12) describes the role of these meetings as “not to establish design by committee but to have an active exchange of ideas on projects at various stages of their development,” emphasising that despite this communal feedback, “the final decision, however, as to how or whether to incorporate the ideas was up to the partner in charge.” As each partner would manage a number of their own projects within the office, responsibility and authorship was distributed throughout the office rather than being hierarchically controlled.

The second of these practice distinctions was the conception of the practice as an architectural community. In the various reflections upon TAC, the authors stress the democratic structure of the collective, playing down the influence of Gropius, who was by far the most experienced, established and well known of the founding members. Harkness (1980, p.13) states “This is not an office built...
around the cult of an individual, great as Gropius was, but rather, I hope, the ideas and ideals of that individual and those who founded the office with him or joined the firm later.” Similarly, Louis McMillen (quoted in Harkness 1980, p.13) writes,

*Figure 33: TAC group meeting*  
(Gropius, Fletcher et al. 1966)

> the one thing that I believe gives me the most satisfaction...is the knowledge that we have been able to build into our firm real strength in depth. It is not a one-, two-, or three man office, it is in fact an architectural community.

Just as Richardson viewed the training of young architects as part of his broader responsibility to the discipline, the TAC community extended beyond the practice to also encompass education, with many members holding positions at the Harvard Graduate School of Design, where Gropius had chaired the Architecture Department from 1937 to 1952.

Indeed all of the founding partners had themselves been taught under Gropius at Harvard, which leads to another key distinction of TAC; that the majority of the partners brought to the practice a shared training, background and conception of architecture. As opposed to a number of specialists with a particular expertise working together, the partners “aspired to be generalists” (Harkness 1980, p.12), an aim designed to elicit a more fruitful collaborative engagement. Partner Louis McMillen (Gropius, Fletcher et al. 1966, p.8) describes the group dynamic that resulted from this common understanding and background;

> We realised that we had to recognise the virtues and tolerate the weaknesses in each other and acknowledge our own shortcomings. With the group firmly established on this base, we were able to achieve the most important aspect of collaboration – effective intergroup criticism.
Despite these assured aims and foundations in collaboration and democratic leadership, it was not to last. Boyle (1977, p.337) writes that eventually TAC had become “indistinguishable from that of any other large office in America.” While Harkness (1980, p.15) claims this may be due to “many other offices [having] adapted procedures pioneered by TAC – design review, the collaborative process, etc. – [making] TAC look less unique,” he also concedes that “the mere fact of size has of necessity changed our method of operation.” Indeed, the number of staff at TAC at the time of Harkness’ reflection in 1980 had increased to 250 people, almost 4 times that of 1966 levels, when many of these claims to the success of collaboration were made in the TAC monograph. Boyle (1977, p.337) likens TAC at the end to the archetypal large hierarchical corporate firm, claiming “division of labour and separation of responsibility apparently characterised the operations of The Architects’ Collaborative as much as the operations of Skidmore, Owings and Merrill.”

Apart from this increase in size, it seems the gravitas of Gropius meant that he never truly fitted the role of ‘partner’, and nor was he regarded as one. Despite Harkness’ insistence of Gropius’ equal status, he refers to Gropius having “taught” the other partners “a philosophy” (1980, p.13), implying that Gropius had assumed the role of leader. Of the 45 projects presented in the TAC monograph, Gropius is listed as the partner-in-charge on 14 of them, well beyond any democratic sharing of authorship. These projects also tended to be the high profile commissions, including the Pan Am building, the University of Baghdad, and the Harvard Graduate Centre. Boyle concludes

(1977, p.339) bluntly that “Gropius’ ideal of teamwork was a myth; the profession of architecture had become not a free collaboration of equals, but a business of employer and employee.”

However Boyle stops short of connecting this regression of organisational structure back to a traditional hierarchy with a decline in the quality of the practice’s output. Fortunately, Klaus Herdeg (1983) devotes an entire volume to analysing the dehumanised work of TAC and the various
other practices to emerge from Harvard having been schooled during Gropius’ term as head of the Graduate School of Design.

In an attempt to broaden the scope of this study of practice models, particularly to include parallel developments in Australia, the Melbourne practice of Roy Grounds, Frederick Romberg and Robin Boyd (GRB) [Figure 35] makes an instructive comparison. This partnership had close ties to the work of Gropius in America most notably through Boyd’s friendship with him, although it would adopt a more traditional structure than that of TAC. Furthermore, Boyd was also outspoken on future models for architectural practice.

Formed in 1953, GRB brought together three architects all teaching at Melbourne University to form what would become the “undoubted focus of…modern architecture in Australia” (Hamann 1981, p.129). In terms of their organisational structure, Serle (1996, p.144) in his biography of Boyd, describes the partnership agreement as having “little legal rigour; it was largely a matter of arranging to work together as absolute equals and sharing facilities and profits. They would work as a partnership and not accept individual commissions.” This agreement appears to be consistent with the running of the practice, particularly in the case of design. Although Hamann (1981, p.137) cites a handful of projects that were designed collaboratively, including early unbuilt schemes for Melbourne University and the Myer Music Bowl, he writes that “collaborative designs were rare and generally one partner predominated in the design.” Indeed, the three partners assumed the traditional roles of ‘finder, minder and grinder’, with Boyd handling many of the firm’s houses,
Romberg handling the large scale projects, and Grounds using his extensive connections to secure clients and projects.

Each of the partners played roles of equal importance, and in contrast with TAC, set up eight years earlier, GRB was less hierarchical because of the more or less equal standing of the partners. For this reason, GRB did not need the collaborative rhetoric of TAC to continually play-down the powerful influence of a figure like Gropius among a group of relatively inexperienced partners. However this
equal standing would not last long. Serle (1996, p.144) writes that Grounds was “always eager to take the lead” and was dubbed “The Chairman” by Boyd who was in turn sometimes termed “The Boy”. This may have started harmlessly enough, and was perhaps justified given their difference in age, but the rivalry and implied hierarchy would ultimately spell the end of the partnership.

Gropius first met the partners of GRB when they arranged through the local institute chapter to host his visit to Melbourne in 1954. Gropius was taken on a tour of local architecture [Figure 36], where Boyd and Gropius “established a friendly relationship” (Serle 1996, p.159). This friendship was furthered when Boyd was invited to teach at the Massachusetts Institute of Technology in 1956, where he extensively studied the work of east-coast American mid-century architects, including Paul Rudolf, Eero Saarinen, Louis Kahn and Phillip Johnson, many works of whom appear illustrated in his The Puzzle of Architecture (Boyd 1965) [Figure 37].

Like Gropius, Boyd is also vocal in his opinions on the future of the profession and the structure of design practice. However, where Gropius and the other partners of TAC aimed to be “generalists, interested in the whole scope of architecture” (Harkness 1980, p.12), Boyd endorsed the splitting of the design professional into two distinct specialist roles. He believed that “one man may produce either an architectural poem or a businesslike report”, and that we must “eliminate the architect as he stands in the place he has been occupying for two centuries or so, and replace him with two men: a complete technologist and an unapologetic artist” (Boyd 1957, p.75). This difference of opinion reveals far more emphasis on the ‘poetic’ and ‘artistic’ qualities of architecture on behalf of Boyd. Gropius and TAC continued to view architecture foremost as a rigorous problem-solving exercise.

Unfortunately, the partnership of Grounds, Romberg and Boyd was not to last due to internal conflicts over projects and authorship. Tension had been building between Grounds and Boyd over the amount of time Boyd had been away in America. Shortly before his return, Romberg (Serle 1996, p.180) wrote to Boyd claiming

> Roy [Grounds] is constitutionally not capable of working in a team with anybody for any length of time…he has for some time been avoiding any kind of partnership contact with me. He is positively allergic to advice…The sooner you are back the better.

Grounds would eventually split from Romberg and Boyd in 1962, taking with him the practice’s major commission for the Victorian Arts Centre complex (Hamann 1981, p.139)
It is again interesting to compare the reception of the work following these hierarchical struggles. Grounds, Romberg and Boyd produced their most enduring buildings when the practice relationships were at their strongest. A clear example of this shift can be seen in the two projects attributed to Grounds before and after the break-up of the practice, the Academy of Science of 1958 [Figure 38], and the National Gallery of Victoria completed in 1968 [Figure 39]. Hamann (1981, p.138) argues that

while the Academy of Science retained much of the softness and warmth of his earlier work, [the NGV] was unmistakably cold. The extensive timbered interior never really compensated for the outside which is monumental and vaguely hostile,

concluding that, “the transition in scale was not successful.”

The culmination of the shift ‘from collaboration to division’ can be attributed to the rise of the large corporate firm following World War II. As explained by Boyle (1977, p.330), in the 1950s “Although the very small office was the norm for more than half of all registered architects, it was plain that the remainder with their much larger offices, controlled a disproportionately large part of the professional activity. In fact, by every professional measure—number and size of projects
undertaken, value of contracts, number of employees—the large offices effectively dominated the field.” In Boyle’s exploration of architectural practice in America, the very large office of Skidmore Owings and Merrill (SOM) offers the clearest example of such dominance.

Founded in New York in 1936, SOM has produced over ten thousand buildings, hundreds of partners and thousands of employees (Adams 2006, p.9). It is the archetypal corporate firm, that from the very outset sought to combine sound economics with aesthetics, as recollected by Nathaniel Owings (1973, p.66):

*Through combining group practice and good design, social change, showmanship, we would marinade our architectural demands in sound economics to meet the criteria of our doubting critics – who didn’t believe that one could have both economy and aesthetics – with proof that they were one and the same.*

The key to achieving these hybrid goals within such a vast organisational framework was to develop a culture of specialisation and specific expertise throughout the workforce in either management, materials, structure, interior design, representation and so on, to the point whereby “The collective enterprise creates collective competence” (Adams 2006, p.11). However as this ‘collective
competence’ was now distributed amongst the various sub-disciplines of architectural production, SOM required a means of ensuring these diverse skills could be harnessed together. Boyle (1977, p.330) describes how

the large office gradually included more and more specialists is an attempt to maintain the generalist character traditional to architectural practice, paradoxically the team of workers progressively lost its original identifying characteristic of collaboration as the coordinating function was taken over by a new level of management.

This managerial efficiency combined with uniform and predictable products was what SOM would become known for (Filler 1990, p.30), and generated considerable success with large corporate clients, a strength which continues to be associated with the practice today. Although “This considerable achievement was not without its consequences in terms of other things than service and efficiency.” (Boyle 1977, p.330) Even founding partner Owings (1973, p.99) had come to express doubts about the direction of the firm, admitting “as SOM grew larger and older the firm became more rigid.” This ultimately had its effect on the design work of the practice, as Owings (1973, p.99) asked “What had we become? Certainly not designers in the classic sense. We were entrepreneurs, promoters, expediters, financiers, diplomats; we were men of too many trades and masters of none.”
The ascension of large practice was not limited to the United States, with the practice landscape of Australia also undergoing a similar shift in emphasis. The practice of Bates Smart McCutcheon (BSM), originally founded as Bates Peebles and Smart in 1853 and continuing today as Bates Smart, was one of the largest and most influential firms in Australia in the mid to late twentieth century.

Following the material and economic restrictions that characterised the austerity of wartime development, Phillip Goad describes BSM’s rise to “become the pre-eminent corporate practice in postwar Australia, a status achieved primarily through expertise in the curtain-walled skyscraper.” (2004, p.148) [Figure 41] The rise of BSM and the concurrent expansion in the size of the practice led to substantive changes to the organisational structure, as “the office reconfigured its entire working procedures,” whereby in 1955, design responsibility was evenly spread across its partners and associates (Goad 2004, p.148).

BSM successfully rode the late-modern boom of commercial architectural development in Australia, the legacy of which is evident in every state capital. However this position would be put into question in the mid 1970s by “a younger generation of architects impatient with the mannered politeness of moderate Modernism’s postwar transformations of the city” (Goad 2004, p.213). By the 1980s and 1990s this questioning would be compounded by significant changes to the discipline as a whole, as summarised by Goad (2004, p.242):

*The rise of the design-construct package, the need to form joint venture partnerships to manage large-scale projects, the increasing phenomenon of architects who might complete the exterior of the building but not be chosen for interior fit-out commissions, [and] the technological upgrading (through computers) of the documentation process, and the competitive environment that surrounded the setting of architectural fees…*

Each of these changes has led to a radically new context for architectural practice, that posed significant restructuring challenges to the large corporate firm. The design work of Bates Smart could no longer depend upon the clarity offered by modernism, and became “increasingly diffuse.” (Goad 2004, p.242)

This brief snapshot of the transition in scale and organisation of architectural practice up to the close of the twentieth century reveals tremendous changes in both structure and general attitude to business. While there are many contributing factors for this shift - including increasing mobility of the workforce, the effects of globalisation, increasing rapidity of communication - above all
it is due to the associated effects of an increase in technology to pervade every facet of society. These effects have accelerated in the intervening years, producing a fundamentally different context for architectural practice in the early twenty-first century. This next section explores the characteristics of this new context, the impact it has on design and the new opportunities it creates for architectural practice in the future.

3.2 Organisations in the network society

Spanish sociologist and globalist Manuel Castells is arguably the most influential academic to address the key characteristics of our contemporary global context. Referring to it as the ‘Network Society’, Castells, in his book of the same name (2000), defines the distinctive features of this world as being "informational, global and networked.” The following passage captures the concept of the network society by defining these key terms:

*It is informational because the productivity and competitiveness of units or agents in this economy (be it firms, regions, or nations) fundamentally depend upon their capacity to generate, process, and apply efficiently knowledge-based information. It is global because the core activities of production, consumption, and circulation, as well as their components (capital, labour, raw materials, management, information, technology, markets) are organised on a global scale, either directly or through a network of linkages between economic agents. It is networked because, under the new historical conditions, productivity is generated through and competition is played out in a global network of interaction between business networks (Castells 2000, p.77).*

Many factors have conspired to produce this network society, but above all it is the increasing pervasiveness of information technology and global communications such as the internet that “provided the indispensable, material basis for its creation” (Castells 2000, p.77). Each of the factors explained above, and the intertwining of them, defines a fundamentally changed context for business compared to that of the late twentieth century where the previous section of this thesis left off. Business and society are subject not only to the influence of global trends, but increasingly depend upon them for productivity and growth. And despite Castells' frequent reference to the ‘global’ nature of this new context, the impact of the network society is not limited to large multinational firms, but has direct and profound implications for businesses and society at all scales.
One instance where this impact is felt is in the increasing complexity and sheer amount of information that is shared, produced and proliferated around the world. John Thackara (2005, p.5) provides a compelling measure of this complexity in the introduction to *In the Bubble*:

On just one single day of the days I have spent writing this book, as much world trade was carried out as in the whole of 1949; as much scientific research was published as in the whole of 1960; as many telephone calls were made as in all of 1983; as many emails were sent as in 1990.

As these figures clearly illustrate, we are not merely witnessing an ‘increase’ in information and complexity, but an explosion of several orders of magnitude, requiring a fundamentally different approach to managing this information that can respond dynamically to these immense changes. Considering this information merely quantitatively – as vast amounts of emails or research papers – abstracts this data from its purpose or meaning. Each of these emails or papers is not just data to be measured in gigabytes, but units containing knowledge to be interpreted, processed, understood for its importance, and acted upon in order that it hold any meaning or relevance. Indeed, economists Björn Bjerke and Claes Hultman (2002, p.3) argue that “the only meaningful resource today is knowledge and the modern business challenge is to handle knowledge workers.” In the network society, the ability to construct, capture and use information and knowledge supersedes the old competitive assets such as production capacity and financial strength.

American researcher Richard Florida argues that this economic imperative to create and manage information and knowledge intelligently has spawned an entirely new sector of the workforce defined by the creative nature of their work, which he calls the ‘creative class’. Although this term is not universally admired (Thackara 2005, p.77), it is useful to describe the influence of our economic context on the demands of the designer. Florida (2002, p.4) proposes “We now have an economy powered by human creativity. Creativity…is now the decisive source of competitive advantage. In virtually every industry…the winners in the long run are those who can create and keep creating.” The creative class is independent, individual and self-motivated – all characteristics that stand contrary to the strengths of the preceding era of hierarchical organisations – but above all what defines them is that their “economic function is to create new ideas, new technology and/or new creative content…[they] engage in complex problem solving that involves a great deal of independent judgement and requires high levels of education or human capital.” (2002, p.8)

Florida’s emphasis on ‘creation’ as a fundamental characteristic of the new workforce leads to another key characteristic of the network society, the role of innovation. Melbourne-based researcher
Mike Berry (2003, p.13) provides a useful summary of the various authors and perspectives that form the economic and theoretical territory of innovation; among these perspectives is the definition used by the Confederation of British Industry (CBI) for their Innovation Trends Survey (1999):

*Innovation occurs when a new or changed product is introduced to the market, or when a new or changed process is used in commercial production. The innovation process is the combination of activities (such as design, research, market investigation, process development, organisational restructuring, employee development and so on) which are necessary to develop and support an innovative product or process.*

Importantly, innovation is directed toward a market or commercial production, it is a tool used to attain economic growth and productivity; this is what distinguishes it from ‘invention’ and ‘research’. However it is invention and research that feed the innovation cycle, creating a close relationship and dependency between each of these activities. Furthermore, innovation is not limited to the outcomes of an industry or firm, but can refer to the entire process of production and management. Berry (2003, p.21) suggests that because of this pervasive presence throughout a company, sector or region, “innovation as a central process is much more than information or knowledge bites in isolation.”

This integrated and pervasive nature of innovation leads to the final key characteristic of the network society, that of the *network itself*. Castells (2000, p.180) defines networks as “the fundamental stuff of which new organisations are and will be made.” In this sense, ‘network’ does not just refer to the infrastructural network of information and communication technologies – although this largely enables it – but to the social and collaborative networks formed at multiple scales between people, firms, cities and regions. Indeed the degree to which these units are networked can impact upon their innovative potential. Smith (1995, p.17) states “the overall innovation performance of an economy depends not so much on how specific formal institutions (firms, research institutes, universities, etc) perform but on how they interact with each other as elements of a collective system of knowledge creation and use, and on their interplay with social institutions (such as values, norms, legal frameworks and so on).”

Each of these fundamental characteristics of our contemporary network society – networks, technology, complexity, information, knowledge and innovation – are of critical importance to the contemporary designer and design practice. They form the context in which architecture and
architectural practice are undertaken, and an understanding of this context is required in order to produce an economically and socially sustainable practice. The following section explores the new opportunities this context offers for design practice and examines a number of examples where these principles have been challenged or embraced to produce new practice types that intimately respond to these characteristics of the network society.

3.3 New opportunities for design practice

This new economic context has demanded a significant reconceptualisation of design practice. These changes were the subject of the exhibition ‘Design and the Elastic Mind’ held at the Museum of Modern Art (MOMA) in New York in 2008, which claimed to explore how designers have engaged “the momentous advances in technology, science, and social mores that have characterised the last quarter century” (Antonelli 2008, back cover). Curator Paola Antonelli (2008, p.17) views the scope of the designer as expanding from that of a “form giver to fundamental interpreter of an Extraordinarily dynamic reality.”

Thackara (2005, p.7) similarly views designers’ roles as shifting in response to the increasing complexity of technology from an emphasis on individual talent and hierarchical organisational models to more collective forms of practice:

As we suffuse the world with complex technical systems – on top of the natural and social systems already here – old-style top-down, outside-in design simply won’t work. The days of the celebrity solo designer are over. Complex systems are shaped by all the people who use them, and in this new era of collaborative innovation, designers are having to evolve from being the individual authors of objects or buildings, to being the facilitators of change among large groups of people.

This new role will require new skills and attitudes to design that are inherently more adaptive and improvisational. McCullough (1996, p.221) attributes this need to the rapid rate of technological change in society today, as “there are too many possibilities for any methodology to anticipate in advance.” Stating that “improvisation plays a major role in serious matters with real stakes, from business plans to scientific research…people take pride in thinking on their feet, inventing solutions when under pressure, and practicing originality in the face of risk.”

Antonelli (2008, p.14) prefers the term ‘elastic’ in lieu of ‘improvisational’ or ‘adaptive’ to describe this new attitude of designers, defining it as a condition of human intelligence that enables “the
ability to negotiate change and innovation without letting them interfere with one's own rhythms and goals. It means being able to embrace progress [and] understanding how to make it our own.”

This attitude is a direct response to the rapid rate of change occurring today. Designers can no longer ignore these changes by depending on premeditated or standard responses, but must embrace and engage change directly, developing strategies that are open ended and flexible, able to be informed by this context, evolving new responsive design solutions and forms of practice.

The most thorough endorsement of the need for designers to embrace and respond to the messy reality of the world is Jeremy Till’s recent book Architecture Depends (2009). Till claims architecture is inherently shaped by ‘contingencies’, external forces beyond the autonomous world of the designer that ought to be acknowledged and sought out as opportunities, rather than ignored. He states “Ideas developed away from the world may achieve a semblance of purity—of truth and reason—but this purity will always be tormented by the fact that the knowledge has arisen from within the world and eventually will have to return to the world.” (2009, p.35) Engaging the real and the local, simultaneously in all its complexity has the potential to bring architects closer to their subject: building. Although Till reveals ambivalence toward technology (2009, p.87) – attacking the “too clean”, dishonest and manipulative intent of architectural renderings and fly-throughs – could digital design strategies conversely be an aid in responding to the contingent? Chapter 4 returns to this idea by exploring design strategies developed through this research that are both modest and responsive to local conditions.

This reactive or elastic approach is not only relevant to the architecture or design disciplines, but as Castells (2000, p.177) argues, is more broadly critical to the success of firms in the network society. Firms need to be able to identify, integrate, and respond adaptively to “on the spot information”, as “designing a strategy in a top-down approach will invite failure in a constantly changing environment… Information coming from a specific time and place is the crucial factor.” This approach, when enabled by information technology allows “small and medium businesses to link up with major corporations, forming networks that are able to innovate and adapt relentlessly.”

The remainder of this chapter examines specific examples where architectural practices have developed innovative organisational models or roles in response to this new global context characterised by rapid change and increasing complexity. These examples cover a diverse selection of responses, including: the new role of the architect as ‘digital master builder’; the opportunities offered by emerging digital fabrication tools and how they can reconfigure practices; collaborative
coalitions of practices enabled by communication technologies; flatter organisational structures that encourage increased worker autonomy and independence; and the changing products of practice to include not only buildings but also the research that is undertaken throughout their production. Collectively, these examples offer a snapshot of a profession undergoing a rapid reconfiguration under the emerging conditions of the twenty-first century.

3.3.1 The information master builder

The term ‘master builder’ refers to the integrated role of designer, engineer and builder that the architect used to occupy before increasing complexity necessitated specialisation into distinct disciplines. As Addis (2007, p.30) explains, the Greek word *architektura* “embraced what today would be called both engineering and architecture” Similarly, the ‘master masons’ and cathedral builders of the Middle Ages “were in charge of all aspects of their buildings, from their form to the production techniques used in their construction” (Kolarevic 2003, p.57).

The term has resurfaced today to describe the re-integration of design and construction as enabled by digital means of design and fabrication. ‘Master builder’ today is often prefaced by the words

![Figure 42: Diagram of the architect as the central coordinator of the building project, managing information and orchestrating interactions between the various disciplines. (Kieran and Timberlake 2004)](image-url)
‘information’ or ‘digital’, to highlight that the designer is not literally undertaking the construction. In this case the distinctions between architect and builder remain, but the information for construction is increasingly being produced and managed by the designer.

Kieran and Timberlake (2004, p.31) view the shift toward increased knowledge management as critical to maintaining control over the architectural process, and endorse the adoption of this territory by architecture as a necessary antidote to the current disparate collection of specialists:

> By allowing architecture to become reduced to the current degree and relinquishing responsibility for assembly, product development and materials science to specialists, the architect has allowed the means and methods of building to move outside the sphere of architecture.

These ambitions to re-gain control of the “means and methods of building” are manifest in the model Kieran and Timberlake (2004, p.22) propose for the architect: an “overseer of the exchange of information.” [Figure 42] A role they describe not as a ‘master builder’, but rather “a twenty-first century maestro.”

This approach to creating architecture is demonstrated by Kieran and Timberlake in their ‘Loblolly House’ (2007) [Figure 43]. The building is made up of “smart cartridges” that are “composed entirely of off-site fabricated elements and ready-made components”. These cartridges contain all the necessary structure and services for the entire house, including heating, hot and cold water, ventilation and electricity. They are fitted into a structural frame with “only the aid of a wrench.”
In order to create such an accurate prefabricated system that can be manufactured in a workshop and snapped together on site requires the components of the house to be conceived in a fundamentally different manner than traditional piece-by-piece construction. Kieran and Timberlake have based their approach on the automotive and aerospace industries where typical details and 2 dimensional drawing sets give way to Building Information Modelling (BIM) that represents every component and detail to high tolerances in three dimensions.

Defining components at this level of detail requires the expansion of understanding, tasks and agendas into disciplines traditionally beyond architecture, to become “an amalgam of material scientist, product engineer, process engineer, user and client” (Kieran and Timberlake 2004, p.xii).

3.3.2 Flexible specialisation and personal fabrication: a return to craft

The motivation for Kieran and Timberlake’s challenging of architecture’s role in construction are to take advantage of the efficiencies of factory production, while the design of the product remains largely unchanged. By contrast, an emerging niche of design and production termed ‘flexible specialisation’ or ‘personal fabrication’ employs similar technological advances to explore notions of craft.

This interest has been enabled by an increase in computer processing power, a decrease in hardware costs, and decreased costs of specialist computer-driven manufacturing machines. These conditions offer a challenge to the pre-existing Fordist paradigm of mass production – which requires similarly massive machinery – instead favouring localised production and high-tech personal machines.

