

Carving Away:  
An Inquiry into the Act of Making

by

Matthew Peddie

A thesis  
presented to the University of Waterloo  
in fulfillment of the  
thesis requirement for the degree of  
Master of Architecture

## AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

## ABSTRACT

The act of creating anything, from a novel to a simple meal to a building, requires the combination of many elements. Broadly speaking, these elements are technique, technology, and materiality, the three of which are brought into combination according to the intent of the maker.

The effects of the combination of these elements can be very powerful. One need only call to mind the cool, damp weightiness of stepping inside a church whose walls are made of solid stone or to contrast this experience with that of picking up a lightweight rowing shell whose thin wood frame and taut fabric skin combine amazing strength with impossible slenderness. These experiences amaze and move us because the various elements that brought them into being are combined in a harmonious way and one that is aligned with a poetic ambition.

This is not to say that all three elements need to be mixed in equal proportions or that there is a hierarchy of importance; it is the mixing that is essential, not the presence of any one element. A specific focus of this thesis is technology and the way that architects use it and are shaped by its use. Many architects have rushed to embrace recent advances in digital design and fabrication tools, forgetting that the act of making requires the convergence of a number of forces. Focussing too much attention on one will often come at that detriment of another.

Through a series of projects, this thesis explores a number of methods of designing and making. The projects undertaken range from a series of hand carved spoons, to sculptural, physical translations of flowing water, through to the full-scale realization of a suspended ceiling for the North House prototype. An effort has been made to work across a variety of scales, and to employ as wide a range of techniques and technologies as possible. These projects have afforded a kind of research through making, one that engages the entire body rather than merely the mind, and which has been supplemented with more traditional means of research.

In addition to the role of technology in architectural practice, attention has been paid to the relationship between ways of making and time, and to the way in which certain artists, designers, and architects are able to slow, compress, or even transcend time. A series of brief case studies serves to illustrate how this is possible while also describing a set of values against which the work of this thesis can be calibrated.

By its very nature this thesis takes the form of an ongoing project, one in search of a somewhat elusive goal. The path that a powerful and moving project must take is often full of uncertainty. If I am certain of anything however, it is that achieving the proper mixture of elements requires patience, persistence, and a willingness to let a project take on a life of its own.

## ACKNOWLEDGMENTS

I would like to thank my committee for their support and guidance. Robert Jan, thank you for taking on a thesis that might not fit within your typical area of expertise and for treating it with respect and patience. Furthermore, I would like to thank you for not once mentioning the Holocaust. Dereck, thanks especially for an inspiring MI term that formed the basis of much of this work and for making sure that the rest of my work lived up to the high aspirations that were formed early on. John, thank you for timely and sage advice and criticism, and the energy that a fresh voice brings to the table. I would also like to thank my external reviewer, Fred Thompson, for bringing a unique perspective (and some unique friends) to my defense.

To the many faculty and staff that have helped me along the way, thank you.

To the gentlemen who run the workshop, John Debrone, Dan Jessel, and Heinz Koller, thank you for taking my sometimes hare-brained ideas seriously, and for always offering a word of advice or a helping hand.

I would also like to thank my friends and classmates who have made this journey bearable, enjoyable and memorable. Perhaps the greatest asset that this school has is its students, and we all have so much to be proud of.

I would like to thank my family for putting up with my absence and for always giving me a place to stay, a warm meal, and a supportive hug.

Finally I would like to thank my editor, my personal chef, and my closest friend Christine. You have helped me more than you can know, and I feel blessed to have you beside me holding my hand, ahead of me leading the way, and behind me, pushing me along.

## DEDICATION

I would like to dedicate this thesis to my parents. Your love and support has allowed me to follow my dreams, truly the most wonderful gift you could give.



## Table of Contents

Author's Declaration	ii
Abstract	iii
Acknowledgements	iv
Dedication	v
Table of Contents	vii
List of Illustrations	viii
Introduction	I
<b>1/</b> Transcending	8
<b>2/</b> What does a spoon have to do with architecture?	28
<b>3/</b> Embedding	32
<b>4/</b> Ten Spoons	40
<b>5/</b> Thickening	62
<i>Epilogue - Material Transformations</i>	72
<b>6/</b> The Bosphorus	82
<b>7/</b> The Question of Computers	88
<i>Epilogue - North House Ceiling</i>	104
<b>8/</b> The Staring Contest	110
<b>9/</b> Hydrophilia	114
<i>Turbulence</i>	122
<i>Vaporization</i>	132
<i>Wind and Water</i>	144
Conclusion	158
References	164