Such a shift has a fundamental impact in architecture. The ability for designers to own the means of production enables the establishment of a seamless digital process chain from design to manufacture. With this capacity, Evans’ (1986, 1997) description of the architect’s “peculiar disadvantage…never working directly with the object of their thought” is potentially dissolved. The ‘object of thought’, or medium, is no longer a set of documents for interpretation by a builder, but the digital instructions for the digital fabrication of the physical artefact itself. This direct connection to the object allows a greater control and level of detail – even ornament – that is difficult and expensive to achieve in today’s construction marketplace.
It has been proposed that this use of technology could usher in a return to the small-scale production shops like those that existed prior to the industrial revolution. McCullough (1996, p.180) suggests that just as digital technology has migrated from research labs and corporations to personal computing, “if the means of fabrication follow a similar trajectory, masters and their small ateliers may reappear.” William Morris, a key proponent of the British Arts and Crafts movement of the late nineteenth century – which itself was a reaction against industrialised design – viewed craft as a means to “improving man’s lot” by contributing to his “social and spiritual betterment” (Pevsner 1936 2005, p.23). While Morris sought to enfranchise the worker with these benefits of craft production, due to the intensive labour and skill required to produce these objects, the products of this movement could only be afforded by the very wealthy. In an inversion of this paradox, the

‘Fab Labs’ developed by MIT’s Centre for Bits and Atoms under the direction of Neil Gershenfeld, place both the means and outcomes of craft production in the hands of under-served communities around the world.

The associated website (MIT 2008) describes the ‘Fab Labs’ (an abbreviation of ‘Fabrication Laboratory’) as "a group of off-the-shelf, industrial grade fabrication and electronics tools, wrapped in open source software and programs”. They include laser cutters, sign cutters, a milling machine, electronic components, programming tools and computer-aided-manufacturing software, giving users “around the world the ability to locally conceptualise, design develop, fabricate and test almost anything… open[ing] up numerous possibilities for solutions to common problems.”
Discussing the general potential for flexible production beyond this application in developing communities, Gershenfeld (2005, p.15) sees opportunities to “nip at the heels of complacent companies that don’t believe that personal fabrication ‘toys’ can do the work of their ‘real’ machines”. Furthermore, he does not see a similar limitation in scale of output, declaring that the boundary between proprietary mass-production and open-source localised production will recede “until today’s marketplace evolves into a continuum from creators to consumers, servicing markets ranging from one to one billion.”

As the ‘Fab Labs’ are currently geared to produce electronic components and small mechanical parts, the question remains whether this approach could be applied on the scale of a building. The answer probably lies somewhere in the middle ground. While ‘rapid-building-manufacturing’ is currently unfeasible – although much research is being undertaken in this field (Yeh and Khoshnevis 2009) (Buswell, Thorpe et al. 2008) – the production of computer-generated components for architecture is well established in the construction industry. What the ‘Fab Labs’ demonstrate is a critical shift toward localised control of the process of production and the new opportunities for customisation and craft this allows. Application on another scale – like that of a building – is a matter of degree, not of type.

3.3.3 Design about production

The ability to computationally control the fabrication of building components and their assembly has enabled practices to explore and refine the digital supply chain from design to fabrication with unprecedented accuracy. Critics have termed this approach “post-critical” (Somol and Whiting 2002, p.72), as instead of architecture being motivated by an idea or theory which is external to the subject, its own internal means of coming into being is the generative idea itself. As Speaks (2007, p.214) suggests, “these new practices are thus more concerned with ‘plausible truths’ generated through prototyping than with the received ‘truths’ of theory or philosophy.” Far from being ‘post-critical’, this return to focus on buildings has its equal share of manifestos (Gardner and van Sintfiet 2006), the key difference being that these are not sought from beyond architecture.

This shift toward ‘process as idea’ is not only touted by critics and academics, but also resounds with practitioners. Thom Mayne (2005), director of Morphosis, describes a shift from architecture as “styling” to one where a practice places “more emphasis on making” and where “conceptual thinking is increasingly embedding tectonic, constructional and material design parameters.”
An important part of this shift is the ability to test and refine design and production ideas quickly, with many practices now employing rapid-prototyping within their offices. This ability to directly fabricate represents a scaled-down version of the actual supply chains used to translate digital mock-ups into the 1:1 building components.

The New York-based practice of Sharples Holden Pasquarelli (SHoP) has not only embraced this ‘design about production’ approach to architecture, but has also largely defined it’s terms as editors of the ‘Versioning’ issue of Architectural Design (Sharples, Sharples et al. 2002). Central to their thesis is the role of contemporary software in enabling architects to have a deeper understanding and influence in the constructional logic and procedures of their designs. Their introduction states, “The computer has enabled architects to rethink the design process in terms of procedure and outcome in ways that common practice, the construction industry, and conventional design methodologies cannot” (p.7).

This emphasis on real-world construction is positioned as a reaction to architecture’s fascination – at that time in 2002 – with the free forms offered by emerging 3D animation software. SHoP (p.9) claim “when the blob is left in its rendered state it leaves us flat”, but do not dismiss complex geometry altogether, qualifying this statement with the suggestion that these forms be carried through with the rigor required for any other project. Arguing that “without making the intentional

Figure 45: ‘Dunescape’ by SHoP in construction at MOMA PS1, 2000
connection between the digital geometries on the screen and the execution of a technique to produce that geometry at building scale, the work seems limited” (p.9). This attitude remains at the core of the practice, with SHoP’s (2008) website proclaiming principles such as “how it's built doesn’t matter except when it’s the only thing that matters” and “building buildings is better than talking about buildings.”

This has a number of implications for practice, particularly in the services offered by the architect. Put simply, traditionally architects produced paper-based documentation consisting of plans, sections, elevations and typical details that would be interpreted by the builder, who would subsequently order materials and coordinate their assembly. Under SHoP’s ‘Versioning’ approach, the architect produces specific digital artefacts used for direct manufacture; steelwork drawings or CAD/CAM instructions for example. While this increase in services offered by effectively taking on the intermediate shop drawing stage may bring with it an increase in fees, it also brings with it an increase in risk. SHoP (2006, p.31) warn that “this approach requires the design strategy to accommodate dimensional tolerances with a frequently high level of precision, since elements are not ‘built to fit’ in the field, and increases the architect’s accountability for the final product”. Although as their website proclaims “push design, embrace responsibility”, this added risk would appear to be justified by the increased ability to control the final product.

Despite the ability to define complex form for construction in the computer, the building industry's reliance on standard assembly procedures and materials is deeply entrenched. SHoP (2006, p.31) attribute this resistance to the “dominant [use] of extruded and panellised materials”, a problem that can be overcome through the “invention of customised parts, manipulation of standardised parts, or deployment of standardised parts in non-standardised configurations.” Although the computer may have liberated design from its dependence on Cartesian alignment, the construction industry and construction material suppliers may be slower to adapt.

The accumulation of these shifts may engender a new form of practice. In another of their paradoxical micro-manifestos, SHoP (2008) declare “use technology to build practice, see practice as technology.” Which raises the question, ‘what is practice as technology? This is a practice where the efficiency and set of techniques is extended with technology, enabling, as SHoP (2002, p.7) claim, “small firms to perform large”, an ability made possible by directly operating upon the processes of building, and not the intermediate layers of fuzzy documentation.
The ability for ‘small to perform large’ takes on added relevance with recent shifts in economic and organisational trends toward practice structures based on highly networked small firms, and away from top-down ‘command and control’ hierarchies that dominated twentieth-century economic and management thinking.

### 3.3.4 Small, networked practice

The challenge to industrial means of production and of industrial-scaled organisational hierarchies is best captured by Ernst Friedrich Schumacher’s *Small is Beautiful: Economics as if People Mattered* (1973, p.68). Schumacher argued that:

> the economics of giantism and automation is a left-over of nineteenth-century conditions and nineteenth-century thinking and it is totally incapable of solving any real problems of today. An entirely new system of thought is needed, a system based on attention to people, and not primarily attention to goods.

The key to achieving this aim according to Schumacher is to “learn to think in terms of an articulated structure that can cope with a multiplicity of small-scale units.”

This preference for an ‘articulated structure of small-scale units’ has evolved from its leftist fringe origins in the 1970s to its current position as predominant in organisational thinking; a shift characterised as a move toward emulating the dynamics of natural systems. Pioneering organisational thinker Peter Drucker (2001, p.259) compares the performance and size of mechanical systems with natural systems as an illustration of this concept: “greater performance in a mechanical system is obtained by scaling up. Greater power means greater output: bigger is better. But this does not hold for biological systems. There size follows function.” In a similar preference for the ‘small is beautiful’ model, McCullough (1996, p.263) explains that “unlike the detachment and waste of late modern industrial production, natural systems thrive on interconnection, diversification, and self-regulation of huge numbers of very small entities.”

The key enabler of this dynamic networked economy is the connectivity offered by the Internet. Although the decentralised and indiscriminate nature of this infrastructure has the potential to relax dependence on location, a paradoxical outcome of our networked culture is the importance of the points of concentration. The formation of localised, small, well-connected entities are described in economic discourse as ‘creative clusters’, defined by Michael Porter (1990, p.197) as
“a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities.”

Creative clusters are emergent and bottom-up in structure, and unlike the late-modern command and control approach that proceeded them, they promote connections and collaboration. This in turn affects the role designers play, as Thackara (2005, p.7) states, they have “to evolve from being the individual authors of objects or buildings, to being the facilitators of change among large groups of people…old-style top-down, outside-in design simply won’t work.” The following practices examined here offer examples where innovative clustered practice models have contributed to the production of equally innovative design.

The team comprised of the small architectural firm Six Degrees, sole practitioner Andrew Maynard, and sustainability consultants Sustainable Built Environments (SBE) in their design of the new architecture school at the University of Tasmania (UTAS) is a strong case for the advantages of collaborative practice. Louise Wallis (2005, p.72) describes the reasons for this collaboration as both practical – driven by a need to combine resources and experience – and informal – as the members each held pre-existing social ties. This resulted in an “egalitarian” coalition, which Wallis suggests is in contrast with the usual hierarchical relationship in architecture where a “larger practice [is] the lead consultant, with the smaller practice acting as architects in association.”

Not only was this collaboration convenient for the practices involved, it was also attractive to the client. As member of the client group Ceridwen Owen (2007) writes in his review of the project, “this partnership…was a key factor in the selection of [the] design team by UTAS.” Furthermore, upon commencement of the project, this partnership was extended beyond the designers to include the clients, consultants, staff and students of the University in an “intensive design charette.” Peter Malatt from Six Degrees views this open and collaborative approach as enhancing the questioning process which underpins good design. “If you’re interested in having a good design outcome you’ve got to really look at how decisions are made within all aspects of the design and how you run a job and that is what cooperative collaboration is all about. It’s about empowering more people to inform the design process” (Wallis 2005, p.73). The success of this small, networked approach to collaborating on a medium-sized project is evident in the positive reception of the building, having received the RAIA National Award for Sustainable Architecture 2007, the RAIA Lachlan Macquarie Award for Heritage 2007 and the RAIA state award for Public Architecture 2007, among others.
The small, networked approach has not gone unchallenged however. Vishaan Chakrabarti (2002), an associate in the multi-national architecture firm SOM, questions the effectiveness of the small practice network due to its inability to interact in a global market, preferring instead the large-scale practice restructured internally as collaborative teams. Chakrabarti’s criticism of small firms is levelled at a curiously dated stereotype: those “sole practitioners wielding singular visions on blank yellow trace.” Hopefully these concerns would be alleviated by the above description of a successful and democratic collaborative partnership of small firms. This internally articulated large practice structure is also covered by Schumacher (1973, p.58), who claims that “as soon as great size has been created there is often a strenuous attempt to attain smallness within bigness.” The question then follows, if you are big, why strain to attain smallness? As Schumacher again argues, the appropriate scale is dependent on what you are trying to do, and to engage in a large and complex project does not require a large corporation, but a greater number of “relationship arrangements” that need to be established.

In the case of small practices, the incentive for collaboration comes naturally, as simply by virtue of being small they avoid the forced strain to act small, while to engage in larger projects, they need only build relationships as required on a project by project basis. However it is worth clarifying that the age of the large corporation is not over, but that the organisational principles upon which they are largely based are increasingly incapable of operating competitively in this network society. As Castells (2000, p.179) argues “what emerges from the observation of major organisational changes in the last two decades of the twentieth century is not a new, ‘one best way’ of production, but the crisis of an old, powerful but excessively rigid model associated with the large, vertical corporation, and with oligopolistic control over markets.” Similarly, Florida (2002, p.27) also dismisses the notion that large practices will cease to exist, instead likening the economy to a dynamic natural system, claiming that “An economy composed of only small, short-lived entities would be no more sustainable than an ecosystem composed only of insects… The key point is that organisations of all sizes and types have distinct roles to play in a creative economy.”

3.3.5 A dissolution of hierarchy

Despite this diversity of practice size and type, what draws them together is a similar preference for a flatter, less hierarchical organisational structure. Castells (2000, p.176) states “The corporation itself has changed its organisational model to adapt to the conditions of unpredictability ushered in by rapid economic and technological change. The main shift can be characterised as the shift from
vertical bureaucracies to the horizontal corporation.” Baxter and Lisburn (1994, p.119) confirm this position, describing the new type of management structure as “like a network, with multidisciplinary project-oriented teams taking the place of the functional departments that have served us for 200 years.”

A number of theorists propose that the most successful networks are comprised of small project teams or connected practices. Berry (2003, p.31) states industries “are increasingly driven by competitive pressures to ‘de-verticalise’ – or express a process of vertical dis-integration – creating interacting complexes of smaller firms specialising in different but linked parts of the overall production process.” Similarly, Bjerke and Hultman (2002, p.1) view smaller practice structures as more suited to the characteristics of the information economy. They argue that skills of constructing and using information and knowledge,

*do not seem to improve with size; on the contrary, they often seem to be best understood as consisting of fast-moving small business units with leaders having both ears and noses close to the customer and with loose organisational structures for highest flexibility and intimacy.*

A key to the success of this flat organisational model is to engender a culture of information responsibility within the networked components, a condition Baxter and Lisburn (1994, p.117)
describe as “about empowerment, not hierarchical control”, managed through trust, not rule books. Berry (2003, p.21) describes the adoption of this approach as “not for reasons of industrial democracy”, but as a means to “encourage all workers in the firm to learn and apply a collective entrepreneurial search for the ‘next big thing’.”

The highly networked and independent characteristics of work in the contemporary economy have led to the emergence of a number of surprisingly structured architectural practices. Servo, established in 1999 is made up of partners Chris Perry, Marcelyn Gow, David Erdman and Ulrika Karlsson who are distributed across the world, “each inhabiting a geographically different urban space – spanning one ocean, two continents and three countries” (Erdman, Gow et al. 2002, p.17). While the constantly networked and travelling architect is a common enough occurrence today, what distinguishes Servo is the absence of a central base or hub. Their office is formed over the communication network itself, through the sharing of information. Not only do these networks enable this practice to function, they also form the subject of exploration, as Hight (2007, p.104) explains, “Servo’s most recent work suggests a shift from focusing on innovating the object of architecture to reconfiguring its subject: the redistribution of borders of the discipline into the power structures of the networked economy.”

This interest is also evidenced through their projects, such as ‘Lattice Archipellogics’, which itself is a network of physical objects connected to sensors and able to respond locally to sensory input to produce an emergent display that is greater than the sum of its individual components.

This shift to flatter organisational structures has also had an effect within the firm. As creative work is characterised by independence, architectural practices have had to develop strategies for effectively mining this autonomy by capturing this autonomously created knowledge. Furthermore, the dependence of practices on staff with skills with the latest software further challenges the traditional importance of experience in architectural practice. Foreign Office Architects (Zaera-Polo and Moussavi 2000, p.130) bluntly describe this condition as a clear demographic split: “the people who are actually doing the jobs in every single office are under forty, and mostly even under thirty. And they are the only ones able to do the job because they can use computers, they have access to technical means that have become central to the production processes."

Not only is this division merely determined by technical know-how, FOA (Zaera-Polo and Moussavi 2000, p.130) suggest it extends to a way of thinking, as younger staff members “work as a research process, producing knowledge as they are producing the project…they are simply more
sensitive to what is going on.” According to FOA, the impact and importance of technology in reshaping practice hierarchies has been so great that standard processes and established knowledge have become a hindrance to practices as they run counter to innovation and progress. In this sense, the traditional office politic is not only flattened but, perhaps worryingly, inverted. Junior staff with little experience but skills with the latest software are valued equally if not more than the mid-career professional.

### 3.3.6 Innovation through increased risk and accountability

Despite these numerous examples of practices creatively exploiting new construction technology, forming successful collaborations between practices and empowering their staff with autonomy and creativity, the construction industry at large remains steadfastly adversarial and complex. James Glymph (Glymph 2004) of Gehry Partners describes the relationship between architects and other consultant parties as “divided, fragmented and often undisciplined…the most unstable and insecure industry one could choose.” Driving this division is an aversion of risk and a requirement for protection due to an increasingly litigious commercial environment, the result of which Fischer (1996, p.37) describes as “a form of slow suicide for the profession.”

This has had the effect of stripping architects of their control over the process and end result. Frank Gehry summarises this issue simply: “when you give up responsibility, you give up power in the equation, and it’s always been my fantasy to try to find a way to become the responsible part of the team with the client and become a partner with the construction company instead of an adversary” (Day 2004).

This culture of division is perpetuated by an industry-wide dependence on a two-dimensional system of documentation, itself tied to issues of litigation by representing part of the contract between architect, builder and client. As Glymph (Day 2004) explains,

> the paper-centric process creates sharp divisions between each phase of the project and the process becomes very linear. So you go from one stage with the architect, to one stage with the engineer, then the contractor would take over and they would regenerate information at each stage. This fragmentation reinforced a culture in the industry, in its legal structures, contracts, in the way that architects, craftsmen, fabricators and builders relate to one another. It separates one another and creates a much more antagonistic environment.
In a presentation sensationally titled “Change or Perish”, Thom Mayne (2005), director of the practice Morphosis, proposes architects re-engage with the physicality of building as a means to overcome this culture of division and loss of control. In a threatening final statement, Mayne declares, “if you’re not dealing in the direct performance of a work and if you’re not building it and taking responsibility for it, and standing behind your product, you will not exist as a profession.”

This re-engagement with the physicality of building is key to the aims of Gehry Technologies, the software division affiliated with the architecture practice Gehry Partners. Chief Technology Officer (CTO) of Gehry Technologies, Dennis Shelden (2006, p.82), describes the company’s approach as one that views “building from the process of making rather than the prevailing view of making as design’s outcome.” This is achieved through the development of advanced 3D modelling software – named Digital Project – adapted from the aerospace and automotive industries, that enables far greater accuracy, error detection, scheduling and cost analysis than the 2D equivalent, thereby providing a common platform for collaboration with the various disparate professions that make up the construction industry.

Such accuracy and control has resulted in a far less adversarial process. As Gehry (Day 2004) himself explains:
we have been able to delineate the parts of the buildings in such detail, to seven decimal points of accuracy, that the construction people are comfortable because their margin of error and misunderstanding is very small… Here, the clarity gave them safety.

The effectiveness of this approach can be evidenced in the complexity and scale of the projects produced by Gehry Partners, which represent arguably the most significant exploration of new formal possibilities in architecture today [Figure 48].

However, for such efforts to make an impact beyond these particular projects, it will need to be adopted by the architecture and construction industry more broadly, requiring significant shifts in practice and significant effort to overthrow the long-standing pervasiveness of working in two dimensions. As Glymph and Chazar (2006, p.213) highlight:

> decades, even centuries, of effort have gone into creating the present sets of regulations and contractual forms governing the design and construction of buildings. Older still are the concepts of property that are an underlying motivation of much human activity. Digital working, on the other hand, implies (if it does not demand) a significant transgression of many of these boundaries.

Putting this new technology into practice requires similarly new contractual arrangements. Glymph and Chazar (2006, p.218) list a number of alternative structures, from design-build, where “many of the customary defensive obstacles are mitigated or eliminated by sharing financial risk and reward”, to an adaptation of the common CM (Construction Management) At Risk scenario, whereby parties establish standards for the sharing and checking of information (such as who controls the ‘master model’), and may require contractors to pre-qualify with CAD/CAM ability. In summary the authors state, “the seamless flow envisioned by digital working methods requires much greater flexibility (and perhaps agility) from the participants.”

In reference to the subject of this research, the question remains as to how might these tools and strategies developed by Gehry Partners be relevant or applicable to the small practice working on smaller projects? Mitchell (2003, p.363) expects this technology to ‘trickle-down’, claiming that,

> [Gehry’s] remarkable late projects will ultimately be remembered not only for the spatial qualities and cultural resonances they have achieved, but also for the way in which they have suggested that everyday architectural practices can be liberated from its increasingly sclerotic conventions.
Glymph’s (Cocke and Glymph 2000) response to a similar question has less to do with legacy and more to do with the underlying shift that this software represents; “if you forget the curves, and simply think about a centralised database for coordination, there are obvious advantages regardless of the nature of the architecture.”

### 3.3.7 Practice as research

The expansion of Gehry’s practice to include software development through the affiliated company Gehry Technologies represents the increasing importance of research and development in architectural practice. While the design and development of any single project may be considered research in itself (Allpress 2005, p.1), involving great amounts of time and often large groups of people, generating large amounts of information and knowledge in the process, Gann and Salter (2000, p.4) suggest that because of the architecture and construction industry’s project-dependent structure, this knowledge is rarely captured effectively for subsequent referral or implementation. Further to this extreme, Finch (2005) questions whether designing a building is research at all, suggesting it is merely an “experiment”, where architects are “more engaged in pushing manufacturers to advance their thinking than in doing direct research themselves.” Despite this, a number of practices have identified the value of research, and have established internal R&D labs that can independently explore techniques and ideas while not constrained by the

![Figure 49: D-Tower by NOX, Left: Suspended research model. Right: completed structure](image)
demands or deadlines of specific projects. The following practice examples set out the contexts and organisational structures that enable this research and innovation to occur.

The Rotterdam-based firm NOX, led by Lars Spuybroek, manages to combine a focus on research and innovation within a functioning practice context. Spuybroek (Hyde 2006) explains that this is achieved both through a relationship with the University of Kassel and by carrying out experimentation on small projects, which is then used to inform the larger buildings. Spuybroek describes how the knowledge generated in art projects is fed back into the architecture, in a “looping system of theory, practice, knowledge and trying things out and experimenting.” When I ask Spuybroek how he affords to approach each project as an experiment, and whether there are many conventional, unpublished NOX buildings subsidising the practice, he explains,

no, no, it’s all done by organisation. The research is done at the university, where I have assistants and PhD students, and a lot of them come to the office, so where there’s specific projects we bring in the knowledge. That is one channel. The other channel is more for the art projects, where we conduct research…try things out…and bring that into the architecture projects.

The built body of work by NOX to date is largely comprised of art projects, pavilions, exhibition design and interiors. Spuybroek concedes himself in the introduction to his monograph that there “is not enough building”. (Spuybroek 2004, p.4) This perhaps explains some limitations to the viability of this model, as such a dependence on the university for extending practice through research may not be possible for constructing larger projects.

By contrast, another Rotterdam-based firm, Rem Koolhaas’ Office of Metropolitan Architecture (OMA), is unquestionably large and yet innovation and research are an integral product of this practice, produced through “OMA’s mirror-image” (Koolhaas 2004, p.20) ‘AMO’. The motivation for establishing this arm of the office is captured in characteristically bleak terms by Koolhaas (2005, p.19) in the following passage:

The typical architecture office generates a sad form of knowledge. The process of realizing a building produces idiosyncratic expertise, particularly in the uniqueness of local conditions – architecture, politics, contractors, history… But by the project’s end, it is already clear that the architect’s prodigious knowledge will never be reinvested in new, even more subtle projects in the same environment. We always have to move on, to the next frontier of unfamiliarity. We also become ‘experts’ in typologies that we will never be asked to repeat. To maintain the ‘professional’ abilities
to which our medieval origins condemn us, we are forced to maintain huge, permanent ‘staffs’ in an age when the mobility of the workforce guarantees economic and intellectual survival.

AMO is described on OMA’s website as “a research studio and think tank that…applies architectural thinking in its pure form to questions of organisation, identity, culture and program” (OMA 2006). The relationship of the architectural practice OMA with this research studio is explained as follows: “AMO often works parallel to OMA for the same clients, providing extra services in the domains of organisation and identity while, at the same time, work on the design of a building is being conducted.” This is a peculiar distinction between research and practice, as one would assume understanding a client’s “organisation and identity” would be necessary and important in the formulation of any architectural project. A split that Bruce Stirling (2003, p.176) describes as being “odd and archaic that they were ever separated in the first place.” But what this separation allows is the creation of “knowledge independent of chance” (Koolhaas 2004, p.20), outside the disjointed project-dependent context of typical architectural practice.

Figure 50: Page spread from the ‘AMO Atlas’ illustrating an analysis of global think tanks. in Content (Koolhaas and McGetrick 2004)
Traditionally architectural ‘research’ has been a synonym for the study of history and theory undertaken at university; a retrospective field of indirect reference to the day-to-day procedures of architectural practice. Ironically, AMO enlist these same strategies of history, namely “collecting, evaluating and contextualising information” in the contemporary aim of “reanimating the creative mission of the designer” (Speaks 2003).

In this case, the viability of undertaking research is justified through the affiliation with the practice and the usefulness of this research to the development and direction of the architectural projects and to the clients. The success of which is achieved through offering “singular targeted advice that is highly biased” (Speaks 2003), as opposed to the quantitative studies produced by dedicated management consultancies. Koolhaas (2004, p.20) views the potential for this research approach beyond the service of the practice’s projects altogether, arguing that rather than deploying this collected knowledge in the service of built architecture, it may in fact be architecture itself. “Liberated from the obligation to construct, [architecture] can become a way of thinking about anything – a discipline that represents relationships proportions, connections, effects, the diagram of everything.”

In this sense, the OMA’s active engagement of research as a strategy has led to the questioning of the nature of practice itself, opening up new markets for architectural thinking. The extensive list of projects attributed to AMO on OMA’s website – including publications, corporate branding, feasibility studies, clothing and self-initiated speculative research – would seem to be evidence of

Figure 51: Dutch designer Marcel Wanders on the cover of the ‘Masters of Design’ special edition of business magazine Fast Company, October 2008
the independent viability of the expanding scope of architectural production into these new areas of research.

### 3.3.8 Design thinking

This development has not gone unnoticed in the business world. A relatively new approach to innovation in business – termed ‘design thinking’ – seeks to draw upon the particular methods designers use for research and development. Key to this theory is a broader understanding of design as not just aesthetic value or physical objects. Tim Brown (2006) of the U.S industrial design and research firm IDEO states “Design is everywhere, from products, services, consumer experiences, and communications. It really is the fabric of our lives and therefore has a pretty big impact on us. But beyond the stuff, designers have a unique way of solving problems, and that’s what I call ‘design thinking’.” It is the perspective that designers bring to problem solving, when compared with other parties or stakeholders in the development of a business idea in which Brown is particularly interested. Designers bring an integrated approach “that uses the designer’s sensibility and methods to match people’s needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity.” (Brown 2008, p.86)

What is interesting about ‘design thinking’ is how it repositions the role of the designer within the world of business. Rather than passively accepting commissions to give aesthetics to a project or product that has already largely been determined, designers are now being invited to play an integral role in defining its terms. Indeed, this interest among the business community in design as a driver

![Diagram of new relationship of design to nature culture and business by Bruce Mau (2008)](image-url)
of innovation is reflected in the recent issue of U.S business magazine *Fast Company* devoted largely
to the implications of design and creative processes in business.

Brown (2008, p.86) views this renewed interest as representing a shift in where design operates in
the overall development process,

> Historically, design has been treated as a downstream step…the point where designers, who have
played no earlier role in the substantive work of innovation, come along and put a beautiful
wrapper around the idea… [Now] companies are asking them to create ideas that better meet
consumers' needs and desires. The former role is tactical, and results in limited value creation; the
latter is strategic, and leads to dramatic new forms of value.

One studio in particular that has identified the opportunities of an expanded agenda for design
is the Canadian firm of Bruce Mau Design. Although established as graphic designers, the studio
actively generates original research and content, which feeds projects initiated by the studio such
as books and exhibitions. Founding principal Bruce Mau (2000, p.319) views the design work of
the practice as extending beyond formal solutions based in an aesthetic discipline, stating “We have
tried to develop a new stance for the designer, one that confronts demands both from the world of
business and from the world of culture.”

A key initiative in this reshaping of the designer’s role is Mau’s establishment of the *Institute Without
Boundaries*, a post-graduate studio-based program offered in partnership with George Brown
College in Toronto. The aim of the program is to “re-envision the designer as an evolutionary
strategist” by exposing students to real-world design problems “so they continually resist the simple
solution in favour of the real opportunities inherent in a project” (Mau 2008). This is achieved by a
broader definition of the scope of design’s implications and the context it is informed by.

Figure 52 beautifully captures this shift in design’s relationship with its context of nature, culture
and business. Although no explanation of the diagram is given by Mau, it clearly illustrates the
expanded role of design as not merely the final aesthetic input for a product or building at the end
of the development cycle, but as a pervasive force capable of bringing order and meaning to a larger
context through strategic thinking.
3.4 Summary

Despite having shown architectural practice taking a wrong path with the rise of corporate practice and its associated impact on collaboration and creativity, this chapter identifies an optimistic future for the organisation of architectural practice. The burden on practice of rigid vertical hierarchies and numerous layers of middle management that came to characterise the twentieth century offers important lessons on the value of staff autonomy and intimate networks of workers and practices. The ‘divided’ structure of these late-Modern practices produced elegant and abstract works that captured the dominance of the corporate world, a language that is at once celebrated for its clarity and criticised for its corresponding hostility.

The rise of the ‘Network Society’, driven by the impact of global information technology and communications, posed a radical challenge to established practice models and industrial-era business models more broadly. But far from denoting the end of the ‘large’ and the triumph of the ‘small’, the shift to information as the key competitive asset produced a diverse ecosystem of practice types and sizes. Emerging practices termed ‘information master builders’ are exploring new means of producing, communicating, and managing construction information within networked teams of consultants and producing correspondingly new forms of architecture. Flexible and personal fabrication has democratised the means of production, and offers digital means of articulating a new level of craft and detail. This unprecedented connection with the means of construction has (according to some critics) unseated ‘theory’ as a driving force of architectural generation, with a number of practices exploring production as a design idea in and of itself. Small practices are able to form effective collaborative networks with other firms using new information sharing technology, thereby enabling them to compete for projects typically outside of their individual scope. New information management systems enable the production of vastly more accurate design information, forging new roles of responsibility and accountability within the project team. And finally, research has assumed a renewed importance in practice as a generator of innovation. New practice models are emerging that apply ‘design thinking’ to issues beyond architectural problems and offer services beyond building.

In regard to the theme of this research, the diversity of these emerging practice models effectively forms a catalogue of precedents for the small practice today. Each of them engages with the issues and opportunities of our contemporary condition in unique ways and provides an important foundation for the continued development of new practice types that challenge established forms of practice and the discipline’s engagement with technology.
Chapter 4. Case study projects: Strategies for expanding design

Chapter 4 documents and explores the specific strategies developed through the research and how they have been applied in particular case study projects in the context of practice. These strategies include: ‘closing the loop’; ‘deferred decision designing’; ‘hand made digital fabrication’; ‘design as goal-oriented experiment’; ‘refolding complexity’ and ‘pleating rationalism’. While these strategies, their titles, and the case studies they are explored through are developed by the author, each is informed by research of the literature and precedent design strategies explored in Chapter 2.

Each strategy is examined firstly through a diagram that seeks to express its contribution to this research. The strategy is then described abstractly, without reference to any particular case study project or precedent, in an attempt to emphasise the generic applicability of the strategies beyond its specific context. This is followed by a practical description of the particular implementation of the strategy in practice through case studies or projects. Examination of each strategy is concluded in reference to the subject of this research by responding to the question ‘how does this strategy expand design in small architectural practice?’ The methodology for examining these design strategies is derived directly from the experience of the author as a key participant engaged in the process of designing within real constraints of deadlines and economy associated with working in practice (see section 1.2). This is an unusual position for a researcher as it openly acknowledges the potential to influence the subject of study – designing – through participation and intervention.

To be very explicit about the way these case studies came about, the author was literally sitting in the office over the course of 2 years as part of the design team. When a new project would come into the office - a commission, competition, or invitation to collaborate - it would be evaluated for the potential to benefit from the kind of research into digital design strategies that the author was working on. The criteria for determining what would make a good project to focus on was manifold. For instance, did the project have a client receptive to new ideas? Was it of a certain scale that could be manageable when experimenting with new techniques? Was it a project type that perhaps lacked a well-defined approach or set of established skills to address it within the office? Not all case study projects met these criteria, and not all criteria were accurately perceived from the beginning, and indeed, some case studies which were embarked upon were abandoned, and are not represented here.
It is important to note that all of the following work was completed within the demands and constraints of real project deadlines and demands of practice. These are not isolated experiments extracted from the flow of deliverables to be examined in vitro, they were presented to clients; they were developed under regular project timetables; and were used to create the projects which (in most cases) resulted. This required long nights, and the trust and generosity of the practice directors willing to take some risks and experiment with new ways of doing things with the potential for failure. In many ways, this demonstration of the capacity to insert a researcher within a design office as a key contributing member is a major contribution of this research.

The following descriptions are of the design strategies developed through this research and how they have been applied to the case study projects.

4.1 Closing the loop

![Diagram: Closed loop diagram, Pavilion project]

The ‘closing the loop’ strategy employs parametric software as a structure for refining a design solution through the integration of performative and constructional constraints into a looping process of design, representation, fabrication and prototyping. The parametric – and thereby flexible
nature of the information being translated and interpreted offers the potential for the smooth communication and revision of the design.

The relevance of this strategy lies in the ability to generate multiple design variations without the penalty in time and effort of needing to subsequently ‘draw it up’ for construction. As is explored in section 2.3 on trial and error, testing and the feedback derived from testing are critical to developing a design from a concept to a final outcome. Often architects test ideas or designs using scale models or prototypes, which can reveal the appearance and functionality of a design. But the usefulness of traditional prototyping or models is limited as they are rarely constructed in the same manner as the final object would be, and therefore offer limited feedback on constructional issues.

As modes of production become increasingly process-driven, through the introduction of generative design techniques and CAD/CAM capabilities, it becomes increasingly necessary to test the way a project is to be manufactured, and to test the communication of this manufacturing information. This testing is enabled by contemporary computer-aided manufacturing processes that are increasingly scalable, whereas traditional methods of prototyping such as model-making employ a very different set of methods and materials from those of the final building or project. Contemporary tools such as laser cutters are employed both by domestic-scaled model-makers and for the fabrication of full scale architectural components. Prototypes can therefore be created that explore the translation and communication process of the actual means for construction, enabling this feedback to be re-introduced into the cycle of design testing.

Another critical aspect of this strategy is that changes to parameters defined early in the process are propagated downstream to update subsequent procedures without the need for erasure and redrawing. This enables knowledge gained through the production process to inform both design and outcome. Furthermore, if these subsequent procedures are fabrication oriented, a closed loop between design and construction is established, whereby subsequent iterations can be developed from or be informed by the previous iteration, simulating the common design refinement process of trial and error. It should be noted that for real benefits downstream in a project, the potential future options must be anticipated to an extent. This is sometimes impossible, as further information about the design problem is often discovered through the process of designing, thereby requiring a more fundamental rethinking of the design proposal, and subsequent rebuilding of the parametric model.
Nevertheless, the potential benefits of this strategy extend beyond ‘efficiency’. McCullough (1996, p.178) describes tightening this loop between conception and execution as having the “potential to reconcile some of the separation of design and fabrication that industrialisation had previously imposed on craft”, resulting in “the conception and execution of everyday objects [being] once again in the same hands”, ‘closing the loop’ also has implications for the way information is communicated in the construction process.

This strategy was deployed on the Pavilion project, an installation piece for an exhibition of emerging Melbourne-based practices titled ‘Pavilions for New Architecture’ at the Monash University Museum of Art in 2005. The exhibition aimed to present architectural space as an alternative to the common tactic of exhibiting architecture through photos of buildings on the wall. It was achieved by commissioning each of the nine practices involved to produce a ‘pavilion’ that would explore the history of pavilion architecture as exhibition itself. The concept for the project was driven by Tim Black, one of the directors of BKK, whose interest in ‘pure’ form and geometry led us to explore the singular architectural and structural solutions that are so common in pavilion designs for world fairs and expos, namely the single idea or gesture, continuity between wall and roof, and an integrated structural solution. Buckminster Fuller’s geodesic U.S Pavilion designed for the 1967 World’s Fair in Montreal [Figure 54], and more recently, Toyo Ito’s Serpentine Pavilion of 2002 [Figure 55] were cited as key precedents exhibiting these properties.

Figure 54: U.S Pavilion, Buckminster Fuller, Montreal, 1967

Figure 55: Serpentine pavilion, Toyo Ito, London, 2002
The design was created using an explicitly defined series of geometric operations resulting in a cube of folded cells converging upon a centre point. The series of operations to create the working digital model are explained in detail in section 5.5 on ‘re-folding complexity’. What is critical to this discussion of ‘closing the loop’ is that each of these steps is parametrically linked to the others, for example, the cutting templates are updated automatically when the overall form is modified, negating the labour needed to update them manually. This integrated system allows knowledge of the materials or form gained through the design process to be fed into a looping cycle to inform the next iteration or prototype.

This potential to input knowledge into the production loop was implemented between the development of the 1:10 scale prototype and production of the 1:1 scale completed pavilion in response to how the pavilion was to be exhibited in the gallery. It was decided that the piece would be suspended from the ceiling allowing the audience to duck underneath it and experience the interior. The point of convergence – which for the prototype was located in an upper corner of the cube [Figure 56] – was moved to a position lower down and centred, allowing the viewer to position their head at this point of convergence [Figure 57].

When viewing the piece from this point, only the cell edges are visible, rendering the piece as a net devoid of depth, reinforcing the projected nature of the design [Figure 58]. As the centre point—and indeed the entire model—was parametric, this late change did not require significant additional work as all the unfolded profiles were parametrically linked to the 3D model.

One way to illustrate the efficiency of this closed loop strategy would be to document this (twice) using a set of traditional 2D plans, sections and elevations and compare the time it took to do so. Not only would it be extremely difficult to calculate accurately the positions of the complex geometry manually, these drawings would not communicate enough information to construct the piece. The parametric approach exploits the internalised operations of the software, so that the designer is not exposed to the geometric mathematical complexity of the project, but is free to compose the process and manipulate the higher-level parameters that influence the outcome. As this design is the result of an integrated 3D process it requires a customised approach to communicating this information.
Figure 56: 1:10 scale card prototype with the centre point located in the top corner of the design

Figure 57: Completed pavilion with point of convergence located at the audience’s viewpoint

Figure 58: Interior view of pavilion taken from the point of convergence
4.2 Deferred decision designing

Deferred decision designing is a strategy for extending the design process further into subsequent stages of production to enable the new knowledge and feedback from these subsequent stages to inform the design. It is similar to a ‘closed loop’ process, except it sits within the standard sequence of project phases that are native to the architecture and construction industry.

The relevance of this strategy is in its ability to extend the time available for design. Design is often frozen at a point from which the scheme is taken through a series of stages of increasing resolution. The problem with this is that often design decisions are made early, before more complete information, including cost, site conditions, structural requirements, feedback from builder, etc. is available. The introduction of this information inevitably requires the original design to change, triggering a series of revisions downstream through the subsequent stages. Setting up a project in a way that acknowledges the inevitability of this increased information can enable design changes to be made without costly and time-consuming revisions to the downstream documents.

John Wardle (2001) describes a technique of “stretching design time” as a means to “maintain control, authorship and consistency within the complexity of the office environment”, whereby the initial design intent is left intentionally fuzzy, allowing the “sporadic intervention [of] the design author.” While the concept of stretching the design phase here is the same, Wardle employs ambiguity rather than specificity as the operative tool. Deferred decision designing as described here attempts to offer a complete – yet inevitably incorrect – version of the design proposal at a very early stage in the design process. This resolution allows issues to be clearly and accurately identified by the other team members and stakeholders and for feedback to be introduced into the design. In order to achieve this, it requires the project to be set up with significant rigour, employing parametric design rules (as described in section 2.2) that can be modified throughout the process.
Deferred decision designing lies closer to what Burry (2006, p.52) views as the “acceleration of the normal change-represent-reflect-communicate cycle.” Using the example of the Rose Window in Antoni Gaudí’s Sagrada Familia, which Burry and his team designed and fabricated, he describes a process whereby “as site circumstances become inevitably better understood during the construction process, adjustments can be made to the parametric model accordingly, giving greater accuracy and precision to building information.” Here, parametric software and proxy design information enable the design process to be extended into the construction phase, to be tweaked and refined as more information becomes available.

This strategy was implemented in practice on the first case study project undertaken as part of this research; a pergola designed in parallel with the renovation of a house in the Melbourne suburb of Elwood. The pergola design sought to respond to a range of requirements posed by its function and the immediate context, including visual screening of a block of flats opposite, shading from the sun of varying densities, protection from weather, and to open the house interior to the outside. The design began with a simple folded paper model that was overlaid on the site plan. It sought to respond to the above requirements by folding down in places to block views and opening up in places to admit light into the house.

While very simplistic, the material properties of the paper placed useful limits on the formal possibilities and implied a basic formal language, resulting in a form composed of flat quadrilateral and triangular surfaces. In addition to this language imposed by the material, there were a number...
of underlying intuitive rules which also contributed to the composition. These included the location of surface corner points relative to the length of an edge, an overall symmetry and a similar fold angle between adjacent surface planes. With the intention of rebuilding this model digitally using parametric software, it became necessary to declare explicitly these underlying compositional relationships that had governed this intuitively created model. Figure 60 is an idealised, abstract version of these relationships.

One particular challenge in the translation of this physical model into a digital one was encoding the material properties of paper into the parametric structure. Constraining a surface to a single flat plane is intuitively simple in physical space, but to rebuild these forms in digital space requires a more rigorous approach, as the computer does not distinguish between flat and curved surfaces unless specifically directed to do so. In a manner seemingly inverse to the intuitive folding of paper, defining a planar polygon parametrically requires the trigonometric calculation of corner and intersection points in advance of drawing the surface itself. While the mathematics required is managed by the computer, the system of relationships need to be defined manually inside the parametric model.

These compositional parameters restrict the potential forms created, placing useful limits that are central to deferred decision designing as a strategy, and indeed parametric design in general. While the extent that a parametric model may be modified is only limited by the structure adopted by the user when building the model, the possibilities are most likely to be different by degree, not of
type. For example, it is possible to alter parametrically the form of the pergola within its general configuration and encoded formal language by changing its overall size or angles between planes, but not to turn the pergola into a freestanding gazebo. This limitation on what the design can become has implications in practice for how this strategy is integrated into the traditional phases of a construction project. As long as the design remains roughly the same, the engineering will not need to be dramatically recalculated, material quantities or construction quotations will not be affected and planning approval will not need to be revised or sought again; all factors which can importantly effect the cost and timeliness of a project. In this case, what can be modified are the finer details of the stated purpose of the pergola: to shield from views, to protect from weather, and to open up the house.

Key to the success of this approach was the collaborative relationship and trust between the architects, clients, and builder. From the outset we engaged a builder with whom the practice had developed a productive relationship by working on similar scaled projects. With the indicative parametric model in place, the specific height and angle of the pergola, the spacing of the timber battens, and the location of the columns were calculated on site in close consultation with the clients and the builder. The parametric model was then adjusted and the associatively linked

Figure 62: Construction of pergola on site
documentation updated accordingly. This documentation is explored further in the following section on ‘hand-made digital fabrication’.

In reference to the title of this research, this strategy literally expanded design further into the production phase through a ‘stretching’ of design time using parametric techniques to refine a proxy model based on a rigorous formal language. Importantly, this technology served the social aspects of the project. The digital encoding of this formal language enabled the complexity of this approach to fade into the background, avoiding interference with the collaborative decisions made on site.

### 4.3 Hand-made digital fabrication

![Figure 63: Translation from a physical model, to a scanned-in digital model to a re-constructed physical prototype of the ice cream lamp project](image)

Hand-made digital fabrication is a hybrid approach to communicating designs for construction that leverages the advantages of digital fabrication and traditional craft skills. All of these strategies are exploited for their strengths. Hand-made craft skills are employed where an intuitive understanding or physical connection with the material is required, and digital techniques are used to augment this craft-based approach by re-purposing this information for analysis and manufacture.

Hand-made digital fabrication is made viable by the increasing affordability and availability of CAD/CAM equipment. No longer just the domain of large-run manufacturing, it is now within reach of producers of small-run custom objects, including, notably in this case, the small practitioner. In small practice, with correspondingly small budgets and small builders, it is often unfeasible to have access to these manufacturing machines on a small project. Whilst a lot has changed and continues to change since this case study was undertaken in 2005, it still remains largely true that while architects may be very ‘tech-savvy’, many small builders are not. In addition, employing CAM can overlook the potentially valuable resource of established craft skills of the small builder. Thus in order for these small, accurate, complex projects to proceed, ways of working
around these issues are required. The broader impact of CAD/CAM on practice is discussed further in section 3.3.2.

Two examples of the application of ‘hand made digital fabrication’ at significantly distinct scales are demonstrated here through the case study projects. The first is a prototype lamp produced for the ‘Lightcycle’ sustainable lighting design competition by the collaborative team of visual artist Tai Snaith, Simon Knott of BKK Architects and myself. Titled ‘Slow-Motion Catastrophe’, the concept was to produce a lamp in the shape of a melting ice cream as a visual reminder of the relationship between electricity consumption and global warming.

Unlike other projects described in this chapter which have been designed intentionally and precisely through digital means, the complex and somewhat unpredictable material transformations of a melting ice cream elude a calculated approach. While high-end software of the animation and film industry can be used to simulate melting in the 3D space of the computer, we opted for a more analogue approach by building a model out of plasticine [Figure 64] based on observation of the real thing.

This physical model was then imported into the computer using a high-resolution hand-held 3D scanner available at the university [Figure 65]. The cumbersome file size of the resulting mesh, and the inaccuracies of missing information in difficult to scan undercut zones [Figure 66], required the manual rebuilding of the object in the CAD program Rhino. A careful attempt was made to retain the imperfections of the physical model in this translation so as not to lose the handmade quality. Additional detail relating to its function as a lamp, including space for the fitting, the cable, the ability to change the globe were also added at this stage.

This streamlined model could then be used as a reference for the production of 2D templates for laser cutting. This requires the repeated sectioning, numbering and laying out of each layer of the 3D form at intervals equal to that of the material thickness. A set of scripts (see appendix 7.2.1) were written for Rhino using the ‘RhinoScript’ Visual Basic scripting plug-in to automate this process, an approach ideally suited to the repetitive nature of the task. Scripting this process enabled different options including material thickness, section angle and the associated resolution to be tested virtually. Once a satisfactory set of templates had been produced [Figure 67], they were cut out of coloured Perspex and numbered using a hobby-scale laser cutter at the university [Figure 68].
Figure 64: Original plasticine model of ice cream lamp

Figure 65: Scanning plasticine model using handheld 3D laser scanner

Figure 66: Screen grab of model scan

Figure 67: Layed-out templates prepared for laser cutting
Figure 68: Cutting templates using hobby laser cutter

Figure 69: Assembling 2D templates by hand

Figure 70: Final model with light fitting
In another return to the craft-based production methods, these templates were then glued, aligned and stuck together by hand [Figure 69].

The completed object retained the qualities of the different steps of this process. Although it had been produced using high tech methods of scanning and cutting, the imperfections derived from starting with a physical model and assembling it by hand lent the final product a ‘crafted’ and more personal quality which is arguably more often absent in purely digitally produced projects [Figure 70].

The second case study project that implemented this approach was the pergola project introduced in section 5.2. Initially the design of the pergola was communicated to the builder using traditional plans, sections and details, albeit derived from a parametric model [Figure 71].
However the complex folding planes of the structure resulted in compound angle junctions between the timber batten cladding [Figure 72], which proved difficult for the builder to calculate manually. This issue resulted in the schedule for the pergola being significantly prolonged, compounding the cost and testing the patience of the client.

Figure 73: Unfolded paper template showing cutting angles, part numbers, alignment registration arrows and the distance to the next cut

Figure 74: Paper template wrapped around timber
In response to these difficulties, a system for communicating cutting angles in a manner useful to a builder on site was undertaken retrospectively. This system was based on the automated generation of paper templates that could be wrapped around the piece of timber to be cut, dictating the cutting angle and distance to the next cut. The cutting angle is represented by a line that can be traced, and by the angles written in degrees in both plan and elevation corresponding with the angle settings on a regular builder’s drop saw [Figure 73 & 74].

These paper templates offer a clear illustration of how the system could operate. However, the ability to accurately set the angle of a saw in 3 axes effectively supersedes their use, as the same outcome could have been achieved with a spreadsheet of 4 columns: the batten number; the cutting angle in plan; the cutting angle in section and the distance to the next cut.

The strength of hand-made digital fabrication as a strategy is that it acknowledges the complexity of our increasing relationship to technology. Despite the claims made for CAD/CAM being able to supplant the construction skills of people, the architecture and construction industry remains largely dependent on the manual labour of builders who have limited technical expertise to accept or coordinate digital information. Rather than viewing this as a hindrance, as the pergola example shows, hand-made digital fabrication can integrate the craft skills of this sector with emerging digital design processes, representing a positive extension of the role of the small builder. While one might expect automated manufacturing of building components to pose a threat to the builder, even CAD/CAM components require manual assembly on site. Therefore, it is anticipated that small builders will encounter this hybrid approach more frequently and continue to employ their skills in bringing these components together.

Figure 75: Photo of completed pergola
4.4 Design as a goal-oriented experiment

This strategy is a script-based approach combined with an evaluation process for refining a design concept toward a desirable—but as yet unknown—outcome through a series of experiments.

Similar to parametric design, scripting enables numerous variations of a design to be explored simply and rapidly. The open-ended nature of script-based designing is highly conducive to continuous revision and extension of a design. ‘Design as a goal-oriented experiment’ exploits this open nature in a continuous cycle of writing code, executing code, reviewing results and repeating; incrementally converging upon an acceptable outcome. This approach can be viewed as a digitally augmented version of the traditional ‘trial and error’ approach discussed in section 2.3, whereby successive iterations are produced and evaluated in the process of design refinement. Apart from the efficiency gains achieved by engaging the computer in this process, scripting offers the possibility of producing surprising and unexpected results.