## List of Illustrations

Page	Figure	Description and Source
Introduction		
xvi	Fig X.1	"Piazza" Alberto Giacometti, 1947-48 – Guggenheim Collection online, <a href="http://www.guggenheim.org/new-york/collections/collection-online/showfull/piece/earch=Piazza&amp;page=&amp;f=Title&amp;object=76.2553.135">http://www.guggenheim.org/new-york/collections/collection-online/showfull/piece/earch=Piazza&amp;page=&amp;f=Title&amp;object=76.2553.135</a> (accessed April 20, 2010)
Chapter 1		
10	Fig 1.1	left: Humber River Pedestrian Bridge – Montgomery Sisam Architects, photo by Craig White right: Pünt da Suransuns, Jürg Conzett Eng., photo by Brian Duguid
12	Fig 1.2	Interior view of Bruder Klaus Chapel. Baglione, Chiara "Interview with Peter Zumthor." Casabella Sept. 2006: 91-2
13	Fig 1.3	Construction photo Bruder Klaus Chapel. Baglione, Chiara "Interview with Peter Zumthor." Casabella Sept. 2006: 91-2
14	Fig 1.4	La Morphinas Door Handles – Commonwealth Studio <a href="http://www.commonwealth.nu/projects/26/morfinas">http://www.commonwealth.nu/projects/26/morfinas</a> accessed June 21, 2010
15	Fig 1.5	"La Morphina" – Santiago Rusinol, 1894, Wikipedia Commons <a href="http://commons.wikimedia.org/wiki/File:La_morfina_%28Santiago_Rusi%C3%B1ol%29.jpg">http://commons.wikimedia.org/wiki/File:La_morfina_%28Santiago_Rusi%C3%B1ol%29.jpg</a> (accessed July 18, 2010)
15	Fig 1.6	Morphinas in Bronze SLA originals and wax duplicates – Commonwealth Studio <a href="http://www.commonwealth.nu/projects/26/morfinas">http://www.commonwealth.nu/projects/26/morfinas</a> (accessed June 21, 2010)
15	Fig 1.7	Morphinas in Bronze, Bronze Silicate being poured – Commonwealth Studio <a href="http://www.commonwealth.nu/projects/26/morfinas">http://www.commonwealth.nu/projects/26/morfinas</a>



(accessed June 21, 2010)

- 16 Fig 1.8 Pünt da Suransuns, Jürg Conzett Eng., photo by Brian Duguid
- 17 Fig 1.9 Topography of the Viamala Gorge.  
Conzett, Jürg. and, Mohsen Mostafavi. Structure as Space. London:  
Architectural Association, 2006
- 17 Fig 1.10 Section through footbridge.  
Conzett, Jürg. and, Mohsen Mostafavi. Structure as Space. London:  
Architectural Association, 2006
- 18 Fig 1.11 Collation Gallery, Le Thoronet.  
Lucien Herve. The Architecture of Truth. London: Phaidon Press, 2001
- 19 Fig 1.12 Plan of Le Thoronet  
Lucien Herve. The Architecture of Truth. London: Phaidon Press, 2001
- 20 Fig 1.13 Apple iPhone – Apple website  
<http://www.apple.com/iphone/>  
(accessed May 18, 2010)
- 21 Fig 1.14 Iphone gestural interface system- patent drawing  
<http://www.slashgear.com/apple-multitouch-fusion-patent-mixes-touch-with-voice-biometrics-0415319/#entrycontent>  
(accessed may 18, 2010)
- 22 Fig 1.15 plywood sculpture by Tapio Wirkkala  
Periainen, Tapio. Tapio Wirkkala. Helsinki: The Finnish Society of Crafts and  
Design, 1981.
- 23 Fig 1.16 Tapio Wirkkala's hands at work  
Periainen, Tapio. Tapio Wirkkala. Helsinki: The Finnish Society of Crafts and  
Design, 1981.
- 24 Fig 1.17 date painting, On Kawara – Ikon Gallery website  
[http://www.ikon-gallery.co.uk/online\\_shop/ikon\\_catalogues/artistsmonograph/item/eternal\\_return/image/153/](http://www.ikon-gallery.co.uk/online_shop/ikon_catalogues/artistsmonograph/item/eternal_return/image/153/)  
(accessed May 31<sup>st</sup>, 2010)
- 25 Fig 1.18 On Kawara's date paintings in progress, photo: Henning Weidemann  
Chiong, Kathryn. "Kawara on Kawara". October. Vol. 90, Autumn 1999: 50
- 27 Fig 1.19 3 standard stoppages, Marcel Duchamp – MOMA Collection online  
[http://www.moma.org/collection/browse\\_results.php?criteria=O%3AAD%3AE%3A1634&page\\_number=8&template\\_id=1&sort\\_order=1](http://www.moma.org/collection/browse_results.php?criteria=O%3AAD%3AE%3A1634&page_number=8&template_id=1&sort_order=1)  
(accessed July 7<sup>th</sup>, 2010)

## Chapter 2

- 28 Fig 2.1 Spoon # 1, Walnut, 30cm x 6cm. Photograph.
- 29 Fig 2.2 Spoon Carving Techniques. Diagram.