Its implementation in a real project for the design of freeway soundwalls by BKK Architects illustrates this approach. The technical complexity of the project necessitated a large number of stakeholders and specialists assigned by the client, each bringing their own particular expertise and requirements. Figure 77 illustrates these various parties, their different roles, and the paths of communication and negotiation between them.
Feedback from this collaborative network steered or limited the possibilities, and largely dictated our initial approach. The key aims of this project was to provide a visually appealing set of walls that achieved the required sound absorption as dictated by the road authorities. The main parameters informing this outcome as determined from the preliminary meetings with the clients and consultants were: 1) that as much of the fabrication as possible occur off-site to avoid the need to block traffic; 2) that significant savings could be achieved by developing a repetitive system; 3) that the required height of the walls be adhered to; and 4) that the panel widths be based on standard material sheets to avoid wastage.

The design concept of 'pleating' was established by the directors, a decision informed both by an intuitive response to the site, the practical constraints outlined above, and the project budget, as it could potentially offer a complex formal language comprised entirely of flat panels. Folded paper models [Figure 78] were developed in parallel with manual 3D modelling to explore the range of possibilities offered by this language, and as a means to compile the geometric parameters.

These parameters were then used to inform a script (see appendix 7.2,2) which took numeric values for each of the geometric parameters [Figure 79] and generated pleated panels in 3D space using a series of modelling operations and transformations.
Quantifiable requirements as determined by the network of collaborators above were built into the script as bookends to the design space, so that only possible solutions would be explored. Performance parameters of the walls generated by the script were also delivered as outputs which could be used to aid evaluation and to compare the success of particular configurations [Figure 80]. These performance criteria included the amount of material used, the efficiency of the material use compared with a flat wall, and the number of panels used to make up the wall. Experimentation subsequently occurs within this design space as a goal-oriented experiment informed both by the range of possibilities and output properties.
Through experimenting with the script – or learning to ‘play’ it – a system that used identical panels was developed that would still give the effect of compression or expansion just by incrementally varying the spacing of the structure behind [Figure 81]. This repetitive and yet customised design has implications for the efficiency and economic viability of constructing the project. This idea is explored further in section 5.5 ‘re-folding complexity’.

In terms of the design process, the incremental modifications and experiments with the script produced an outcome that built upon the successive amounts of knowledge and experience gained throughout the process.

Unfortunately, the amount of time and research dedicated to this project was largely wasted. Due to constraints of cost the pleated design was not built as the client opted for a much simpler design.
Despite support and confidence from the consultant team to build the apparently geometrically complex, yet underlyingly simple wall within the given budget, it was the appearance of complexity that ultimately resulted in the client’s selection of a simpler design.

Perhaps this reflects a failure on our behalf to communicate the project effectively to the client, I don’t believe it refutes the usefulness of this design strategy in general, but merely reflects architecture’s exposure to larger forces of will that cannot be controlled, but can only be responded to as intelligently as possible (Till 2009).
4.5 Re-folding complexity

'Re-folding complexity' is an integrated design approach to the rebuilding of complex 3D designs using flat material. The promise of digital fabrication to enable new complex 3D forms to be designed and constructed has yet to overthrow the construction industry’s dependence on flat sheets. Despite emerging machinery that can accurately produce 3D parts and components from 3D information such as multiple axis-mills and digital printers, even formally-complex architectural projects remain dependent upon very elemental techniques such as stacking and slotting (Kolarevic 2003).
Stacking consists of slicing up a complex shape in the computer, laying out these resultant slices, cutting them out, and stacking these pieces up. If the intervals between the slices are equal to (or proportionate to) the thickness of the material from which the object is to be constructed, a scaled physical version of this digital model is re-created. These contour layers may then be sanded back to approximate the original smooth surface. The ice cream lamp described in section 4.3 previously is an example of this method of construction.

Slotting is similar to stacking in that it begins with a complex shape in the computer that is sliced up to produce templates for a physical version. It differs by slicing the shape in (at least) two axes with a spacing between the slices, forming an open framework of intersecting 2D templates which can be notched and slotted together to approximate the original 3D form.

To these techniques, may be added a third: re-folding. Unlike stacking or slotting, which can be applied retrospectively to almost any free-form shape, re-folding needs to be anticipated as the intended means for fabrication in order that the logic is embedded into the digital model itself. The integration of fabrication information into the design represents a step beyond the often arbitrary post-rationalisation of complex form seen in the above examples of stacking and slotting.

Continuing from the process briefly described above in section 4.1 ‘closing the loop’, re-folding was key to the construction of both the prototypes and final piece of the pavilion project. Central to re-folding complexity as a strategy is the controlled development of a system of templates. The first paper prototype could be described using a simple set of 5 templates, which were repeated at
different orientations to form the entire 3D object [Figure 87]. These templates were assembled using a ‘zig-zag’ pattern, whereby the templates run lengthwise; every second flat surface being shared with a neighbour.

Figure 87: Complete set of 2D templates for the paper pavilion prototype 1

Figure 88: Paper pavilion prototype 1

The simplicity of this system of templates was enabled by the point of convergence being located at the exact centre of the cube, producing a regular structure with a large number of repeating elements [Figure 88]. By contrast, the second prototype was developed to allow an eccentric point of convergence, resulting in a set of 160 individual templates [Figure 91], requiring a fundamentally different approach to managing this information. The digital model was rebuilt parametrically using the software CATIA. As this digital model would be used to generate directly the templates for the final model – a closed loop strategy – the construction of this model needed to embed the anticipated method of construction within its structure.
This requirement has implications that extend right from the initial planning of the model, or the "metadesign" (Burry 2003, p.151). It was built using a rigorous series of steps, with each decision made at the start of this procedure impacting on the subsequent steps. As is illustrated in Figure 89, firstly, the geodesic structural pattern of a Fuller dodecahedron was located in 3D space, with each honeycomb cell being constructed as a hexagonal loop of straight lines (1). Each of these cells is then projected to a centre point located within this sphere, resulting in a set of joined surfaces converging on a single point (2). These surfaces were then trimmed against an inner and outer cube, producing a visually and geometrically complex hollow cube of closed honeycomb cells (3,4).

![Geometric sequence diagram for pavilion prototype 2](image)

**Figure 89: Geometric sequence diagram for pavilion prototype 2**

Within this rigorous metadesign, flexibility was introduced in the form of independent parameters. These parameters governed the key geometric relationships of the design, and could be modified to adjust its overall size, wall thickness and the position of the central point of convergence. Positioning this point of convergence at the centre of the work produced the same regular form of the paper prototype, while moving this point caused each cell to be unique [Figure 90].

![Complete set of unfolded and nested 2D templates for pavilion prototype 2](image)

**Figure 90: Complete set of unfolded and nested 2D templates for pavilion prototype 2**
For the construction of the prototype, these 2D profiles were cut out of card using a laser cutter [Figure 91]. Two cutting 'layers' were used, the first was half-power – cutting through only half the material – to produce score lines and numbering, and the second was full power, cutting right through the material to form the perimeter shapes. These 2D card profiles were then re-folded into 3D cells and nested together to form the 1:10 scale model [Figures 92-93].
Having tested the reliability of this digital model and the ability to accurately derive templates from it, we set about scaling it up for building the final exhibit. The ability to refold card along score lines without breakage may seem obvious and mundane, but is a rare material property in a construction industry which largely depends on rigid flat sheets and solid compressive material. While there are other materials, including thin metals, Perspex and polypropylene that share similar properties, it seemed consistent while scaling up the digital model to also scale up the original material. For this reason, card was also chosen for the final work, albeit much thicker at 2mm.

However, scaling up a digital model can have different implications when translated into the physical world. A different strategy for fixing would be required to withstand the much greater weight and the associated possibility that at this scale the card would crumble and break when scored. As a proof of concept, we built a small cluster of cells [Figure 94] and experimented with 3 fixing techniques: industrial staples, glue, and double-sided tape. Each of these fixings was then very unscientifically subjected to being pulled apart by two staff members, with the double-sided tape being both the strongest and least visually intrusive.

Despite the rigorously technological approach to designing the piece, investigations into the possibility of laser cutting the full-scale templates indicated that large sheets of card would have to be cut on a larger, more powerful machine, which even at its least powerful setting would ignite the material. Due to this, in addition to the limited budget allocated for the exhibition, we opted to print the templates onto paper, fix these to the card, and cut and score each laboriously by hand [Figure 95-97].
Failing to produce this computer aided designed project with computer aided manufacturing, should not be viewed as falling short of our aims. The strategy would not have been possible without the software-side tools developed for preparing geometry for CAM machinery; namely the ‘unfold surface’ tool which is built in to many new 3D software packages. We merely substituted the efficiency and power of a laser cutter with the hand, still mechanically following the same instructions.

A key intention of the exhibit was to express a dialogue between the very complex and the very simple, which was successfully interpreted by reviewers in the media. Karen Burns (2005, p.66) states “In an era of head-line grabbing buildings, of ‘non-standard geometries’ rendered in biomorphic or organic forms (a category of architectural special effects), it is interesting to note that a building of roughly orthogonal proportions can contain and derive its tension from the interplay between a square format and other kinds of surface/geometric gymnastics.” Similarly, Norman Day
(2005) summarised the piece as “a plastic form that describes order in chaos.” In both instances, this interplay between complexity and simplicity is successfully conveyed. I would argue that re-folding as a strategy is consistent with this approach. Quite literally, the process of unfolding the very complex individual cell shapes into 2 dimensions simplifies them, and enables them to be produced by 2D means, in this case either with a laser cutter or by hand. In addition, the cellular nature of the re-folded templates is a very efficient distributed structural network. Even though each version of the pavilion was made of lightweight paper or card, it was able to retain its shape due to the internal balancing of compressive and tensile forces, which are shared in all directions.

Evaluating this refolding strategy more generically, beyond reference to the pavilion project, the first key advantage is cost effectiveness. While fully 3D fabrication techniques exist, these systems require large amounts of material and have yet to challenge the economic advantages of flat sheet construction methods which continues to define the construction industry. This use of flat sheet material is also simpler to manage and manufacture.
Further, the act of re-folding 2D templates helps to conceal the means of construction. With a stacked or slotted approach, the construction method contributes to the visual tectonic of the piece. While this is often desirable – as in the Ice Cream lamp project which uses the strata of material to evoke a sense of ‘melting’ – this process of construction is difficult to hide. When re-folding geometry, it is more difficult to trace the original shape of the templates when viewing the final piece. Thus, it represents an integrated approach to design and representation paired with simple and cost effective construction which does not restrict or diminish the effectiveness of the final product, characteristics central to the demands and requirements of small practices.

This project stands as a benchmark in the trajectory of the practice, with BKK Architects recently submitting a revised version of this exhibit to be exhibited in the Australian pavilion at the 2008 Venice Architecture Biennale [Figure 100].

![Figure 100: BKK’s model as exhibited in the Australian pavilion at the 2008 Venice Architecture Biennale](image-url)
4.6 Pleating as surface rationalisation

The term ‘pleating’ is used here to describe a scripted strategy for rationalising a curved surface into a composite surface of flat panels. This process of rationalisation ensures that the resultant surface can be constructed using flat sheet material. In this sense, the strategy, and the script tools it is based upon, act like an economic and constructional ‘safety net’ for formal experimentation. The ability to rationalise construction geometry down to flat sheets is a recurring concern of this research into expanding design in small practice.

Pleating is a term native to fashion design used to describe the folding of material often to allow for movement or expansion in a garment. There are examples where this technique has been applied on a larger scale in architecture, namely Renzo Piano’s IPE Factory in Genoa of 1968 which used a system of pleated panels to create an efficient curved arched hangar [Figure 102].
However, this example is based on a regular pleating pattern. Non-uniform pleating is more easily attainable on the intimate scale of clothing, as famously developed by the Japanese fashion designer Issey Miyake in his ‘Pleats Please’ range first produced in 1993 (V&A 2010) [Figure 103]. The strategy of pleating as surface rationalisation as described in this section seeks to explore the potential for non-uniform pleating on the architectural scale by employing computational design and manufacturing.

The strategy of ‘pleating as surface rationalisation’ was developed for the competition entry for a new gallery for the permanent collection of the Monash University Museum of Art in which BKK Architects were invited to participate following the success of the pavilion project that was exhibited by this same gallery. The designated competition site was the ground floor of a 1960s Modernist office slab block clad in a repetitive glass curtain wall system [Figure 104].
The brief called for the new gallery to form a signpost to attract visitors and to announce its existence in what is a less prominent building on Monash University’s Caulfield campus. Two distinct architectural responses to this condition existed in contemporary projects adjacent to the competition site. Lyons Architects’ new entry and foyer space to the School of Fine Art to the east introduced a singular foreign element in the form of a large yellow tube as a way of signposting the new building. In contrast, Denton Corker Marshall’s School of Art and Design to the west replicated the existing curtain wall condition, albeit more delicately. We were interested in a third, more sensitive approach to engage the Modernist repetitive language of the existing condition. We sought to deform the 1960s curtain wall, by gently pulling it apart to create a new entry and pleating it with non-uniform language that might better represent more contemporary architectural concerns.

This was achieved using a script-based procedure (see appendix 7.2.3) for generating the new form as illustrated in Figure 105. The mullions of the existing building were located in 3D space (1). Then the proposed walls that define the new spaces and circulation were added approximately using free form surfaces manually created by the intuitive process of pushing and pulling surface control points (2). This free-form source surface is then ‘pleated’ using the custom script. The script locates a number of points along the U and W isocurves of the surface corresponding with the spacing parameters input by the user. Flat triangular surfaces are then added in a cycle between these corner points producing the rationalised pleated surface (3). As this pleated surface extended beyond the bounds of the interior, it was then trimmed against the model of the building (4). Structural mullions were then added to this trimmed model of the pleated panels (5) which lined up with the existing mullions of the original 1960s façade (6).

Figure 105: Steps in scripted process of manipulating existing curtain wall with new pleated elements for the Monash gallery project
Like ‘design as a goal-oriented experiment’ (see section 4.4), the starting parameters of the script (as well as the input surfaces in this case) are modified to produce different outcomes which are subsequently compared and evaluated for their success. Developing a system for the evaluation of these options is key to the usefulness of this strategy. Evaluating a soundwall is relatively simple as it serves a very explicit function to dampen sound. In addition the material required offers a quantifiable measure for evaluation. In this example the only real requirement was to create a new identity for the gallery, a qualitative and difficult aim to measure. In an attempt to make the otherwise highly subjective process of evaluation more rigorous, a number of cameras were set up in the model at the key views of the project; the appearance from the library opposite, the main entry space, the gallery space and the view from traffic on the adjacent main road. Renderings of the different outcomes of different starting parameters were taken from these same vantage points and compared and discussed in the office to decide upon an appropriate density of pleat and material quality.

The final scheme was selected because of the way it integrated with the existing building façade. Horizontally, the diamond shapes of the pleated pattern neatly stitched into the spacing of the mullions, and vertically the transition from flat glass plane to dynamic curved element appeared seamless. The qualitative system of evaluation was central to this decision.

Figure 106: Rendering of final proposed scheme for Monash gallery. Dandenong road elevation, far
Figure 107: Rendering of final proposed scheme for Monash gallery. Entry space

Figure 108: Rendering of final proposed scheme for Monash gallery. Dandenong road elevation, close

Figure 109: Rendering of final proposed scheme for Monash gallery. Courtyard and main entry
In an effort to convince the competition jury that the complex façade could be fabricated easily and efficiently, a number of scale models were made. The production of these reveals various methods of how the 3D pleated geometry could be translated for construction, albeit at a small scale. These translation techniques were developed by the author specifically in response to the geometry of pleated surfaces, which, unlike simple folded surfaces, are made up of panels folding in alternating directions. Conventional surface development tools available within modelling software (such as Rhino’s ‘unfold’ command) can typically only manage surfaces that can readily be developed, such as ruled surfaces or simple folded surfaces. The faceted surface produced by the pleat script was neither, consequently we researched other options and were directed toward the Japanese ‘Pepakura’ (2006) program, which judging from the online gallery is used typically for creating templates for paper monsters and robots from 3D files. By inputting a single joined surface, the software flattens the geometry, automatically producing score and fold lines, removes components that would otherwise obscure other pieces and numbers adjacent edges.

The template for the 1:20 card model was produced using this method [Figure 110], which was then cut out of card and re-folded manually [Figure 111]. The strength of this method is that it allows scale models to be produced easily, however this is also its limitation as it is not applicable at the scale of a building where each surface would have to be treated individually with allowances for framing and structure.
In an effort to understand the constructional reality of this complex structure more fully, a larger 1:10 model was produced that used individual panels as opposed to a continuous surface cut from one material. A custom unfold surface script was written that runs sequentially through each of the individual panels generated by the pleat surface script, laying out each panel and automatically adding numbering and tabs [Figure 112]. The script also numbered the source 3D model as a reference diagram for subsequent assembly. These panels were then cut and scored with a laser cutter and assembled by hand [Figure 113].
This individual panellised approach more closely resembles the actual fabrication process of a pleated surface such as this. Although more work would be required to integrate this approach with the supporting structural system, it represents a key step for the practice in engaging directly with means of fabrication and the expertise to follow a project right through from design to construction. This technological ability is a critical advancement in the recasting of the architects’ role in the production process, which – as is explored further in section 3.3 – has the potential to produce new forms of practice.

For the final model we also experimented with stereolithography, a form of rapid-prototyping that produces a physical model from a digital 3D file [Figure 114]. Although this method was arguably the most accurate – as the card models previously discussed were prone to distortion – BKK and myself did not view this as contributing usefully to the project. Although it is revealing from an aesthetic perspective to be able to extract a digital model and view it in real space (especially for a client not accustomed to reading drawings), the process of laser accretion is so abstract and unscaleable compared to the reality of building that this process did not reveal anything new about how this project might be constructed.
In summary, the importance of ‘pleating rationalism’ as a strategy, and its associated surface development scripts, is the ability to reconstruct a complex arbitrarily curved surface out of flat material. Arguably this could also be achieved by using ‘meshing’ tools available in most 3D software, however the algorithms underlying these commands often result in an arbitrarily subdivided surfaces that are difficult to control. The pleated surface, as created by the controllable custom script, has a level of rigour that was particularly suited to the above example where it is grafted onto a rigid and uncompromising Modernist façade.

Another key aspect of this strategy is that it is script-based. Unlike parametric models which need to be structured carefully from the ground up, such as those developed for the pavilion project, scripts are inherently more open-ended and more easily applied on other projects. Thus although we did not win this competition, the scripts developed through the project are added to the incrementally expanding code library or generic toolkit, waiting to be revived for another proposal. One such project was the collaborative bid for the creative director position of the Australian Pavilion at the 2008 Venice Biennale. The ‘pleat surface’ script was again deployed, this time to create a temporary cardboard skin that re-clad the existing pavilion and formed a continuous projection surface for the interior [Figure 115]. The project is discussed in further detail the following chapter.
4.7 Summary

Working in a small and technologically enabled practice context has undoubtedly informed these design strategies and the approaches taken in these projects. The strategies discussed in this section inherently address the needs of small practice as they have been developed within a small practice, responding to the issues encountered while working with small builders and have been developed within the deadlines and pressure of these small projects. But aside from this relevance derived from the context, a number of recurring themes run through these strategies and projects could be characterised as specifically relevant to expanding design in small practice in particular: the integration of design and construction information, the expansion of design time, the use of flat sheet material to describe complex form, the embedding of design knowledge in explicit procedures, and the expansion of trial and error.

Integration of design, representation and construction information has the potential to open up new territory for small practices. As demonstrated by ‘closing the loop’, using parametric design to embed the information for the entire process from design to final product in a single model minimises translation errors and additional drawing time. While this is a strategy that could be deployed by a practice of any size, it is especially beneficial for small practices as the technology can be used to internalise the complex geometry and information management role that would ordinarily require a larger team to coordinate, thereby placing such projects within the reach of practices with limited resources. A clear demonstration of ‘punching above your weight’.
The expansion of design time, from sketch, through design development and into the construction phase – as enabled by ‘deferred decision designing’ – is a strategy that is arguably only possible on a small project. There are a number of reasons for this. Large projects typically are composed of numerous interrelated parts contingent upon each other for their coordination and assembly. And all but the very smallest projects need to be tendered, which requires the design to be highly resolved, with subsequent changes incurring extra construction charges. By contrast, on small projects it is often possible to negotiate a contract directly with a builder, facilitating a more collaborative relationship that allows additional or changed information to be integrated and resolved directly on site. This strategy offers a distinct advantage to the small practice and the small builder that can enable better design outcomes and a less adversarial process.

The use of flat sheet material to describe complex 3D geometry is another recurring theme throughout the strategies described here and through the research more broadly. It responds to an issue identified very early in the research, that despite an architects’ ability to produce complex 3D forms in the computer, the construction industry remains largely dependent on flat sheet materials. This stood as a critical bottleneck between the proposals we could produce on the screen and what we could build in reality. ‘Stacking’ and ‘slotting’ are identified as existing common methods for addressing this issue, to which this research contributes ‘refolding’ and ‘pleating’ as demonstrated by the pavilion project and the Monash gallery competition entry. These techniques are particularly relevant to small practices, as they frequently work on small projects, with limited budgets. The techniques of ‘refolding’ and ‘pleating’ rely upon software to calculate the most complex transformations for developing surfaces and templates, producing highly accurate sets of components that can be assembled easily by any builder regardless of their skill with technology or access to expensive CAD/CAM equipment.

Relying upon software to perform complex geometric procedures not only benefits the builder, but also the designer. Emerging parametric design software and, to a lesser extent, scripting methods, conceal the complexity of geometric form and transformations from the user. This enables the development of libraries of tools that can be used easily by others in the office, not only by their creator. Encoding these techniques in a library poses a radical challenge to practice knowledge structures, as an individual’s skill can be encoded and shared. This creates opportunities for small practices in particular, as the ability to share knowledge releases the physical dependence upon a particular team member, opening up new possibilities for informal coalitions and networked practices, as discussed in section 3.3.5.
Beyond their specific purposes, what is common throughout all the design strategies discussed in this chapter is that they engage technology to automate a task or encode knowledge of a procedure. This procedural approach is a fundamental aim of this research into design strategies, as it opens up a space for testing designs that would ordinarily be occupied by manual labour. These tools and strategies now allow designs to evolve and develop easily in a manner that can keep pace with the conversation in practice and can be tailored specifically to the design problem at hand, thereby enabling practices of limited resources in particular to test designs more thoroughly and easily by automating this trial and error process.
Chapter 5. Interview: Structures for expanding design

Where Chapter 4 presents the case studies of where digital design strategies have been applied on real projects in the partner office of BKK Architects, this chapter presents the impact that this work has had in the practice itself, and how it has influenced the organisational structure. This is where the two parallel aspects of this research – design strategies and organisational structures – hit the ground.

Its main body is comprised of an interview conducted with the 3 partners of BKK Architects – Tim Black, Julian Kosloff and Simon Knott – at the conclusion of the Embedded Practice research program in November 2008. It extends the research of the literature in Chapter 3 by examining how organisational principles are deployed in the real context of practice as a means of expanding design. I have chosen to present the interview in its entirety – without editing or highlighting passages – primarily because the content is already clearly directed to the purpose of this chapter, and secondly to let the directors’ voices and perspectives speak for themselves.

The central aim of the interview was to capture a snapshot of the current state of BKK Architects. Key themes discussed are: the practice size and its organisational structure; the directors’ attitudes and approaches to ways of working, including collaboration, staff autonomy and management roles; methods of information sharing and communication within the office and with collaborators and consultants; how the practice is positioned within the broader design community as part of a creative network; and the relationship between design strategies and the practice aims. The chapter summary will revisit each of these ideas, reflect upon them, and locate them in context with the literature explored in Chapter 3.

5.1 Interview with partners of BKK Architects, November 2008

Rory Hyde: Just picking up from the last interview [in October 2006, see appendix 7.1], we discussed the idea that bigger practices suffer under their size, and that you were interested in keeping a studio atmosphere but still doing the bigger projects. How has that outlook changed now that the practice has expanded in size?
Simon Knott: The practice has certainly changed in size, but I think we're at the size we wanted it to be when we spoke to you last.

RH: How big is it now?

Julian Kosloff: Fifteen, well fifteen when Lauren gets back next week [Figure 116].

SK: The practice has started to get to a good mass where there's still the three of us, and we're working with small teams within the office, so there's still a collaborative environment, but it's big enough where we can move stuff around and switch between jobs; you're not just dependent on one job in the office. People often say to us that around fifteen is the ideal size, I remember JCB [Jackson Clements Burrows Architects] saying they made more money when they were fifteen people than they do now they're twenty-five.

Figure 116: Revised BKK practice network diagram, 2008. Refer to introduction for original
RH: So it settles in at that scale?

SK: Well it’s good with three directors, because there’s three of us and then five staff each almost. I think the structure we’re at now is good, where there’s three directors, one senior staff member each, then Stephanie as office manager who can flip around and do a bit of everything, and then all the people working around them and switching around depending on where the jobs are at. And that feels pretty good as a model. The latest submission we did we started looking at how we might team up with some larger practices, to be able to do bigger scale work without taking on more staff, and particularly in this current [economic] climate, I think you’d be pretty unwise to take on more staff.

RH: And how have your roles changed? Have you assumed a split of responsibilities?

JK: I think our roles have changed as since there’s a bigger pool of staff to draw on we can play a management role a bit more easily than perhaps previously when we’d be running around doing tasks ourselves, which in an ideal model isn’t effective for us to be doing. And I think partly the growth of the office has allowed for a lot more specialisation; we’ve been really careful in the way we’ve selected staff based on their skills and how they might plug into the rest of the practice. We’ve noticed a huge difference in being able to shift people around dependent on the project.

RH: What do you mean by ‘specialisation’? Somebody who’s good at residential, or commercial, or detailing, or graphics?

JK: It’s partly skill based, well it’s partly experience based initially, so there’s an idea of what sort of experience level we need, but also it’s the sort of thing we were doing when you were here, where we’d take on people who have a cultural interest in architecture and that’s begun to feed back into the practice too. So not only their experience in terms of projects, but what they’re interested in or what they’ve pursued individually. And we’ve noticed that’s had a huge influence on the practice.

RH: Ok, I’m really interested in this idea that the staff might have an impact back on the practice, that it’s not necessarily a top-down directed thing, where you each have the ideas and determine the direction of the projects and dictate that down the line. How does that play out in the practice?

SK: I think it necessarily has to happen, unless we’re going to work 90 hour weeks or something, and get involved in every aspect, you have to let go, you have to let that stuff happen. I was thinking about this today actually, just on a house we’re doing, I’ve thought just to let it run a bit, and it gives people more confidence and a bit of licence.
RH: So it’s about autonomy?

SK: Yeah, I think Francine Houben from Mecanoo put it best when she said [at the 2008 RAIA conference] it’s like “steering a ship”, good ideas can still come from the sort of ‘lowliest’ person in the office, from a student or whatever, but you need to just push it in the right direction now and then. And I think that’s part of understanding the changing managerial role, is knowing when to step in a bit, saying “ok, let it run that way a bit”, then to push it back here, push it back there, and eventually it will come to a point where everyone is kind of happy with it.

RH: On that point, in terms of skills, how does that change the traditional apprenticeship model where you might bring someone in and train them up? I suppose that doesn’t change…

SK: Well it does, because you need people with good initiative, and people who can think for themselves, because if they don’t then they need to be told what to do. And we’ve noticed that with some staff we’ve had previously, where we’ve really had to sit down with them and say “you need to do this, this and this”, almost plan out the week for them, whereas we’d much rather have people who come in and just get the job done. And if you go down that path, you’ve got to expect that someone’s going to get lost now and then, or they’re going to go and do some stuff that’s not necessary, but I think if you give people a little bit of licence then generally they’ll get it right. And certainly that’s the experience we have in an architectural practice, is to give people a fair bit of licence to just go and play with stuff.

RH: Just back on this shift in scale, obviously the new office space is tangible expression of that. Has the new space changed the atmosphere or changed the way the practice feels or the way it runs?

JK: Initially it might have, until everyone had settled in, but we still do the Friday night presentations¹, pens down at 4.30 and somebody presents a project or somebody comes in externally or somebody might talk about a play they’ve been involved in, whatever – so I think that that’s tended to draw everyone together. But I do think that initially – and it’s interesting, staff actually raised this when we were doing staff reviews – there was definitely a sense of change from a setup
where just by the very fact that you're sitting so close to someone, you can hear their conversations and the transfer of information just naturally occurs. But now [since moving into the new office space, Figure 117] Michael is a good ten meters from where Bojana is, so he's not privy to those conversations. I think that's more of an adjustment than a problematic thing.

SK: Yeah quite a few [of the staff] were worried that we were starting to lose the 'studio', but I don't think that's happened, and it's actually been quite good.

JK: If anything it's made the office more efficient in the way we can transfer that information, so rather than just the 'eavesdrop' exercise, we've thought about how we might structure the transfer of that information. So again for example the Friday night presentations, it's far more effective to sit everyone down for an hour and hear about a project than it is to hear it through phone conversations.

SK: And I think its also changed a lot in it being an easier place to work in, you know everything is laid out properly and organised. We had gone from a space that had just evolved from the 3 of us with doors on Ikea legs and cables running everywhere to actually sitting down and thinking about how we wanted to plan out the space and have everything where it should be. And now we've got someone answering the phones and the first admin person we've had and a whole lot of support staff which means we don't have to do so much of the boring stuff we used to do.

RH: So does that organisation extend to the projects? Are the staff clustered into project teams?

SK: No, everyone just picked where they wanted to go.

JK: It's friend based.
SK: I think this Christmas after the clean up we’re going to shift people around a bit, so that it shifts the office around a bit.

RH: Females 2 seats to the left?

SK: Yeah, something exactly like that. Just so it shakes things up a little in the office and puts people next to different people and learning different things.

JK: I also think within the office, there are a lot of smaller projects where people can move on and off them, we don't have dedicated teams that are on the same job for 12 months.

RH: And that’s to do with the size of the projects?

JK: Exactly, and although there’s the key projects like Harbour [Esplanade, a large urban project, Figure 120], the tower [renovation project] and Dandenong [masterplan, Figure 122], there’s still all that work that’s of a lesser expense – it’s not like you’re doing a museum and there’s one team sitting in a room.

SK: And the new office has certainly changed the way people perceive us.
JK: Particularly the government clients.

SK: I mean you can’t be charging the sort of fees we are for these kinds of projects and going into that old office. And people have responded really well to the space, which is good. It’s convenient more than anything else.

RH: Just thinking about the building [Total House, Figure 118] and how it’s become a hub of so many design practices, do you think that affects the perception of the practice? Does that rub off at all?

JK: Well it doesn’t hurt, often the conversation goes “well we’re here and so are [established practices] Peter [Elliot] and John [Wardle]”. I mean we’re collaborating with Peter on the tower project.

RH: And do those relationships come about because you’re here?

JK: I think so, it might start with a conversation in the lift, and I guess we tend to speak to those guys regularly anyway. But put it this way, it’s not like I speak to Rob McBride every week, so I think the locational thing has an impact.

SK: But I don’t think it’s a huge influence, it’s secondary if anything, certainly being in the city helps.

RH: And just to jump back to the Friday night presentations, what is their role? What do they achieve?

SK: Well it’s not just about presenting our own stuff, it’s about bringing other people in as well. Whether it’s other architects, like we had Antarctica in last week, or we had [graphic designers] 3 Deep in the other day, or [artist] Alexander Knox came in and showed some work, so a whole range of different things.

RH: So it’s not just collaborators or people you work with.

SK: It’s just a way of getting something happening, and it’s a good end to the week too. We start at 4.30 so people don’t have to hang around late, we just stop work, have a beer; it’s a good way to finish off. It is good to show people projects as well, I think that’s a really important part of it.
JK: For example, Leah who’s a student, and probably one of the least experienced members of the office, was presenting the Footscray bus interchange last week; having the confidence to get up and present a project to the office is a potentially tricky thing. So we tend to mix it around as well, it’s certainly not the 3 of us getting up and talking about projects, in fact that’s not preferable, it’s about getting people who are working on it to talk about the process, and I think interesting things come out of that.

SK: I guess going back to your earlier question about being part of Total House and being part of the design community, I think its always been part of our philosophy to be part of the larger design community in some way, so this is just one facet of it, like doing the radio show², or doing talks, or being involved in the Institute [of Architects], or teaching, all those sorts of things that you do around architecture that are sort of hard to put your finger on how that benefits the practice, but it certainly does. So I think the Friday night presentations are just one part of a larger attitude to being part of the design profession.
RH: The other thing I wanted to cover is the collaborations, and how they might have changed over the last couple of years. So, I assume the reason you were teaming up to begin with was because the practice was quite small and you would go in with someone like Perry [Lethlean, from landscape firm Taylor Cullity Lethlean] or someone like Peter [Elliot] to get these jobs. Has that changed given you are the lead consultants on the Dandenong masterplan and on the Harbour Esplanade project?

Tim Black: I don’t think it has changed, while the scalability issue was one part of it, I don’t think it was all of it. Jumping ahead to one of your next questions too regarding my MBA training, I think that collaboration – we’ve come to recognise – is a really key part of the culture of the practice, and in fact a very valuable and interesting model that very few architectural practices, I think, are successfully carrying out. And so even the Friday nights are another expression of that where we might not be asking people we are currently collaborating with to come and present; they’re always there as potential collaborators.

RH: So they’re people whose work you’re interested in and looking to build that network?
TB: Yeah, exactly, so we’re building networks in a slightly indirect way, and constantly on the look out for interesting people to collaborate with. I think I spend a lot of my time – either consciously or unconsciously – at professional events looking for people to collaborate with, and just people who are doing interesting stuff. A good example is somebody like Mike Xie at RMIT, Mike has been somebody that we’ve been trying to collaborate with for some time – not entirely successfully with so far⁴ – but he’s someone I try and retain a relationship with and make sure every 3 months I go and see him and see what interesting stuff he’s doing, and he feeds us interesting stuff and we feed him ideas without actually working together yet, but one day I know that we will work with him because he does fantastic stuff. So I guess the collaboration component of the practice has become clearer in our mind as to how important it is, how valuable it is, and what a good thing it is.

SK: It also comes from the core of how we operate, and we keep going back to that now, because it gets harder to do when you’re busy, but always the best design work to come out of the practice has happened when the 3 of us sit down together, it has always been the case, and we’ve tested that over such a long time now that we kind of understand that so, I guess that then gets applied out to other people. And I don’t think it’s anything remarkable – but it’s remarkable that not many people do it – if you give people a bit of licence then they give you so much more back on the project. We had that with lighting designers – guys like Electrolight – or the ESD consultants or landscape architects or [graphic designer] Gary Emery, where we’ve sat them down right at the start of the project and asked them “what are your ideas about the building?” and they come back and say “no one’s ever asked us that”.

RH: So in that sense it parallels the way you might work with the staff, you give them a bit more licence and you’re likely to get a lot more in return.

SK: Yeah, and they come up with fantastic ideas. For example the Lonsdale St design we did on Dandenong was a remarkable collaboration between artists, the landscapers, us, the client who was involved really heavily, and the lighting guys were having a huge input on the tree selection and vice-versa. I find it in a strange way that it’s such an obvious thing, but its remarkable how few people actually do that and would prefer to do a – well it’s not just ‘top-down’ – I think a lot of architects are control freaks.

RH: Is it an inability to let go?
JK: It’s also the notion that you coordinate consultants, which by its very nature you coordinate their input but that they don’t form a part of the design team, which is how the traditional model works, where you have someone up top who’s shifting information around underneath.

RH: All on a need-to-know basis…

JK: Yeah, and you’re just keeping things on track, and I think we’ve sort of changed that model.

TB: There’s a lot of literature on collaboration – which I’m sure you’ve touched on – and a lot of it points toward how difficult it can be, especially coming from a professional culture which is steeped in the sole great singular architect genius figure.

RH: So it’s about challenging that, bringing everyone into a room together, and not being too precious?

TB: That’s right, one of the key difficulties is that it takes a long time to build a level of trust to collaborate with somebody really successfully, and I guess we are actively building relationships
with people who we think it might be interesting to collaborate with, with the view to building the relationship now for a later collaboration.

SK: And that might also include builders.

RH: Yeah, so how useful or how important are those kind of ongoing collaborations?

SK: I think really beneficial, because you do all that groundwork, and I think its sometimes challenging for some people, for example a lighting designer would normally just get the design and be asked to work around this, compared to sitting down with them and saying “what do you think about the building?” And if they’re sitting in a room with ten people, they’ll probably say “I don’t really know”, so it might take a little while to build that confidence, and that’s the same with a student in the office, it might take a little while for them to get into it. And that extends right across to builders and clients, which can also be problematic, but if you can lead it in the right way it can be hugely beneficial to the project. I know Frank Gehry has spoken about this, about involving the client so that they feel they have ownership of the project, getting them in to turn the sod, which can give a real enthusiasm, and if you can build that into the project then it can be hugely beneficial.

RH: Does that enable you to take more risks with the project?

SK: Well it builds trust, but also just gets them enthused, it’s awful when a client sits back and is wary and not really sure. So yeah, it might lead to different outcomes, you might be able to go in different directions.

TB: With regard to fabricators, builders and suppliers, I think collaboration in the construction industry remains difficult because of the very nature of the way contracts are traditionally let, there’s a great pressure still on competitive pricing and collaboration is seen as potentially undermining a competitive pricing situation. So that remains a bit of a stumbling block.

JK: I agree, the collaboration we have done with builders is generally on the smaller projects where you may have met a builder during a tender, done a job with them, perhaps had another tender with them, and then decided on the 3rd or 4th job to just negotiate the contract with them directly with the client. Realistically, that’s the extent of the collaboration. I guess the trust is built where we can confidently go to the client and say “for these reasons we think you should just go with this builder”, and then measure that cost against the quantity surveyor. That’s really all we’re talking
about at this stage. There’s a potential with [shopfitters] Leeda, particularly with the software they have in their factory, to do more than that, but I do agree with Tim that it is limited. Particularly with government clients.

**RH:** Because everything needs to be tendered?

**JK:** Yeah, for everything there’s got to be 3 quotes, so trying to challenge that existing model is very difficult.

**RH:** The other collaboration I’m interested in exploring is the practice’s relationship with the university, not just through this program. How do you see that relationship in terms of staffing or teaching? Does it play much of a role? Do you think it could play more of a role?

**TB:** I think it’s always been important to the practice, and it continues to be so, although we’re all teaching less and are involved less. I’d be interested to see the relationship with the university develop in a slightly different way though than just teaching through the architecture school. I’d really like to see us reaching out to academics within RMIT or universities across the board for specialists like mathematicians, materials scientists. Yeah, so I’d really like to see a maturation of SIALs and the ARC Linkage Grant program’s notion of forging better links between the academy and industry by somehow us continuing to develop a relationship with people who are doing interesting stuff. That’s who I’d like to collaborate with.

**RH:** People like Mike Xie?

**TB:** Exactly, yeah.

**SK:** I would like to teach a bit more too and I think we’ve all got a lot out of doing it, but I think for all of us it’s a time thing, with the radio show, and these guys have got kids; so I think it’s more about time than anything else. And also we’ve obviously been focussing on the practice as well; there’s been a lot of time put into here. Personally I’d always thought I’d like to teach and I think it would be good for the practice for the 3 of us to run a studio together, but it’s a commitment we probably don’t have the time to make at the moment.

**RH:** Ok, moving on then, just on your MBA Tim, how has that work been fed back into the practice? What were the goals of doing that?
TB: I think it’s interesting that you’ve mentioned the areas of design thinking [in the thesis document], and they’re all areas that I’m really very interested in and would love to pursue – I’ve noticed flicking through the draft that you’ve mentioned the AMO model…

RH: Yeah, I’m looking at some alternative practice-research models. It’s interesting reading about AMO (Speaks 2003) and the way they might use research to re-design a client brief, because you need to fully understand their organisation and requirements – areas that might be typically outside the scope of the architect – who might traditionally respond to a brief with a design, rather than with an analysis of a company for example.

TB: Well that’s typically what a management consultancy would do. McKinsey [& Company] would go in and analyse a company – depending on their brief – but sometimes they will be asked to do exactly that: build a design brief.

RH: And AMO talk about this, they say “yeah McKinsey’s will do this report for you, but it will be statistics-based and objective, whereas what we do as AMO is give you a biased opinion”, which they argue is far easier to act on, and might be informed by broader design thinking.

TB: Yeah, yeah absolutely, and it’s still analytical, but its analytical in a very different way, it’s not necessarily quantitative, but more holistic.

RH: I guess it’s more connected to design, which I’ve always thought of as being inherently generative and driven by action. Whereas research or observation is often just about what’s already there.

TB: Look, I would be really interested in expanding our scope into some of this territory, but we just don’t have the depth of market here [in Australia], you really need to be dealing with very sophisticated multi-nationals to be talking about establishing a consultancy business that can provide strategic advice through design thinking. You need to have 5 of them at a time to all be hungry for it, and there’s not the sophistication here at the corporate level, and we just simply don’t have the numbers here to be supporting it successfully. If you think about the companies that are doing it successfully, like the Harvard Business Review article (Brown 2008) that points to IDEO expanding into this territory, they’re doing that out of Palo Alto, which is where you can do it – or New York, or London – but there’s probably not that many cities that could, and Australia just doesn’t have that depth of market.
RH: So the MBA then, it feeds into the practice at the level of running the business?

TB: Well, I do still have ambitions to develop other areas of the practice that aren't necessarily to do with design thinking, but in the meantime, I think the value of the MBA has been for doing things we knew at a gut level – like the collaborative approach is a prime example – we knew at a gut level that it was a worthwhile thing to peruse, but I guess I did a fair bit of reading on collaboration during the MBA and it affirmed the value of that approach.

SK: A few people have asked me that before – how do you think the MBA has affected the practice – and it’s not really in the way you think it would.

TB: No it’s not like we’ve rebuilt the business around some crazy scheme to market ourselves.

SK: Or got time clocks in or something. Which would be the worst thing to happen, you know when the boss has gone to some business seminar and says “right, every time you pick up the phone you’re going to say BKK 3 times” or something, it’s certainly not in that kind of sense.

TB: Well that’s partly a misunderstanding of what an MBA teaches though. One of the things that I was keen to understand through the MBA was ‘value’ and particularly the value of design. And I understand much more now about economic value and how people perceive value and why people value design.

SK: Because all the basic skills we had anyway, we had already set up the practice in a certain way.

TB: One of things I’ve got to say it has greatly improved my focus on, is communicating the needs of others, and I think architecture so often inwardly focussed – well architects can be – and I’ve learned that you can address clients’ needs without compromising design, and you can produce terrific design while addressing their needs. So I think that’s been enlightening for me.

RH: So how do all the other things you guys do feed into the practice? Like the radio show, or lecturing?

SK: I’ve thought about that quite a bit, and I don’t really know.

RH: So you’re not getting any jobs out of it?

SK: Not directly, it’s certainly benefited me in a lot of ways, in terms of my confidence in the way I approach things and as a way of learning. So yeah it’s benefited me personally enormously.
TB: I did notice when we got interviewed for a magazine in Canberra recently, how crap I was (laughs). I learned pretty quickly to let Simon do the talking.

SK: It's a really hard one, I can safely say we've never got a job because somebody's heard me on the radio, but it feeds into a whole lot of other stuff.

JK: I think the thing is it's not linear, in the same way that we've never got a job directly out of a magazine article, but it has come back at other points, all the things you do build up step by step.

SK: I remember talking about this with Gerard [Reinmuth] from Terroir, that if you show a generosity to the profession and the community, you'll get it back in spades. And I think that's something we've always done in the practice. And people often ask how we find the time, but I really enjoy doing it, it keeps me interested in architecture and it keeps me actively going to stuff or reading stuff. And I think I probably get more out of it than I give. And I think that's the same with if you're doing an MBA, or teaching, or giving a lecture, or taking a couple of weeks out to judge the architecture awards.

RH: Ok, to wrap up, how's the scripting going Tim?

TB: Great, I was doing some last night actually. Did you see this thing? (pointing to a rapid prototype model of a perforated topological figure in the meeting room, Figure 125), well I didn't script all of that one, but bits of it are scripted.
SK: Quite often I’ll look over Simon’s [Linardi, a student staff member] shoulder and I’ll ask “what are you doing?” and he’ll say “oh, just another one of Tim’s wacky projects.” (Laughs) They’re always going on in the background somewhere. We’re using scripting on a real project for a bus interchange in Footscray at the moment. It’s certainly had a big impact on our work.

RH: Is anyone else in the office scripting?

TB: Yeah, Linardi is teaching himself at the moment.

RH: Has it changed the way you think about design?

TB: Absolutely, I think it suits my interest in trying to define the underlying principles of a design, and I think it suits the practice in the way we’ve always worked. The better work has come out of a rigorous process where we’ve articulated the underpinning principles before we’ve pushed the design all the way through.

RH: I remember in the last interview (see Appendix 7.1), we were trying to describe what the design of the practice might have been about, and there was a discussion of the idea that you would compress down to a diagram that might sum it up, and then expand out from there as the project develops. Do you think scripting feeds into that?

TB: I think scripting does focus you – especially for the very speculative projects, which is what I use it for mostly – I guess you could call them thought experiments, which is what I was working on last night – it was a square section moebius band – and it’s just a speculative space that leads to other questions, but I guess the point of concentration is when you’re forced to sit and work out the relationship between the elements in a moebius band for example, and how do you draw it, and this articulation of the underpinning rules can lead you into other areas.
SK: I also think the importance of scripting for us – and for any creative practice – is the ability to do multiple tests of something, which no doubt fine-tunes a design and you get a much better result. I think that idea of the ‘one off’, where you have a clear idea from the start and you just go and do it is really dumb, and it never gets resolved or fine-tuned. I think the ability to crank things out and to be able to say “ok adjust that slightly” is a fantastic ability to have. So like Herzog and de Meuron or whoever it is making 200 cardboard models, it’s the same kind of process of testing made so much quicker, easier, and more feasible for the practice.

RH: Thanks, any final thoughts?

SK: How do you think the practice has changed since the last time we met?

RH: Well it’s difficult to articulate because the change has been so incremental, but just coming in here today, it’s a new space, it’s a bigger office, with bigger projects, bigger clients, longer timelines. It also feels more organised and like its got more momentum.

SK: Hopefully enough momentum to ride out the [financial] storm.

RH: What’s the outlook for the future?

SK: Really good, we’re in a good position, we’ve got enough work to keep everyone busy for the next twelve months and that’s without picking up anything else, and unless this slow down really drags on, I think we’ll be ok. We should be able to pick up a bit more work along the way, and I think we’re well placed with the sort of work we have in the office too, we don’t have a lot of commercial developer-driven work which has really hit a downturn with some other practices. But its really hard to tell how its going to pan out, but we feel like we’re pretty well placed, unless it gets to 5 years of depression in which case we’ll all be in the shit.
5.2 Summary

There is a persistent stereotype of the architect as creative genius, who through their mystical intuition creates inspired scribbles on the backs of envelopes, which are brought into the constructed world by a phalanx of disciples, working through the night to impress the master. This stereotype is perpetuated by films such as ‘Sketches of Frank Gehry’, where as the title suggests, the subject is the man and his illusive scrawling, never mind the hundreds of staff. Or ‘Koolhaas: Some Kind of Architect’, again, the emphasis is on the persona, not the process. The popularity of this genre may confirm the public’s belief in the singular genius of these figures and their personal moments of inspiration. While vision and leadership may be important qualities of a director, the sole-genius as source of innovation is a damaging cliché for the profession, as it is near impossible to replicate.

This conception of the intensely hierarchical and top-driven workplace is increasingly characterised as a dying era. Richard Florida terms the new, creative practice as the “no collar workplace”, which “replaces traditional hierarchical systems of control with new forms of self-management, peer recognition and pressure and intrinsic forms of motivation”. Florida terms this form of management “soft control”, where trust, autonomy, independence and identity are given to employees, who in turn become further invested in their work, and form a greater source of innovation for the company at large.

Similarly, Thackara (p.99) describes the “soft aspects” of workplaces, which facilitate innovation as a “social process that involves complex interactions among individuals, communities of practices and customers”. This has little to do with the physical design of offices, but with the particular kinds of personal engagements and opportunities for collaborations that these spaces and their organisational structures promote. Indeed, Florida views the formation of these ‘creative contexts’ for work as an imperative, claiming that companies “either will create these kinds of environments or they will wither and die” (p.13)

As this above interview illustrates, BKK seem to have been successful in curating such a ‘creative context’. They are relaxed and confident managers, maintaining a leadership role while giving the staff generous space for autonomy and experimentation. As characterised by the ‘steering the ship’ metaphor, staff are encouraged to work things out for themselves, but are pushed back on course if they stray too far off on a tangent. The work is collaborative, composed of small teams each with
their own supervisor, and supported by some general positions. The much-discussed Friday night presentations reflect the importance of maintaining strong communication and awareness of what is happening in the office as it expands beyond the size where this happens implicitly. And by inviting practitioners, collaborators and friends from outside of the office to present, the office is exposed to new ideas and can lay the foundations for future coalitions.

And while the directors may have established this context and these initiatives, their role is not a controlling one, but is peripheral. This is reflected by the fact that they rarely present themselves on a Friday, and their willingness and openness to forming new collaborations. It matters little whether ideas come from above or below; there is generally pride and consensus among the staff and directors with the work that is produced. BKK have successfully created a space for creative exploration, which has its own identity and shared momentum. This is not an office of staff propping up a small group of creative geniuses, but a collaborative and supportive context for the shared exploration and creative development of architecture. It is difficult to objectively measure the success this has led to in a design-sense, but certainly critical feedback from publications, and the practice’s success with awards suggests that this organisational structure has not only formed a workplace that suits the staff and partners, but has also had a positive effect on the output of the practice.

Of course, success very often leads to expansion, a trend that is emerging at BKK as they attract larger projects and larger clients. But instead of taking on more staff and further layers of hierarchy, BKK have instead serviced these larger projects through collaborations with larger practices and their associated larger production capacities, reflecting the continued motivation and desire to remain a small, intimate and design-focussed practice.

Although, as this thesis has sought to demonstrate, the ability to ‘punch above your weight’ is not one limited to organisational models, but can also be addressed through design strategies. Indeed, as Tim Black’s explorations into scripting reveal, BKK is also intent on developing these skill sets as a means to managing the greater complexity of projects and design requirements.

The relationship between design strategies and organisational structures is non-linear. Both influence each other. The design strategies are influenced by the practice, in that they are directed to the particular scale and needs of a small practice operating on the kinds of projects that are most common to this sector of architecture (see section 1.3). Similarly, the practice is influenced by the design strategies explored through these projects, as evidenced by the type of work being
produced by the office, particularly their collaboration with engineer Mike Xi, and projects such as the Monash Footbridge. This feedback is inherently blurry, overlapping and difficult to pinpoint. The relationship between design strategies and organisational structures is less ‘active’, and more ‘passive’, in that it’s largely driven by sane judgement and common sense. Particular design strategies demonstrated through the case studies are applied in contexts where they are anticipated to be relevant - such as templates for a small builder, or digitally fabricated templates when working with a major steel manufacturer. There are no ‘control samples’ in the messy reality of practice, and it’s difficult to speculate on the trajectory of BKK Architects in the absence of this research and experimentation. However, as this interview illustrates, the introduction of new means of working has influenced the way the directors think about their projects, they type of people they may approach to collaborate with them, and the kinds of projects they have been approached to produce.

Footnotes

1. The Friday night presentations were established by the directors a number of years ago as a semi-formal platform for sharing the status of a project within the office or for inviting external collaborators or friends to present their work. I believe this to be unique to architectural practices in Melbourne.

2. Simon Knott co-hosts a weekly radio show about architecture on a local community station with Stuar Harrison and myself.

3. Tim Black had recently taken time out of the practice to complete a Masters of Business Administration (check) at the Melbourne Business School.

4. Mike Xie had done some studies of a bridge project which had yet to be implemented, see Figure 123.

5. The ARC (Australian Research Council) Linkage Grant is the fund supporting research that forges relationships between universities and industry partners. It is a supporter of this research.
Chapter 6. Conclusion

This research aims to articulate the conditions for expanding design in small practice. The hypothesis proposed that by managing complex information, increasing efficiency and enhancing collaboration, digital tools and new models of organisational structures could be an empowering force in design, enabling smaller practices to punch above their weight and accomplish a greater amount with limited resources.

This capacity forms part of a broader shift from an industrial paradigm characterised by mass production to one of flexible production and niche markets. In this environment, agile small practices – unburdened by cumbersome verticality and middle management and empowered by technology – have the potential to emerge as an economically viable and relevant model for the contemporary network society and become increasingly competitive with larger practices.

Chapter 3 presented a concise trajectory of shifts in architectural practice structures over the course of the 20th century – from collaboration to division – culminating in the rise of the digital technologies characterising the network society and the transformative effects they bring to practice. Taken together, these shifts open up the possibilities for new opportunities for practices enhanced by these technologies, expanding the capacity and scale of small practices. These opportunities include: a new level of control enabled by the management of information (the information master builder); a renewed engagement with the products and materials of architecture (flexible specialisation and a return to craft); the potential for a new tectonic language that is intelligent and responsive to its constructional possibilities (design about production); new freedoms and possibilities for collaboration (small, networked practice); flatter organisational pyramids through the expansion of knowledge generation and sharing within project teams (a dissolution of hierarchy); the ability to anticipate and manage risks (innovation through accountability); the expansion of independent research as a source for design and revenue (practice as research); and finally, design knowledge applied as a form of consulting (design thinking).

While not all of the practice examples are small, each demonstrate how small organisations can achieve greater competitiveness through the management of information and knowledge, by expanding into new niche markets, or by forging constructive coalitions between firms for tackling more complex projects.
Within these new practice models and opportunities sit the design strategies, the particular techniques employed through the process of conception, resolution and realisation that leverage off these characteristics of the digital, and contain the potential to recast the way we operate as architects. They are the tangible means for achieving the grand aim outlined in the title - to punch above one’s weight - and yet are far more intimate and specific to the contexts of small practices. These are presented in Chapter 4. The key findings, summarised in further detail in section 4.7, are: the integration of design and construction information, the expansion of design time, the use of flat sheet material to describe complex form, the embedding of design knowledge in explicit procedures, and the expansion of trial and error. Taken together, each of the strategies expand design in small practice by implementing technology to automate various processes; by addressing directly the needs and limitations of working with small builders; and most importantly, by expanding the exploratory space for design and design refinement. As the various case studies illustrate, these strategies have been of immense use to the particular context at BKK they were tested within, and by extension could open up new opportunities and ways of working for other small practices.

These new practice models illustrate that size is no longer a restriction on ability. And although I have only had the opportunity to explore these concepts from within a small practice, as the interview with BKK in Chapter 5 illustrates, they have had reliable success despite the testing economy. Through the curation of a collaborative and flexible working environment, generous autonomy and space given to the staff, and the exploration of new design territories and digital tools, BKK have generated a creative momentum without hierarchy that is leading to new clients, to new kinds of projects, and critical praise.

It might be tempting to reach beyond these conclusions and make the larger claim that ‘the future is small’, as while digital tools and organisational change may bring greater efficiencies and capabilities to small practices, they can also help large practice too. Indeed, large practices are reshaping their organisational charts to operate as networked collaborative teams within larger enterprises. Thus, while this research does not conclude that the era of large practice is over, it does identify a challenge to the corporate orthodoxy based on vertical integration and hierarchical management and argues that the benefits of digital technology to all scales of practice would result in the increased viability, competitiveness, legitimacy and relevance of the small practice in the network society. If large practice is trying to be small, small practices need only to play to their strengths.

In summary, I propose the characteristics of a practice relevant to today are:
• A minimum amount of intermediate management between the partners and those undertaking the work.

• A practice atmosphere based on autonomy and trust, conducive to an exploratory research-culture and the development of new design strategies within the regular flow of projects.

• Digitally smart, employing emerging technologies to develop specific solutions and tools to design problems.

• These design strategies should be process-driven, not object-driven. They should develop a systems approach to design that is connected to the larger procedures of construction and communication.

• This construction knowledge should not be confined within the practice, but drawn from a network of collaborators and consultants. Trust within this network is built through successive projects and by opening up the project for discussion at the earliest possible opportunity.

• The practice should have well coordinated systems of communication and feedback. (The BKK Friday night presentations are one such example of this.)

As has been demonstrated throughout this research, these conditions could lead to better design, more socially sustainable practices, and more economically viable practices of all scales. Most importantly, it represents a potential blueprint for a future architecture that embraces the pervasiveness of digital culture and the concrete realities of building in a manner that is intrinsically relevant and meaningful today.
Chapter 7. Appendix

7.1 Projective conclusion

Where the above conclusion summarises the outcomes of this research from within the established scope, this ‘projective conclusion’ attempts to position this research in light of recent events and the anticipated future of architectural practice. It extends beyond the immediate findings of the research, and is not conventional in that sense, but is included here as an appendix.

Two factors in particular, the threat of climate change and the global financial crisis, pose a radical challenge to the foundations of architectural practice. These factors are themselves intimately connected, as the crisis of the global economy, and its patent inability to accommodate the needs of all people and of the environment, offers the greatest challenge to the dominant culture of corporations and capitalism.

Despite admitting that “Today’s capitalism seems an impregnable citadel”, Yale Professor of Environmental Policy James Gustave Speth (2008, p.188) passionately advocates an exploration of alternatives to this economic model, arguing that “capitalism’s inability to sustain the environment is one of the biggest threats to its future… contributing to crises that delegitimises an existing order that is unable to cope.” A key finding of this research is that small practices are a more appropriate model for today’s information society, concluding above that the future will produce a ‘diverse ecosystem’ of practice types and sizes. However the great amount of this research was undertaken within a period of relative economic stability. Architecture as a discipline and business had been experiencing a boom of popularity and prosperity, which all but collapsed as the global economy slipped into crisis in late 2008, with severe consequences for a ‘business as usual’ approach.

The architectural profession in particular has been hit especially hard (Houston and Millar 2008) (Schneiders 2008), with many projects being put on hold and firms needing to retrench large numbers of staff in an attempt to survive the leaner times. Although small practices are likely to be hit just as hard as large – inevitably pushing some of them into bankruptcy – the skills and assets of small practices may offer a strategic advantage in this depressed economic period. A constructive precedent for this line of thinking is Buckminster Fuller’s (1979, p.192) famous statement made during the U.S. energy crisis and buoyed by the then contemporary advances in sustainable technology, which captures this preference for small over large:
All of humanity now has the option to 'make it' successfully and sustainably, by virtue of our having minds, discovering principles and being able to employ these principles to do more with less.

Doing 'more with less' was identified in the introduction as being characteristic of small practices; skills which may place them in good stead for the recasting of design in response to the crises of the economy and the environment. In addition, Fuller emphasises 'principles' as the means for achieving this change, a subject that runs throughout his career of projects and writing. 'Principles' stand in contrast to 'aesthetics', expressing a strategic approach that is more overarching, substantive and quantitative than a mere new language. What could be more irrelevant than to deploy today's powerful new digital tools in the service of a style, as proposed by Patrik Schumacher? (2010)

Indeed, a number of commentators argue that the formal excesses that have come to characterise much of contemporary architecture will cease to be relevant. Nicolai Ouroussoff's (2008) review of the Zaha Hadid-designed temporary Chanel pavilion located in Central Park captured the moment these sentiments changed, published a week after the collapse of Lehman Brothers, sending global markets into freefall. Ouroussoff claims the "wild, delirious ride that architecture has been on for the last decade looks as if it's finally coming to an end," adding that "if devoting so much intellectual effort to such a dubious undertaking might have seemed indulgent a year ago, today it looks delusional." Sam Jacob (2008), partner of UK firm Fashion Architecture Taste (FAT), suggests we will reflect upon this period of architectural history with disdain, associating it with the crash that came to follow. He claims that within the 'swooshing', 'cranked-out' 'lightheadedness' of contemporary architectural 'effects' we "will find the most permanent record of the heady, liquid state of mind of millennial abstract-boom economics. We might rechristen these freakish sites as museums of late capitalist experience, monuments to our quaint faith in the global markets."

If this is the case, then how do we prepare for the coming period of architectural austerity and limitations? The architectural equivalent of a 'market correction'? This research proposes a number of design strategies and systems for small practices characterised by their limited resources. These strategies focus upon design testing, the transfer of design information for construction, deferring design decisions, employing CAD/CAM for fabrication and the representation and rationalisation of complex geometry. An important constraint on these systems is that they do not require large pools of staff to accomplish these tasks. Whereas this thesis set out with an intentionally limited scope – small practices – now that the large majority of practices are suffering in times of economic hardship, these strategies have gained increasingly relevant to practices of all scales. Kazys Varnelis
(2008), writing about the anticipated implications of this recent economic crash, states that “Instead of talking about the cool things that digital technology can make, architects are going to talk about how fast and efficient digital technology makes them.”

Indeed, the projects presented in this thesis have not been immune from the allure of these ‘cool things’; the pavilion in particular was an exercise in geometry for little purpose other than to create an immersive space for the viewer. However, this project remains as an important demonstration of the formation of a ‘closed loop’ system connecting design, testing, manufacturing and construction that could be applied to other, perhaps less indulgent, design problems. The geometry stands as a demonstration of the potential of this strategic approach to design.

Whereas some critics blame technology for these formal excesses (Jacob 2008) – and indeed it is the technology that makes it possible – but working with parametric software or generative scripts also hold the potential to reengage architects with the underlying systems of design and construction in a more informed manner. This technology that has been in the service of form, can now be applied for more ethical purposes. Neil Leach (Hyde 2008), discussing the future direction of architecture’s engagement with technology states:

> the question then is ‘how do we use these new technologies to promote this new [sustainable] culture?’ … I would like to think that the real potential for these digital tools is to benefit humanity, and therefore to find ways in which you can optimise the energy in a building and so on.

The stereotype of the architect as form-maker is not a constructive future for the profession, by focussing instead upon digital processes and strategies that integrate and make sense of the complexity of design and construction, a new sustainable and architecture can be born. We must of course be careful not to abandon form altogether, these systems cannot only be driven by functional and pragmatic concerns, but need to appeal to society and convey a narrative that is worth supporting and can encourage broader adoption.

In addition, these same digital tools and their associated design processes may also provide a positive response to the current financial crisis. The latest digital software may have captured the spotlight for its ability to produce exotic forms, but as practices are increasingly stretched by leaner economic times, the capacity of parametric software and scripting could be repurposed for enhancing productivity and efficiency.
Varnellis (2008) even goes so far as to propose the “main consequence” of parametric design in times of recession is that “it will cement the movement toward downsizing in architecture firms. By allowing vast quantities of permutations to be done rapidly, it will allow firms to slough off more nonessential design staff.” While this may sound brutal, it reflects a trend toward the small digitally augmented practice that forms much of the focus of this research.

Scaling back both the size of the practice and the scope of operation is an appropriate response when faced with such global technological, environmental and economic uncertainty. Samuel Bowles (2005, p.531), discussing the economy more broadly, views the combination of each of these factors as “likely either to bring about fundamental changes in the institutions of capitalism ... or to lead to the emergence of a qualitatively different economic system.”

With the global economic system in uncertain flux, the most relevant zone of architectural operation is small and local. By concentrating our efforts on developing systems that engage to local challenges of sustainability and the environment we can respond to the immediate needs of the community. The strengths of small practices to produce ‘more with less’ and achieve ‘grand gesture on limited resources’ can be directed to produce strategic and responsible proposals for these lean economic times. When viewed in this light, the new technologies, design strategies, and organisational structures explored throughout this dissertation are in many ways prescient.
7.2 Transcript of interview with directors of BKK Architects, October, 2006

This interview with the partners of BKK Architects was conducted part way through this research project. Many of the ideas and themes raised in it were instrumental in refining the research topic and methodology.

**Rory Hyde:** How would you describe or summarise the design interests of BKK? Or do you think there is a particularly BKK project?

**Simon Knott:** I don’t think our work has ever been about establishing a manifesto for this is a way you might move forward. We see it much more aligned with a sort of problem solving, and as an experiment, and with that it combines interests in other things outside of architecture. Its not an academic exercise, but brings together culture or contemporary art and about placemaking or how we can make buildings that are not just a wall on a piece of ground, that its actually invested in some kind of meaning, or some idea about a broader context, or a cultural context, or a site context or a historical context.

**Julian Kosloff:** Which is why I think that for that reason there isn’t really one project that sums that up because in many ways each of the projects are very different, but that the methodology used to explore that is perhaps very similar.

**SK:** In that way it kind of avoids issues of style, it’s not about trying to establish a style, or about saying ‘we’re into post-modernism’ or ‘we’re into modernism’. We look at precedents, but we’re more interested in looking at all the conditions around the problem we have and solving that problem. And I think that’s a fundamental thing of design.

**RH:** Just going back to this discussion of process, how do you set up a process that enables you to extract those problems, or what is that process? Is it about how you work with the staff? Or how you work together as directors?

**JK:** Part of it is – and its something we’ve become quite apt at – abstracting or referencing things like fine art, also understanding their place within their own culture and that has a huge influence on the way that can be used in architectural design. So whether the influence comes through fine art, or it comes through music, there’s already a pre-existing history, and its part of understanding that that informs it. And from there I think it’s a conversation about where those things might lead,
without the presumption of what the outcome might be. So there's a conversation that might lead to a single diagram or a single word or a single motivation that then is built upon.

**SK:** We've talked a lot about the ideas of consolidation, distillation and expansion, I think is a good way to describe it. There's a whole series of conversations with client, with other people, looking at the site, talking to the staff within the office, and then that gets distilled down to an essence of what the project might be about, from which then the whole project expands. So there's some idea of a kind of narrowing down, and then an expansion out.

**JK:** For that reason it works well within an office that is perhaps more studio orientated than a hierarchy, because if a particular idea is established, and then communicated, all inputs are valued and added to that. So it's not a secretive thing about aesthetics, its something that can be discussed, so therefore everyone's input is equal in many ways. Rather than just the studio being a 'nice idea'.

**RH:** Just to try and unpack this idea of 'consolidation, distillation and expansion' a bit further. For example, when a project is at its 'expanded' point, is that when you're just throwing a whole lot of stuff at it, which is then narrowed down to a diagram. Is that how you see it working?

**SK:** Yeah, but it's not limited to that, as Jules was saying, it's about identifying a clear way forward. Hopefully within that diagram or idea there is contained a whole lot of little seeds which allow the project to grow back out from that. So it's a question of understanding the parameters of which you're working in and allowing them to inform the process. It allows us to be, in some ways I think, also slightly intuitive in the way we approach it as well. I detest architecture that's purely academically driven, that's about this next step process, because in the end all the life gets sucked out of it.

**JK:** Well you can't build text, there has to be a point when you leave that behind.

**SK:** When its purely in the realm of academia, I tend to find the buildings quite dry. And that's not to say that buildings shouldn't be ideas driven, and I think fundamentally they have to be ideas driven, but we would lean much more towards that of contemporary art practice in that it allows much more experimentation and for the direction to change. And that's why we deliberately said when we started that we didn't want to be fixed in what we were setting out to do. We wanted to allow our architectural practice to develop and evolve a bit. We talk about it, and we think 'oh its moving in this way' or 'its moving in that way', and if we look back we can see the things we were interested in and the direction it was going in, but its never been about saying 'ok, lets see how we
can make architecture do this’, and then establishing a process. Part of that is that it’s a process of continual questioning too, a continual questioning of what we’re doing, what the building actually is and how it sits within its context as well. So I think that continual questioning process what underpins a lot of good art and architecture; its a questioning of orthodoxies.

RH: How important is this compression down to a single diagram or idea? Is it about clarification, or to be able to communicate it to someone else? Could these ideas remain in their intuitive state?

JK: I don’t think its necessary, as the building ends up existing on its own regardless of what the diagram is.

RH: I suppose what I am thinking about is for example the Wrap House or the 2 Parts House where there is one diagram that perhaps explains one key formal aspect of the house, but which also may distract you from what else is going on.

JK: It’s a difficult thing, because often these diagrams are used as a communication tool within the office, or to a client, or even later in a media context or the way that you discuss a project, or the way that you hook it or the way you make somebody understand it. But you’re right, it is in many ways the undoing of it as well and I think there’s a lot of other layers which are going on which are hard to sum up in one diagram.

SK: And in some ways that’s why we’ve started to rely on them less and less. I think that’s us also becoming a lot more confident in what we do. When we started, we felt a bit of a need to justify things a little bit, and I guess we’re not concerned with that anymore. I think you’re right in what you’re getting at, is that it is many things and so maybe it should be left to be read as many things. But maybe it doesn’t need to come down to a key diagram but the same process might still exist there. When we sit down and talk about it, we’ll talk around a whole lot of different things, and then keep coming back to ‘ok, what is this about’ or ‘what are we actually trying to do here’. And we’ve noticed in the work, when we haven’t really nailed that, it hasn’t been as strong.

RH: So it’s less about a compression, but more about a clarification?

SK: Yeah that’s it, and a direction for the project to move forward. While the diagram may be limiting in that way, its kind of about establishing those seeds, from which the project can really expand out. So yeah the diagram is maybe limited because it focuses on one thing.
JK: Maybe it’s a question of what the diagram is… For example DCM (Denton Corker Marshall), they design something and all sixty people in the office know how to take it forward, and it wasn’t because there was a key idea, but because there is an established style. And in that office, a building can literally grow to design development stage right from one of Barry’s [Marshall] sketches, because they understand the key details and the language of the practice. Whereas I think the way we work is entirely different to that, as it’s not stylistic, but about everyone understanding the direction. And I think they’re two very different things.

RH: Well that’s the real top-down, director-led, design practice, where the director’s have the ideas and it’s everyone else’s job to see it through.

JK: Yeah, but it still requires huge staff input to execute, it’s just that the language is aesthetic, rather than about an idea, and I think that’s really interesting.

SK: We’re having discussions now, you know we’re five and a half years in, where we go from here. When we first started we said ‘we want to be a big international practice’, and now we’re thinking maybe we don’t want that, maybe we want to be hands on, and keep it back to ten or fifteen people in the office. As long as we can make enough money out of it. The only downside would be that you can’t tackle the really big projects, but maybe there’s other ways you can do that, through collaboration for example. Because I do think those big practices do suffer.

JK: That would be the biggest change to our direction in the last five years, is recently sitting down and questioning this thing where ‘well we just want to be as big as we can’, and considering the impact that has on the practice. And we’re all pretty aligned in that idea at the moment, that maybe big isn’t better.

SK: There’s a sense that our practice has always been exactly that.

RH: So what is Tim’s MBA about? I’d always assumed that was about you setting up to be a larger office?

JK: Well Tim’s interests are pretty widespread, he’s got a particular fascination with strategy and business anyway. And the other conversation we had when we started the practice was about what we wanted to do individually within or outside of architecture. And that was brought up on day 1, where Tim mentioned pursuing other business models. Which sort of fits with the way we work
anyway. In many ways, there’s a chance that the MBA that Tim’s doing may inform the design work more than it does the business side of things. Which would be really interesting. In the same way that your PhD could inform a number of things in the office. And we really enjoy that flexibility, and it’s a good model in that sense.

**RH:** Just on this discussion on the future direction, where do you see the practice in 5 years? Where do you see the practice levelling out?

**SK:** I think the next 5 years is about consolidating the bigger scale work, by really nailing some 5 to 10 million dollar projects. But also to start to diversify into new areas, and that’s partly what Tim’s doing. Whether that’s consultancy work outside of BKK or development work of our own, those are the sorts of things we’re starting to talk about now. We’re wrapped with where we’re at, so it’s not a sense of just building and building.

**JK:** I think the other ambition for the next 5 years is establishing a core group of people that are involved in the practice. At the moment, if you took a cross-section of the staff members, there’s a real variety of strengths, and we think that’s also key to what happens in the next 5 years. We’re really keen to push that a bit, and open up the opportunity, and let it grow.

**SK:** We talk about that a lot, about who’s in the office, their skills, personalities, and the sort of people we might need to bring in. So it’s an ongoing discussion.

**RH:** How do you see the other stuff affecting the design work? I’m thinking of the radio show, or presentations, or teaching or lecturing.

**SK:** I think all of that stuff is a great way to give you different perspectives on architecture. You can get bogged down in practice every day – how do we get this project over the line, stuff going out to tender, going out to 50 million meetings – so like at the housing conference on the weekend, it really got me thinking fundamentally ‘ok this is why we do this’ and ‘these are the things we should be questioning’, same with teaching where you need to clearly articulate your position. And we talk a lot about this, about giving back, we shouldn’t be an insular practice, it should be about giving out to whole lot of other things. And that might include expanding the knowledge out into the public as well – that’s the lesson of Robin Boyd. I’ve always seen that as a fundamental aspect of what we do. It particularly struck me as a graduate, where all of my contemporaries would complain about how much you make in architecture, as though they were getting screwed over by their bosses. But in fact you’ll probably find that their bosses are reasonably generous and that’s all they can afford to
pay. So there’s no point griping about not getting paid enough, you’ve got to go and do something about it, and the only way I can see to do that is to make architecture more appreciated within the broader community. Because remarkably, most people don’t know what you do. So if you can actually get it out there and get people talking about it, then that will come back to you in another way.

I guess your other question was about design, and the discussions we’ve had about where we’re going and what we’re doing is fundamentally about being a design-based practice. And that is the overriding aim. We often say ‘well we could do this’ or ‘we could do that’, and even diversifying into other aspects, we’re always concerned about whether that’s going to affect our work. You often seen other architects where they might sacrifice the design for a development or other variations on that. So the idea that we’re a design practice is overarching.

RH: So what does ‘being a design-based practice’ mean then?

JK: We had a developer ask us that exact question just the other day, which is fairly interesting.

RH: Is it about having a 1 to 1 relationship with each of the projects? Retaining control throughout the process? A close relationship with the client? Keeping things small?

SK: All of those things – well not necessarily keeping things small – but I think all of those things you’ve just mentioned are part of it. It’s about not compromising.

JK: I think it’s about a freedom of decision. Regardless of how lucrative or how much pressure there is outside it, unless there looks to be a good design outcome, then you don’t touch it. And that’s the guiding rule, regardless of any situation.

RH: So it’s to get the practice in the position where you can potentially pick and choose the projects and clients?

JK: That would be good in 5 years.

SK: But essentially now, when a job comes up, we look at the budget, the client, our workload, the morals issues that it might involve. But the fundamental one is whether there is likely to be a good design outcome, which you can pretty much tell. That’s one of our main things, is what are we going to get out of it. And we have knocked stuff back where we haven’t seen it to be worthwhile from that point of view. And for us, the aim is at the end of the day to be able to sit back and say
we’re happy with every project we’ve done. To be able to stick your name on it and say I’m proud of that. That would be the overarching aim. Otherwise, there’s other ways to make money.

JK: There’s better ways to make money.

SK: If I wanted to make money, I’d get out of architecture. It’s just too hard. I’d do something else. Dentistry. But we want to make a profit obviously.

RH: I just wanted to finish by asking how you think my role informed the direction of the practice or your approach to architecture? A bit of a selfish question I know…

JK: I reckon it’s been a further avenue to allow time to research. I was thinking about the diagram thing before, and that in once sense it can mark a departure point, or whether it can constrict an idea, and how that diagram works. I think since the PhD there has perhaps been another way of looking at the diagram, and something like scripting, which is perhaps not a drawing, but text that can be changed. And it’s interesting to think about how that has informed the design and particularly how that design is then talked about at a later date. Fundamentally just the opportunity within a small practice for somebody who’s really good at that to research and to try and push new directions without being too concerned about the outcomes for the specific job or a specific timeline.

SK: To extend what we do. There’s a couple of aspects to that, one is to have someone in the office who’s funded, and that’s a purely pragmatic, mercenary one in a way, but also to have someone in the office who has the ability to question and to think and to be a part of that conversation.

JK: And who’s started right back five years ago as well.

SK: Yeah and that’s why we’re glad that you did it, to have someone who’s thinking about what you’re doing everyday. I don’t want some monkey sitting there just drafting shit up, it’s just not what we want in the office. So its about being part of the conversation and part of that questioning process. And also the level of enthusiasm. You have a great enthusiasm for architecture and for the practice. That’s been an enormous benefit to us.

RH: I suppose the question in that other question was do you think that the available luxury of having someone that’s able to research things or to look beyond the immediate issues posed by a
problem, the site or context, has helped the design work of the practice or opened up a new way of approaching design in the office?

SK: That might become more apparent when you stop doing it. Because in some ways it's hard to separate that out. We sort of think that we've evolved in a certain way, and you've been an integral part of that. Yeah it's hard to separate that out, particularly when you were already a part of it.

JK: And in many ways you were looking at that sort of stuff pre-PhD anyway. Because of your fundamental interest in it, it was always part of the conversation. So for us it feels like an extension of the conversation we've always had in many ways. But like Simon said, in the absence of it, or when the PhD finishes, that's when we'll realise how much fantastic time you've had to do that. At the moment it feels like an extension of what was started.
7.3 Full text of scripts

The following scripts are those that are explicitly referred to in the main body of the thesis. They represent a very small sample of the hundreds of scripts produced throughout the course of this research. It is not expected that they will reveal any insights for the lay reader, or that they will prove useful to future designers (although perhaps they might), but they are included simply to illustrate the wide range of skills and activities undertaken by the author through the course of this research.

7.3.1 Ice cream lamp script

```
Option Explicit

'MULTI-SECTION SCRIPT
'Platform: RhinoScript
'Written by: Rory Hyde
'Contact: rory.hyde@gmail.com
'Version: 1.0
'Date: 9th June 2007
'What it does: Creates multiple section cuts through a selection of objects at a specified interval.
' Created for the Ice Cream Lamp project.

Sub MultiSection()
    'Declare variables
    Dim arrObjects, strObjects
    Dim arrStart, arrEnd
    Dim arrTempStart, arrTempEnd
    Dim strStartPt, strEndPt
    Dim dblDivisions, dblSpacing
    Dim i

    'Get user inputs
    arrObjects = Rhino.GetObject("pick objects to section", 24)
    If IsNull(arrObjects) Then Exit Sub
    arrStart = Rhino.GetPoint("pick section start pt")
    If IsNull(arrStart) Then Exit Sub
    arrEnd = Rhino.GetPoint("pick section end pt")
    If IsNull(arrEnd) Then Exit Sub
    dblDivisions = Rhino.GetInteger("no of divisions",2)
    If IsNull(dblDivisions) Then Exit Sub
    dblSpacing = Rhino.GetReal("spacing",10)
    If IsNull(dblSpacing) Then Exit Sub

    'Start loop
    For i = 0 To (dblDivisions-1)
        strObjects = arrObjects(i)
        'Increment start and end points
        arrTempStart = Array(arrStart(0), (arrStart(1) + (dblSpacing*i)), arrStart(2))
        arrStart = arrTempStart

        'Convert start and end points to strings
        strStartPt = CStr(arrStart(0)) & "," & CStr(arrStart(1)) & "," & CStr(arrStart(2))
        strEndPt = CStr(arrEnd(0)) & "," & CStr(arrEnd(1)) & "," & CStr(arrEnd(2))
```

CStr(arrEnd(2))

If i <= 0 Then
  Rhino.Command "_Section" & strObjects & "Enter" & strStartPt & "Entry" & strEndPt & "Entry" & "Enter"
End If

If i > 0 Then
  Rhino.Command "_Section" & strObjects & "Enter Enter" & strStartPt & "Entry" & strEndPt & "Entry" & "Enter"
End If

Next

End Sub

MultiSection

'**************************************************
Option Explicit

'GROUP BY HEIGHT SCRIPT

'Platform: RhinoScript
'Written by: Rory Hyde
'Contact: rory.hyde@gmail.com
'Version: 1.0
'Date: 9th June 2007
'What it does: Groups sets of objects based on their Z value.
'    Created for the Ice Cream Lamp project.

Sub GroupByHeight()
  Dim arrCurves, strCurve
  Dim arrTestPt, dblTestZ

  arrCurves = Rhino.GetObjects("pick curves to group")

  For Each strCurve In arrCurves
    'get start pt
    arrTestPt = Rhino.CurveStartPoint(strCurve)

    'extract height value
    dblTestZ = arrTestPt(2)

    'check if group already exists
    If Not Rhino.IsGroup(CStr(dblTestZ)) Then
      'create new group named height value
      Rhino.AddGroup CStr(dblTestZ)
    End If

    'add curve to group
    Rhino.AddObjectToGroup strCurve, CStr(dblTestZ)

  Next

End Sub

GroupByHeight

'**************************************************
Option Explicit

'LAY OUT TEMPLATES SCRIPT

'Platform: RhinoScript
'Written by: Rory Hyde
Sub layOutTemplates()

  'user inputs
  Dim arrCurves As Variant
  Dim strCurve As String
  Dim arrBBox As Variant, arrBBoxPt As Variant
  Dim arrTarget As Variant
  Dim arrTargetX(1), arrTargetY(1)
  Dim dblXWidth As Double, dblXSpacing As Double
  Dim dblYSpacing As Double
  Dim dblMaxY As Double, dblYDim As Double
  Dim xCount As Integer

  'start loop
  For Each strCurve In arrCurves

    'get bounding box
    arrBBox = Rhino.BoundingBox(strCurve)

    'point to copy to
    arrTargetX = arrTargetX + (dblLastX + dblXSpacing)
    arrTarget = Array(arrTargetX, arrTargetY, arrBBox(2))

    'copy object
    strCurve = Rhino.CopyObject(strCurve, arrBBox(0), arrTarget)

    'measure lastX
    dblLastX = Rhino.Distance(arrBBox(0), arrBBox(1))

    'measure Y dimension
    dblYDim = Rhino.Distance(arrBBox(0), arrBBox(3))
    If dblYDim > dblMaxY Then
      dblMaxY = dblYDim
    End If

    'when row is completed
    If arrTargetX >= dblXWidth Then
      arrTargetX = arrBase(0)
      dblLastX = 0
      xCount = 0
      arrTargetY = arrTargetY + dblMaxY
      dblMaxY = 0
    End If

  Next

End Sub
layOutTemplates
7.3.2 Soundwalls script

Option Explicit

' PLEAT SURFACE SCRIPT

' Platform: RhinoScript
' Written by: Rory Hyde
' Contact: rory.hyde@gmail.com
' Version: 1.0
' Date: 11th April 2006
' What it does: Builds a pleated soundwall.
' Developed for the Monash Soundwalls project 2006.

Sub Soundwalls()

' DEFINE VARIABLES

' Define variables for starting values
Dim arrBasePt
Dim arrAllValues, arrAllStrings, arrResults

' Define variables for plan line
Dim arrPlanLineEnd, arrPlanLineEndX, strPlanLine
Dim arrPlanLine2End, strPlanLine2

' Define variables for lower half
Dim arrBasePanelCorner, arrBasePanelMid, arrBasePanelPts
Dim arrBasePanel2Pts, arrBasePanel2Corner

' Define variables for upper half
Dim strCrossLine, arrCrossLineMidPt, strCrossLineMidPt
Dim strUpperEdge, strUpperEdge2, strUpperMid
Dim arrRefLine1(1), arrRefLine2(1), arrUpperRotation
Dim arrUpperMidAxis, arrUpperCornerAxis
Dim arrUpperCornerPt, arrUpperCornerPt2, arrUpperMidPt
Dim arrUpperPanel1Pts, arrUpperPanel2Pts
Dim arrDeleteObjects

' Define variables for join panels & loops
Dim strBaseLeftPanel, strBaseRightPanel, strTopLeftPanel, strTopRightPanel
Dim arrAllPanels, strAllPanels
Dim i, dblLoops, dblLoopsLast, dblTotalWidth

' Define variables for array along curve
Dim arrRef1, arrRef2, arrTar1, arrTar2
Dim arrRef, arrTar, strRefArc
Dim arrGuideIntersect
Dim arrArcPt1, arrArcPt2, arrArcPt3

' Define variables for calculator
Dim dblTempArea, dblTotalArea
Dim dblNoOfPanels, dblPanelCount, dblTotalLength
Dim dblPlanLength, dblMatEff
Dim strCalculatorMsg

dblPanelCount = 0
dblPlanLength = 0

' GET INPUT VALUES

' Set unit tolerance- refers to curve-curve intersection for align to curve Rhino.UnitAbsoluteTolerance .5
'Load last settings
dblLoopsLast = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblLoopsLast")
If IsNull(dblLoopsLast) Then dblLoopsLast = 10 Else dblLoopsLast = CDb1(dblLoopsLast)

dblLoops = Rhino.GetInteger("Define number of panels to draw", dblLoopsLast)
If IsNull(dblLoops) Then Exit Sub
dblLoops = dblLoops - 1
Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblLoopsLast", CStr(dblLoops)

'Define whether to array along curve or consecutive
Dim strArrayCurveYes, strArrayCurveNo
Dim strArrayCurveOptions, strArrayCurveResult

strArrayCurveYes = "Along_Curve"
strArrayCurveNo = "Consecutive"
strArrayCurveOptions = array(strArrayCurveYes, strArrayCurveNo)

strArrayCurveResult = Rhino.GetString("Array soundwalls along curve or draw linear?", strArrayCurveNo, strArrayCurveOptions)

' If array is along curve then set new base point
If strArrayCurveResult = strArrayCurveYes Then
    Dim strGuide
    'make base point start of curve
    arrBasePt = Rhino.CurveStartPoint(strGuide)
End If

' If array is consecutive then pick base point
If strArrayCurveResult = strArrayCurveNo Then
    arrBasePt = Rhino.GetPoint("Pick Base Point")
    If IsNull(arrBasePt) Then Exit Sub
End If

'------------------------------------------
'--- Create Dialogue Box Table -----------
'------------------------------------------

'Set Default Starting Values for dialogue box
Dim dblPlanAngle
Dim dblWidth
Dim dblBasePanelH
Dim dblMidPanelH
Dim dblTopPanelH

dblPlanAngle = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblPlanAngle")
If IsNull(dblPlanAngle) Then dblPlanAngle = 20 Else dblPlanAngle = CDb1(dblPlanAngle)

dblWidth = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblWidth")
If IsNull(dblWidth) Then dblWidth = 1.2 Else dblWidth = CDb1(dblWidth)

dblBasePanelH = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblBasePanelH")
If IsNull(dblBasePanelH) Then dblBasePanelH = 2.0 Else dblBasePanelH = CDb1(dblBasePanelH)

dblMidPanelH = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblMidPanelH")
If IsNull(dblMidPanelH) Then dblMidPanelH = 2.5 Else dblMidPanelH = CDb1(dblMidPanelH)

dblTopPanelH = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblTopPanelH")
If IsNull(dblTopPanelH) Then dblTopPanelH = 3.5 Else dblTopPanelH = CDb1(dblTopPanelH)
"Soundwall Script_Settings.ini", "Soundwalls", "dblTopPanelH")
If IsNull(dblTopPanelH) Then dblTopPanelH = 2.0 Else dblTopPanelH = CDb1(dblTopPanelH)

arrAllValues = array(dblPlanAngle, dblWidth, dblBasePanelH, dblMidPanelH, dblTopPanelH)

' Define titles of fields for dialogue box
Dim strPlanAngle: strPlanAngle = "Plan Fold Angle:"
Dim strWidth: strWidth = "Panel Width:"
Dim strBasePanelH: strBasePanelH = "Base Panel Height:"
Dim strMidPanelH: strMidPanelH = "Mid Panel Height:"
Dim strTopPanelH: strTopPanelH = "Top Panel Height:"

arrAllStrings = array(strPlanAngle, strWidth, strBasePanelH, strMidPanelH, strTopPanelH)

' Get new values for variables using dialogue box
arrResults = Rhino.PropertyListBox(arrAllStrings, arrAllValues, "Input Starting Values", "Soundwalls Script")

' Revise starting values
dblPlanAngle = CDbl(arrResults(0))
dblWidth = CDbl(arrResults(1))
dblBasePanelH = CDbl(arrResults(2))
dblMidPanelH = CDbl(arrResults(3))
dblTopPanelH = CDbl(arrResults(4))

Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblLoopsLast", CStr(dblLoops + 1)
Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblWidth", CStr(dblWidth)
Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblBasePanelH", CStr(dblBasePanelH)
Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblMidPanelH", CStr(dblMidPanelH)
Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblTopPanelH", CStr(dblTopPanelH)

' Define whether to increment values
If dblLoops > 0 Then

    Dim strIncrementYes, strIncrementNo,
    Dim strIncrementOptions, strInputIncrement
    Dim dblPlanAngleInc
    Dim dblWidthInc
    Dim dblBasePanelHInc
    Dim dblMidPanelHInc
    Dim dblTopPanelHInc

    Dim arrAllIncValues, arrIncResults, arrAllIncStrings

    strIncrementYes = "Yes"
    strIncrementNo = "No"
    strIncrementOptions = array(strIncrementYes, strIncrementNo)

    strInputIncrement = Rhino.GetString("Increment values?", strIncrementNo, strIncrementOptions)

    ' Get incremental values
    If strInputIncrement = strIncrementYes Then
dblPlanAngleInc = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblPlanAngleInc")

If IsNull(dblPlanAngleInc) Then dblPlanAngleInc = 1 Else dblPlanAngleInc = CDBl(dblPlanAngleInc)

dblWidthInc = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblWidthInc")

If IsNull(dblWidthInc) Then dblWidthInc = 0 Else dblWidthInc = CDBl(dblWidthInc)

dblBasePanelHInc = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblBasePanelHInc")

If IsNull(dblBasePanelHInc) Then dblBasePanelHInc = 0 Else dblBasePanelHInc = CDBl(dblBasePanelHInc)

dblMidPanelHInc = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblMidPanelHInc")

If IsNull(dblMidPanelHInc) Then dblMidPanelHInc = 0 Else dblMidPanelHInc = CDBl(dblMidPanelHInc)

dblTopPanelHInc = Rhino.GetSettings(Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblTopPanelHInc")

If IsNull(dblTopPanelHInc) Then dblTopPanelHInc = 0 Else dblTopPanelHInc = CDBl(dblTopPanelHInc)

arrAllIncValues = array(dblPlanAngleInc, dblWidthInc, dblBasePanelHInc, dblMidPanelHInc, dblTopPanelHInc)

Dim strPlanAngleInc: strPlanAngleInc = "Increment Plan Fold Angle:"
Dim strWidthInc: strWidthInc = "Increment Panel Width:"
Dim strBasePanelHInc: strBasePanelHInc = "Increment Base Panel Height:"
Dim strMidPanelHInc: strMidPanelHInc = "Increment Mid Panel Height:"
Dim strTopPanelHInc: strTopPanelHInc = "Increment Top Panel Height:"

arrAllIncStrings = array(strPlanAngleInc, strWidthInc, strBasePanelHInc, strMidPanelHInc, strTopPanelHInc)

arrIncResults = Rhino.PropertyListBox(arrAllIncStrings, arrAllIncValues, "Input Incremental Values", "Soundwalls Script")

dblPlanAngleInc = CDBl(arrIncResults(0))

dblWidthInc = CDBl(arrIncResults(1))

dblBasePanelHInc = CDBl(arrIncResults(2))

dblMidPanelHInc = CDBl(arrIncResults(3))

dblTopPanelHInc = CDBl(arrIncResults(4))

Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblPlanAngleInc", CStr(dblPlanAngleInc)

Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblWidthInc", CStr(dblWidthInc)

Rhino.SaveSettings Rhino.InstallFolder & "Soundwall_Script_Settings.ini", "Soundwalls", "dblBasePanelHInc", CStr(dblBasePanelHInc)
Rhino.SaveSettings Rhino.InstallFolder &
"Soundwall_Script_Settings.ini", "Soundwalls",
"dblMidPanelHInc", CStr(dblMidPanelHInc)

Rhino.SaveSettings Rhino.InstallFolder &
"Soundwall_Script_Settings.ini", "Soundwalls",
"dblTopPanelHInc", CStr(dblTopPanelHInc)

End If

If Start = vbNull
Rhino.Prompt "Building Soundwalls"

'------------------------------------------
'--- Start Drawing Soundwalls --------------
'------------------------------------------

For i = 0 To dblLoops

'Add Plan Line 1
arrPlanLineEndX = arrBasePt(0) + dblWidth
arrPlanLineEnd = array(arrPlanLineEndX, arrBasePt(1), arrBasePt(2))
strPlanLine = Rhino.AddLine(arrBasePt, arrPlanLineEnd)
strPlanLine = Rhino.RotateObject(strPlanLine, arrBasePt, dblPlanAngle)

'Add Plan Line 2
arrPlanLineEnd = Rhino.CurveEndPoint(strPlanLine)
arrPlanLineEnd2 = array((arrPlanLineEnd(0) + dblWidth),
arrPlanLineEnd(1), arrPlanLineEnd(2))
arrPlanLine2 = Rhino.AddLine(arrPlanLineEnd, arrPlanLineEnd2)
arrPlanLine2 = Rhino.RotateObject(arrPlanLine2, arrPlanLineEnd, -
dblPlanAngle)
arrPlanLine2End = Rhino.CurveEndPoint(arrPlanLine2)

'Add Lower Half
arrBasePanel1Corner = array(arrBasePt(0), arrBasePt(1), (arrBasePt(2) +
dblBasePanelH + dblMidPanelH))
arrBasePanel1Mid = array(arrPlanLineEnd(0), arrPlanLineEnd(1),
(arrPlanLineEnd(2) + dblBasePanelH))
arrBasePanel1Pts = array(arrBasePt, arrBasePanelCorner, arrBasePanel1Mid,
arrPlanLineEnd)
arrBaseLeftPanel = Rhino.AddSrfPt(arrBasePanel1Pts)
arrBasePanel2Corner = array(arrPlanLine2End(0), arrPlanLine2End(1),
(arrPlanLine2End(2) + dblBasePanelH + dblMidPanelH))
arrBasePanel2Pts = array(arrPlanLineEnd, arrBasePanelMid,
arrBasePanel2Corner, arrPlanLine2End)
arrBaseRightPanel = Rhino.AddSrfPt(arrBasePanel2Pts)

'Add Upper Half
strCrossLine = Rhino.AddLine(arrBasePanelCorner, arrBasePanel2Corner)
arrCrossLineMidPt = Rhino.CurveMidPoint(strCrossLine)
arrCrossLineMidPt = Rhino.AddPoint(arrCrossLineMidPt)
arrUpperEdge = Rhino.AddLine(arrBasePanelCorner,
|array(arrBasePanelCorner(0), arrBasePanelCorner(1),
|arrBasePanelCorner(2) + dblTopPanelH))

strUpperEdge2 = Rhino.AddLine(arrBasePanel2Corner,
|array(arrBasePanel2Corner(0), arrBasePanel2Corner(1),
|arrBasePanel2Corner(2) + dblTopPanelH))

strUpperMid = Rhino.AddLine(arrBasePanel1Mid, (array(arrBasePanel1Mid(0),
arrBasePanel1Mid(1), (arrBasePanel1Mid(2) + dblMidPanelH +
dblTopPanelH))}

CHAPTER 7  185  APPENDIX
' Calculate angle of rotation of top panel
arrRefLine1(0) = arrBasePanelMid
arrRefLine1(1) = Rhino.curveEndPoint(strUpperMid)
arrRefLine2(0) = arrBasePanelMid
arrRefLine2(1) = arrCrossLineMidPtp
arrUpperRotation = Rhino.Angle2(arrRefLine1, arrRefLine2)
arrUpperMidAxis = array(arrBasePanelMid, (array((arrBasePanelMid(0) +
(1), arrBasePanelMid(1), arrBasePanelMid(2))))
arrUpperCornerAxis = array(arrBasePanelCorner, 
(array((arrBasePanelCorner(0) + 1), arrBasePanelCorner(1),
arrBasePanelCorner(2))))
strUpperMid = Rhino.RotateObject(strUpperMid, arrBasePanelMid, 
(arrUpperRotation(0) * 2), arrUpperMidAxis)
strUpperEdge = Rhino.RotateObject(strUpperEdge, arrBasePanelCorner, 
(arrUpperRotation(0) * 2), arrUpperCornerAxis)
strUpperEdge2 = Rhino.RotateObject(strUpperEdge2, arrBasePanelCorner, 
(arrUpperRotation(0) * 2), arrUpperCornerAxis)

' Add Upper Panels
arrUpperCornerPt = Rhino.curveEndPoint(strUpperEdge)
arrUpperMidPt = Rhino.curveEndPoint(strUpperMid)
arrUpperCornerPt2 = Rhino.curveEndPoint(strUpperEdge2)
arrUpperPanel1Pts = array(arrBasePanelCorner, arrUpperCornerPt, 
arrUpperMidPt, arrBasePanelMid)
arrUpperPanel2Pts = array(arrBasePanelMid, arrUpperMidPt, 
arrUpperCornerPt2, arrBasePanelCorner)
strTopLeftPanel = Rhino.AddSrfPt(arrUpperPanel1Pts)
strTopRightPanel = Rhino.AddSrfPt(arrUpperPanel2Pts)

' Delete Unused Objects
arrDeleteObjects = array(strCrossLine, strCrossLineMidPtp, strUpperMid, 
strUpperEdge, strUpperEdge2, strPlanLine, strPlanLine2)
Rhino.DeleteObjects arrDeleteObjects

' Join panel sections
arrAllPanels = array([strBaseLeftPanel, strBaseRightPanel, 
strTopLeftPanel, strTopRightPanel])
strAllPanels = Rhino.JoinSurfaces (arrAllPanels, vbTrue)

'******************************************************************************
' ************ ARRAY ALONG CURVE ************
'******************************************************************************

' Calculate total width
dblTotalWidth = Rhino.Distance(arrBasePt, arrPlanLine2End)
If strArrayCurveResult = strArrayCurveYes Then
arrRef1 = arrBasePt
arrRef2 = arrPlanLine2End
arrRef = array(arrRef1, arrRef2)
' draws semicircle around base point toward x direction
arrArcPt1 = array(arrBasePt(0), (arrBasePt(1) + dblTotalWidth), 
arrBasePt(2))
arrArcPt2 = array((arrBasePt(0) + dblTotalWidth), arrBasePt(1), 
arrBasePt(2))
arrArcPt3 = array(arrBasePt(0), (arrBasePt(1) - dblTotalWidth), 
arrBasePt(2))
strRefArc = Rhino.AddArc3Ptp(arrArcPt1, arrArcPt3, arrArcPt2)
arrGuideIntersect = Rhino.curveIntersection(strRefArc,
strGuide
arrTar1 = arrBasePt
arrTar2 = arrGuideIntersect(0,2)
arrTar = array(arrTar1, arrTar2)
strAllPanels = Rhino.OrientObject(strAllPanels, arrRef, arrTar)
strRefArc = Rhino.OrientObject(strRefArc, arrRef, arrTar)
Rhino.DeleteObject strRefArc

If IsNull(arrGuideIntersect) Then
    Rhino.MessageBox "Guide curve and reference arc do not intersect." & vbNewLine & "Start of guide curve must lead off in x direction."
    Exit Sub
End If

' Reassign base point
arrBasePt = arrGuideIntersect(0,3)

If strArrayCurveResult = strArrayCurveNo Then
    arrBasePt = arrPlanLine2End
End If

dblPlanAngle = dblPlanAngle + dblPlanAngleInc
dblWidth = dblWidth + dblWidthInc
dblBasePanelH = dblBasePanelH + dblBasePanelHInc
dblMidPanelH = dblMidPanelH + dblMidPanelHInc
dblTopPanelH = dblTopPanelH + dblTopPanelHInc

' Calculate area
dblTempArea = Rhino.SurfaceArea(strAllPanels)
dblTotalArea = dblTempArea(0) + dblTotalArea

' Calculate length
dblTotalLength = dblTotalLength + dblTotalWidth
dblTotalLength = Round(dblTotalLength, 2)

' Calculate number of panels
dblPanelCount = dblPanelCount + 1
dblNoOfPanels = dblPanelCount

' Calculate efficiency
dblPlanLength = dblPlanLength + dblWidth

Next

Rhino.PrintEx "Soundwalls Completed"

dblTotalArea = Round((dblTempArea(0) + dblTotalArea), 2)


```
dblMatEff = (dblTotalLength / (dblPlanLength * 2)) * 100
dblMatEff = Round(dblMatEff, 2)

strCalculatorMsg = "No. of Panels = " & CStr(dblNoOfPanels) & vbCrLf
strCalculatorMsg = strCalculatorMsg & "Wall Length = " & CStr(dblTotalLength) & vbCrLf
strCalculatorMsg = strCalculatorMsg & "m" & vbCrLf
strCalculatorMsg = strCalculatorMsg & "Material Area = " & CStr(dblTotalArea) & vbCrLf
strCalculatorMsg = strCalculatorMsg & "m2" & vbCrLf
strCalculatorMsg = strCalculatorMsg & "Material Efficiency = " & dblMatEff & "%"

Rhino.MessageBox strCalculatorMsg, 64, "Soundwall Results"
```

End Sub

Soundwalls

### 7.3.3 Pleat surface script

```
Option Explicit

'PLEAT SURFACE SCRIPT

'Platform: RhinoScript
'Written by: Rory Hyde
'Contact: rory.hyde@gmail.com
'Version: 1.0
'Date: 2nd April 2006
'What it does: Panelises any curved surface with a declared number of triangular facets.

Sub PleatSurface()

'declare variables
Dim U, V
Dim i, j
Dim arrPoints, arrParam(1), arrTempPt
Dim nCol, nRow
Dim pt1, pt2, pt3

'get inputs
Dim strSurface: strSurface = Rhino.GetObject("pick input surface", 8)
If IsNull(strSurface) Then Exit Sub
Dim nRows: nRows = Rhino.GetInteger("no. of rows", 20)
If IsNull(nRows) Then Exit Sub
Dim nColumns: nColumns = Rhino.GetInteger("no. of columns", 10)
If IsNull(nColumns) Then Exit Sub

'disable redraw
Rhino.EnableRedraw vbFalse

'Get the domain of the surface
U = Rhino.SurfaceDomain(strSurface, 0)
V = Rhino.SurfaceDomain(strSurface, 1)
If Not IsArray(U) Or Not IsArray(V) Then Exit Sub

'Get the surface points
ReDim arrPoints(nRows, nColumns)

For i = 0 To nRows
  arrParam(0) = U(i) + ((U(i+1) - U(i)) / nRows) * i
  For j = 0 To nColumns
    arrParam(1) = V(j) + ((V(j+1) - V(j)) / nColumns) * j
    arrTempPt = Rhino.EvaluateSurface(strSurface, arrParam)
    arrPoints(nRow, nCol) = arrTempPt
  Next j
Next i
```
```
nCol = nCol + 1

Next
nCol = 0
nRow = nRow + 1

Next

'Panelise Surface
j = 0
i = 0
nCol = 0
nRow = 0

For j = 0 To (nRows / 2)
    For i = 0 To (nColumns / 2)
        'panel type 1
        If nCol + 2 <= nColumns And (nRow + 1) <= nRows Then
            pt1 = arrPoints(nRow, nCol)
            pt2 = arrPoints(nRow, (nCol + 2))
            pt3 = arrPoints((nRow + 1), (nCol + 1))
            Rhino.AddSrfPt(array(pt1, pt2, pt3))
        End If

        'panel type 2
        If nCol + 2 <= nColumns And nRow + 2 <= nRows Then
            pt1 = arrPoints((nRow + 2), (nCol))
            pt2 = arrPoints((nRow + 1), (nCol + 1))
            pt3 = arrPoints((nRow + 2), nCol + 1)
            Rhino.AddSrfPt array(pt1, pt2, pt3)
        End If

        'panel type 3
        If nCol + 3 <= nColumns And nRow + 1 <= nRows Then
            pt1 = arrPoints((nRow + 1), (nCol + 1))
            pt2 = arrPoints((nRow + 2), (nCol + 2))
            pt3 = arrPoints((nRow + 1), (nCol + 3))
            Rhino.AddSrfPt array(pt1, pt2, pt3)
        End If

        'panel type 4
        If nCol + 3 <= nColumns And nRow + 2 <= nRows Then
            pt1 = arrPoints((nRow + 1), (nCol + 1))
            pt2 = arrPoints((nRow + 1), (nCol + 3))
            pt3 = arrPoints((nRow + 2), (nCol + 2))
            Rhino.AddSrfPt array(pt1, pt2, pt3)
        End If

    nCol = nCol + 2

Next
nCol = 0
i = 0
nRow = nRow + 2

Next

'enable redraw
Rhino.EnableRedraw vbTrue

End Sub
PleatSurface
7.3.4 Assign layer by angle script

Option Explicit

'ASSIGN LAYER BY ANGLE SCRIPT

'Platform: RhinoScript
'Written by: Rory Hyde
'Contact: rory.hyde@gmail.com
'Version: 1.0
'Date: 18th July 2007

'What it does: Divides a number of surfaces into different layers depending on the angle of the normal of each surface relative to an input line.
'Developed in parallel with the PleatSurface script.

Sub LayerByAngle()
    Dim arrInputSurfaces, strInputCurve
    arrInputSurfaces = Rhino.GetObject("Select input surfaces", 8)
    strInputCurve = Rhino.GetObject("Select vector curve", 4)
    AssignLayerByAngle arrInputSurfaces, strInputCurve
End Sub

Function AssignLayerByAngle(arrSurfaces, strCurve)
    Dim arrNormalParam, dblTempAngle, arrSurfaceVector, arrSurfaceNormal
    Dim strSurfaceVector, strPtOnSrf, strPtOnSrf2, arrPtOnSrf
    Dim arrSurface
    Dim arrStartPt, arrEndPt, arrRefLine

    arrNormalParam = array(0.5, 0.5)

    ' Add the layers to divide the surfaces into
    Rhino.AddLayer "0 - 30 Degrees", RGB(127, 0, 255)
    Rhino.AddLayer "31 - 60 Degrees", RGB(255, 0, 255)
    Rhino.AddLayer "61 - 90 Degrees", RGB(255, 0, 127)
    Rhino.AddLayer "91 - 120 Degrees", RGB(255, 0, 0)
    Rhino.AddLayer "121 - 150 Degrees", RGB(255, 127, 0)
    Rhino.AddLayer "151 - 180 Degrees", RGB(255, 255, 0)

    ' Create array of start and end point of reference line
    arrStartPt = Rhino.CurveEndPoint(strCurve)
    arrEndPt = Rhino.CurveStartPoint(strCurve)
    arrRefLine = array(arrStartPt, arrEndPt)

    ' Evaluate each surface and assign a layer
    For Each arrSurface In arrSurfaces
        '1. get surface normal = vector
        arrSurfaceVector = Rhino.SurfaceNormal(arrSurface, arrNormalParam)

        '3. get point on surface
        arrPtOnSrf = Rhino.EvaluateSurface (arrSurface, arrNormalParam)

        '4. add point on surface
        strPtOnSrf = Rhino.AddPoint(arrPtOnSrf)

        '5. move surface point by normal vector
        Rhino.MoveObject strPtOnSrf, arrSurfaceVector
    Next
End Function
7.3.5 Lay out surfaces script

Option Explicit

'LAY OUT TEMPLATES SCRIPT

'Platform: RhinoScript
'Written by: Rory Hyde
'Contact: rory.hyde@gmail.com
'Version: 1.0
'Date: 12th June 2007
'What it does: Lays out and numbers laser cutter templates.
'Created for the Ice Cream Lamp project.

Sub layOutTemplates()
    'user inputs
    Dim arrCurves: arrCurves = Rhino.GetObjects("Select templates to lay out", 0, vbTrue)
    Dim arrBase: arrBase = Rhino.GetPoint("Pick base point")
    Dim dblXWidth: dblXWidth = Rhino.GetInteger("Row width", 1000)
    Dim dblXSpacing: dblXSpacing = Rhino.GetReal("Row gap", 10)
    Dim dblYSpacing: dblYSpacing = Rhino.GetReal("Column gap", 10)
'variables
Dim strCurve
Dim arrBBox, arrBBoxPt

Dim arrTarget
Dim arrTargetX: arrTargetX = arrBase(0)
Dim arrTargetY: arrTargetY = arrBase(1)

Dim dblLastX: dblLastX = 0
Dim dblLastY: dblLastY = 0

Dim xCount: xCount = 1
Dim dblMaxY: dblMaxY = 0
Dim dblYDim

'start loop
For Each strCurve In arrCurves

'get bounding box
arrBBox = Rhino.BoundingBox(strCurve)

'point to copy to
arrTargetX = arrTargetX + (dblLastX + dblXSpacing)
arrTarget = array(arrTargetX, arrTargetY, arrBase(2))

'copy object
strCurve = Rhino.CopyObject(strCurve, arrBBox(0), arrTarget)

'measure lastX
dblLastX = Rhino.Distance(arrBBox(0), arrBBox(1))

'measure Y dimension
dblYDim = Rhino.Distance(arrBBox(0), arrBBox(3))
If dblYDim > dblMaxY Then
    dblMaxY = dblYDim
End If

'when row is completed
If arrTargetX >= dblXWidth Then
    arrTargetX = arrBase(0)
    dblLastX = 0
    xCount = 0
    arrTargetY = arrTargetY + dblMaxY
    dblMaxY = 0
End If

Next
End Sub
layOutTemplates
7.4 Paper: ‘Punching above your weight’

Presented at the 2007 ACADIA conference and published in the associated proceedings.

Full citation:

Expanding bodies of knowledge imply expanding teams to manage this knowledge. Paradoxically, it can be shown that in situations of complexity—which increasingly characterise the production of architecture generally—the small practice or small team could be at an advantage. This is due to the increasingly digital nature of the work undertaken and artefacts produced by practices, enabling production processes to be augmented with digital toolsets and for tight project delivery networks to be forged with other collaborators and consultants (Frazer 2006). Furthermore, as Christensen argues, being small may also be desirable, as innovations are less likely to be developed by large, established companies (Christensen 1997).

By working smarter, and managing the complexity of design and construction, not only can the small practice “punch above its weight” and compete with larger practices, this research suggests it is a more appropriate model for practice in the digital age.

This paper demonstrates this through the implementation of emerging technologies and strategies including generative and parametric design, digital fabrication, and digital construction. These strategies have been employed on a number of built and un-built case-study projects in a unique collaboration between RMIT University’s SIAL lab and the award-winning design practice BKK Architects.
‘PUNCHING ABOVE YOUR WEIGHT’
IN A CONTEXT OF COMPLEXITY

This research has been undertaken in collaboration between RMIT University’s SIAL lab and BKK Architects, a design practice comprised of a small number of people, in which the investigator is embedded as a participant-observer. The research, developed within this unique structure, was initiated as a means for research undertaken within the university to be directed toward current issues encountered in practice. A two-way dependent relationship is established whereby RMIT offers a resource network of technical experts, equipment and training, and BKK brings real-world projects with the associated real-world issues to which this expertise can be applied.

What is particular about BKK is that the directors of this practice are intent on limiting the number of people in the practice as a way of remaining close to the designs, collaborators, staff, and clients. In an interview with the partners, director Simon Knott stated “when we first started, we said ‘we want to be a big international practice,’ and now we’re thinking maybe we don’t want that, maybe we want to be hands on, and keep it back to 10 or 15 people in the office” (Hyde 2006). The partners also consider the practice’s high design quality to be their greatest interest and competitive strength—staying small is one strategy to ensure this continues to be so.

There is a strong culture of small practices in Australia; Ian McDougall, during his presidency of the Victorian Chapter of the RAIA, stated, “small practices are the site of experimentation and innovation” (McDougall 2001). Indeed, Australia’s only Pritzker Prize Laureate, Glenn Murcutt, has a practice size of one. However the range of scale and complexity that can traditionally be managed by a small practice is limited. The RAIA’s Small Practice Survey (2002) shows the market dominance of large practices in the case of large projects. Of course there are many factors informing this trend, but one could argue that it is due to large practices having the resources to manage the complexity of procurement for large projects. This leaves small practices—even the highly talented and successful Murcutt—to cater for the smaller markets of housing, retail and small commercial projects (Carter Brown et al. 2002).

This issue is further compounded by the increasing complexity of the practice of architecture. One issue, which Robert Venturi addressed as early as 1966, is that “architecture is necessarily complex and contradictory…today the wants of program, structure, mechanical equipment, and expression, even in single buildings in simple contexts, are diverse and conflicting in ways previously unimaginable” (Venturi 1966). But rather than retreat to simplicity in response to this increasing complexity—the “less is more” attitude for which Venturi criticised the Modernists—many architects today are actively pursuing it. Spurred on by the new possibilities offered by rapidly increasing processing power, increasingly sophisticated CAD software, and the concurrent developments in digital fabrication, architects are everywhere exploring a formal language of complexity (Jencks 2003).
When what is proposed is not conventional, the various subsequent stages of production can also become more complex. Formal complexity leads to constructional complexity, which leads to representational complexity, which in turn leads to the complexity of information management, which implies a larger team to manage this information. This research proposes that, by developing integrated design strategies that incorporate these many layers of complexity, namely material constraints, the process of construction, and the means for representation, innovative, high quality design can be pursued without the subsequent increase in the number of people required to manage this complexity.

TECHNOLOGY AND PRACTICE SIZE

While this challenge is in response to one practice’s particular desires, there is a growing body of economic theory which argues that the new economic era will increasingly favour small firms. Bjerke and Hultman argue this shift is largely due to the changing nature of competitive business assets, wherebyт“production capacity and financial strength are to an ever increasing extent replaced by more intangible, but yet more relevant and adequate, skills of constructing and using information and knowledge.” Furthermore, they state, “these capabilities do not seem to improve with size” (Bjerke and Hultman 2002).

This shift toward more intangible competitive assets is well underway in architectural practice. The task of construction documentation, which is traditionally assigned the greatest number of person-hours to deliver (RAIA 2005), is being made increasingly efficient by CAD documentation systems which can automate the production of drawings and specifications from a coordinated 3-D model. It is the intangibility of the digital information produced, when compared with the
An interesting side-effect of these technological developments is the impact they may have on the organisational structures of practices. While E. F. Schumacher in 1973 blamed modern technology for the irresistible trend of firms becoming even bigger, it now appears technology may offer the potential to reverse this trend. With the ‘brute-strength’ of a large documentation team being superseded by increasingly sophisticated CAD documentation systems, a large practice is no longer a prerequisite for tackling a large or complex project. The question then becomes “what is the ideal size of a practice?” Baxter and Lisburn, using the example of the software development industry, argue that the new information-based organisation should be “flat and lean,” meaning comprised of fewer people in a management structure of fewer tiers, as “you can get a team of six or eight into a war room—a single office with the same working conditions for everyone, and with everything and everyone to hand” (Baxter and Lisburn 1994).

The implementation of this approach is discussed by Frazer who uses Swire’s One Island East project in Hong Kong as an example, which was designed and documented with only a very small, co-located, multi-disciplinary team. Frazer notes that this model “could empower small practices to take on very big projects” (Frazer 2006). While One Island East was documented using the proprietary software Digital Project, which enables specialists from different disciplines to coordinate and share building information through one 3-D model, this represents just one approach for managing expanding bodies of design knowledge as a small team (Khemlani 2006).

LOCAL RESEARCH BY Berry states that “industries in a world of flexible specialisation are increasingly driven by competitive pressures to ‘de-verticalise’… creating interacting complexes of smaller firms specialising in different but linked parts of the overall production process” (Berry 2003). This structure has been adopted by BKK, which is comprised of a small number of people, but who make connections beyond the practice—with the university, professional bodies or media for example—and also by establishing ongoing relationships with consultants and collaborators, including artists and other designers (Figure 1). This network is constantly evolving as staff come and go and new relationships are formed.

If this network of resources and specialist expertise is critical for the small practice to innovate, then the strategies for capturing and integrating these bodies of knowledge into the design and delivery process also become critical. The following 2 case studies explore means for capturing knowledge and information, and propose strategies for implementing these bodies of knowledge as drivers of design processes.
CASE STUDY 1. SOUND-WALLS: DESIGN AS INFORMED EXPERIMENT

This first strategy adopts a script-based approach combined with an evaluation process to refine a design concept toward a desirable—but as yet unknown—outcome or goal through a series of experiments. As a means of illustrating this approach, I will describe how it was implemented in a real project for the design of freeway sound-walls by BKK Architects.

The technical complexity of this project necessitated a large number of stakeholders and specialists, who each brought particular expertise and requirements to the project. Figure 2 illustrates these various parties, what they bring to the project, and the paths of communication and negotiation between them.

Feedback from this collaborative network steered or limited the possibilities, and largely dictated our initial approach. The main parameters were: 1) that as much of the fabrication be done off-site as possible to avoid the need to block traffic; 2) that significant savings could be achieved by developing a repetitive system; 3) that the required height of the walls be adhered to; and 4) that panel widths be based on standard material sheets.

The design concept of pleating was established by the directors, a decision informed both by an intuitive response to the site, the practical constraints outlined above, and the project budget, as it could potentially offer a complex formal language entirely comprised of flat panels. Folded paper models were developed in parallel with manual 3-D modelling to explore the range of possibilities offered by this language, and also as a means to compile the geometric parameters (Figure 3).

These parameters were then used to inform a script written for the proprietary 3-D modelling program Rhinoceros using the ‘RhinoScript’ Visual Basic scripting plug-in. This script took numeric values for each of the geometric parameters as inputs and generated pleated panels in 3-D space using a series of modelling operations and transformations (Figure 4).

The quantifiable requirements determined by the network of collaborators were built into the script as bookends on the design space, so that only possible solutions are explored. Performance parameters of the walls generated by the script were also delivered as outputs. These included the amount of material used, the efficiency of this material compared with a flat wall, and the number of panels used to make up this wall. Experimentation subsequently occurs within this design space—as an experiment informed both by the range of possibilities and output properties.

Through experimenting with the script—or learning to play it—a system that used identical panels was developed that would still give the effect of compression or expansion just by incrementally varying the spacing of the structure behind (Figure 5).

There are a number of advantages to working in this way when compared with a traditional drafted approach: it avoids time-consuming erasure and redrawing, accepts the inevitable modifications required in design development, and information can be easily repurposed and exported for other uses including analysis.

What is important about this strategy in relation to the arguments of this paper and the conference theme is how it enabled a small number of people to manage the complexity of large amounts of tacit design knowledge to deliver a project typically outside the scope of a small practice (Figure 6).

CASE STUDY 2. PAVILION: DEFERRED DECISION DESIGNING

This design strategy implements parametric design software to create a “metadesign” model (Burry 2003), which is composed of relationships, but not explicit dimensions. These relationships are then adjusted
and modified in response to site conditions, aesthetic requirements, material constraints, constructional issues etc., to determine the final, explicitly defined dimensions which are subsequently used for construction. This approach will be illustrated using a project for a pavilion, which BKK Architects was invited to design for an architecture exhibition mounted by the Monash University Museum of Art (MUMA).

The design concept was to investigate the pavilion type, while retaining some of the properties often explored through pavilions namely the single idea or gesture, continuity between wall and roof, and an integrated structural solution. Buckminster Fuller’s geodesic U.S. Pavilion designed for the 1967 World’s Fair in Montreal was used as a key precedent exhibiting these properties.

The geodesic structural pattern of Fuller’s dome was located in 3-D space using the CAD program CATIA, with each honeycomb cell being constructed as a closed loop of straight lines. Each of these cells were then projected to a centre point located within this sphere, resulting in a set of joined surfaces converging on a single point. These surfaces were then trimmed against an inner and outer cube, resulting in a visually and geometrically complex hollow cube of closed honeycomb cells (Figure 7).

Each of these 3-D honeycomb cells were then unfolded in sequence and laid out flat in a 2-D plane. These 2-D profiles were then numbered with a part number, which could be referenced back to their 3-D source cell, and exported for nesting and subsequent cutting out. These 2-D profiles were then cut out of card using a laser cutter. The 2-D card profiles were then re-folded into 3-D cells and nested together to form the 1:10 scale prototype (Figure 8).

An important aspect of this strategy is that changes to parameters defined early in the process are propagated downstream to update subsequent procedures without the need for erasure and redrawing, allowing design decisions to be deferred right up to the last minute. Furthermore, if these subsequent procedures are fabrication orientated, a closed loop between design and construction is established, whereby subsequent iterations can learn from or be informed by the previous iteration, simulating the common design refinement process of trial and error. Furthermore, by connecting the logic of design with the logic of production, cost and time efficiencies can be generated (Figure 9).

This potential to defer design decisions was implemented between the development of the 1:10 scale prototype and production of the 1:1 scale completed pavilion in response to how the pavilion was to be exhibited in the gallery. It was decided that the piece would be suspended from the ceiling allowing the audience to duck underneath it and experience the interior. The point of convergence—which for the prototype was located in an upper corner of the cube—was moved to a position lower down and centred, allowing the viewer to position their head at this point of convergence (Figure 10). When viewing the piece from this point, only the cell edges are visible, rendering the piece as a net devoid of depth, reinforcing the projected nature of the design. As this centre point—and indeed the entire model—was parametric, this late change did not require any extra work as all the unfolded profiles were parametrically linked to the 3-D model.

One way to illustrate the efficiency of this method would be to document this (twice!) using a set of traditional 2-D plans, sections, and elevations and compare the time it took to do so. Not only would it be extremely difficult to accurately calculate the positions of the complex geometry manually, these drawings would not communicate enough information to construct the piece. As this design is the result of an integrated 3-D process, it requires a customised approach to communicating this information.

This approach exploits the internalised operations of the software, so that the designer is not exposed to the geometric or mathematical complexity of the project, but is free to compose the process and manipulate the higher-level parameters that influence the outcome.

In reference to the broader proposition of this paper, this project is an example where design complexity was increased beyond what was previously possible to traditionally communicate for construction, but through the implementation of this project-specific strategy this complexity was managed and the project was delivered by a very small team.
IMPLICATIONS IN PRACTICE
This paper has sought to illustrate how new technologies—and specifically project-specific strategies which implement this new technology—can enable small teams to achieve more in situations of complexity. This section reflects on the implications of the adoption of these strategies in the real context of practice.

The ability to make radical changes quickly has influenced the way directors work with staff. Previously, a director would draw a sketch communicating design intent, which would get drawn up as an explicitly defined 2-D or 3-D CAD drawing by a student or graduate architect. This drawing would then get passed back to the director for marking up, and would then be passed back to the student or graduate to make these changes. This process is then repeated until a satisfactory design is resolved, or until the deadline approaches. Time to produce changes or iterations is limited by the slow process of erasure and redrawing and by the availability of the director to review these changes.

The introduction of parametric design and scripting into the office has meant that although there is greater investment of time up-front to build a parametric model or to write a script, once either has been produced, design discussions can move very quickly with revisions made in real-time, keeping up with this conversation. This model or script artefact also retains its usefulness beyond the design stage, and, as is often the case with scripts and depending on how generic the function is, can be used again on subsequent projects.

However, this shift has also brought with it some issues. Building a parametric model or writing a script requires a more rigorous approach than required when working with explicitly defined objects. Parameters need to be clearly articulated and structured in a manner that embeds the logic of the design in the model, while copying a sketch or making mark-ups requires very little understanding of what is being represented.

Furthermore, the introduction of these various new forms of digital media, has meant that there is no longer one default method of representation dictated by the office manual, but as many strategies as there are projects. At BKK, while most projects will still have a standard set of 2-D documents, these are increasingly being augmented by other forms of representation for direct communication to manufacturing machines, namely, spreadsheets, databases, unfolded templates, and 3-D models.

As reliance on the ‘standard approach’ recedes, which solution moves into its place is—in a minor inversion of the office politic—often most apparent to the operator who has worked through the parametric model or written the script, not the director in charge. BKK has recognised the importance of gathering this insight derived from the “front-line” and has developed strategies for the transfer of knowledge and information between the operators and directors. This is encouraged through regular review sessions where projects that are currently in design are presented by those actually doing the work to the office and directors for feedback.

CONCLUSION
It is strategies and projects like these that suggest it is both possible and desirable for a small practice to punch above its weight because, as has been argued, these systems are much harder to establish underneath the organisational burden of a large practice, and geared toward the strengths of small practice—namely design innovation.

Have we punched above our weight? Certainly BKK are more efficient and capable of engaging projects of greater complexity, but to objectively measure whether it has competed with larger practices is difficult, as there are many factors involved. However, as a tentative conclusion, I will give an example of where the practice seems to have achieved this. The exhibition of pavilions mounted by MUMA featured 9 emerging practices of which BKK was one. Subsequently, and I would suggest due to the success of the piece, BKK was the only firm from the exhibition invited to participate in a competition for a substantial extension to their gallery against a field comprised of all larger firms. Further to this, BKK was also invited, by the same university, to participate in a competition for their new architecture school, again against a pool of larger, more established practices.

As a concluding anecdote, while the practice can now manage large or complex jobs while staying small, they have had to respond to expectations of clients where “capable” often means “large.” In response to this, a curtain was installed in the office foyer to enable clients to make their way to the meeting room which concealed the rest of the office, making the true number of staff in the practice seem ambiguous.

ACKNOWLEDGEMENTS
This research has been supported by the Australian Research Council, RMIT University’s Spatial Information Architecture Laboratory, the Embedded Research within Architectural Practice Linkage Grant and BKK Architects.
REFERENCES


7.5 List of abbreviations

AD  Architectural Design
BIM  Building Information Modelling
BKK  Black Kosloff Knott Architects
CAD  Computer Aided Design
CAM  Computer Aided Manufacturing
CTO  Chief Technology Officer
FAT  Fashion Architecture Taste Architects
FOA  Foreign Office Architects
GRB  Grounds Romberg and Boyd Architects
MOMA Museum of Modern Art
OMA  Office of Metropolitan Architecture
RMIT Royal Melbourne Institute of Technology University
SBE  Sustainable Built Environments
SIAL  Spatial Information Architecture Laboratory
SMG  Specialist Modelling Group
SOM  Skidmore Owings and Merrill Architects
TAC  The Architects Collaborative
UTAS University of Tasmania
Bibliography


205


Mau, B 2000, Life Style, New York, Phaidon.


Rowe, P 1987, Design Thinking, Cambridge, MIT Press.


Wilson, R G 1983, McKim, Mead and White Architects. New York, Rizzoli.

Wodehouse, L 1988, White of McKim, Mead and White, New York, Garland Publishing.


Zaera-Polo, A, Moussavi, F 2003, Phylogenesis: FOA’s ark, Barcelona, Actar.

Acknowledgements

Thank you to Simon Knott, Tim Black and Julian Kosloff of BKK Architects for providing a supportive and challenging practice context to undertake this research.

To the other candidates in the Embedded Practice program, Marcus White, Paul Nicholas and Sarah Benton, without whom this would have been a far less enjoyable experience.

A special thanks to my supervisor Mark Burry for his patience and guidance throughout my candidature. And to Juliette Peers and Judith Trimble for their comments and advice on the final manuscript.


Thanks to my friends and family for all their support and welcome distractions. Stuart Harrison, Scott Mitchell, Bianca Hester, Jane Caught, Cecilia Cook, Ava Warbrick, James Patterson, Martin Mustatowicz, Tobias Pond, Louisa Macleod, Paul Coffey, Michael Roper, Lily Randall, Martin Beaver, Suzanne Silver, Michael Silver, Tom Hyde, Edward Hyde, David and Atalanta Woodward, Anthony and Chloe Hyde.

A very special thanks to Amy Silver.