30	Fig 2.3	Spoon #1 in progress. Stills from Video.
31	Fig 2.4	Spoon Carving Techniques. Diagram.
Chapter 3		
32	Fig 3.1	10 Spoons. Photo Overlay
33	Fig 3.2	Cutting with Woodgrain. Diagram redraw by author from Hoadley 2000
34	Fig 3.3	Carving Tools. Photograph.
35	Fig 3.4	Thickness Planing. Diagram
35	Fig 3.5	Photograph and Diagram of Woodgrain
36	Fig 3.6	Photograph of Monk's Feet embedded in Temple Floor. Duncan, Max. "Ageing Monk's Devotion leaves deep mark on Temple." <u>Reuter's</u> . 26 Feb, 2009.
37	Fig 3.7	Photograph of Spoon Carving
39	Fig 3.8	Black Walnut material sample, sanded and oiled on one face
Chapter 4		
40	Fig 4.1	10 Spoons. Photograph.
42	Fig 4.2	Spoon #1: cooking spoon - walnut, 32 cm. Photograph.
44	Fig.4.3	Spoon # 6: tasting spoon -spalted maple, 32 cm. Photograph.
46	Fig. 4.4	Spoon # 7: sugar scoop - cherry, 12 cm. Photograph.
58	Fig. 4.5	Spoon # 8: jam spoon - teak, 29 cm. Photograph.
50	Fig. 4.6	Spoon # 10: sauce spoon - holly, 18 cm. Photograph.
52	Fig. 4.7	Spoon # 4: serving spoon - walnut, 24 cm. Photograph.
54	Fig. 4.8	Spoon #2: soup spoon - walnut, 20 cm. Photograph.
56	Fig. 4.9	Spoon # 9: rice paddle - white ash, 26 cm. Photograph.
57	Fig 4.10	From block to spoon. Photograph.
58	Fig. 4.11	Spoon #3: tea scoop - walnut, 15 cm. Photograph.
60	Fig. 4.12	Spoon #11: ice cream scoop - teak, 20 cm. Photograph.
Chapter 5		
62	Fig 5.1	CNC Spoon Version 3 - Corian

- 63 Fig 5.2 Open heart surgery. Photograph. Taken from London Telegraph online. <http://www.telegraph.co.uk/health/healthnews/6359356/Half-of-specialist-units-for-children-face-closure-under-radical-Government-plans.html> (accessed April 13, 2010)
- 63 Fig 5.3 The Fulcrum Effect. Diagram. Redrawn by author from Gerald M Fried.
- 64 Fig 5.4 da vinci Standard Surgical System. Photograph from da vinci website. <http://www.davincisurgery.com/davinci-surgery/> (accessed April 11, 2010)
- 65 Fig 5.5 North House Prototypes. Photographs.
- 66 Fig 5.6 "White-Out" - selected images from architectural competitions  
<http://www.barkowleibinger.com/>  
<http://www.patkau.ca/>  
<http://www.wojr.org/>  
(all accessed April 30, 2010)
- 67 Fig 5.7 Photograph of Monkey at Computer.  
<http://jimenapulse.wordpress.com/2009/10/07/jimenapulse-under-construction-over-weekend/>  
(accessed April 25, 2010)
- 67 Fig 5.8 American House 08-William Massie Architect. Massie Architecture website. <http://www.massiearchitecture.com/> (accessed March 25, 2010)
- 67 Fig 5.9 Plasma jet cut steel connections - William Massie Architects  
Massie, William. "Remaking in a Post-Processed Culture." *Architectural Design* 72:5 (2002): 54
- 68 Fig 5.10 CNC Spoon. Version 2, Richlite
- 69 Fig 5.11 Exterior view of Owens House, View of Foundation- William Massie Architect  
Hay, David. "How to Build a House for \$145 000." *Dwell* 75.5 (2002): 13-21
- 70 Fig 5.12 Prototypes and Models Renzo Piano Building Workshop
- 72 Fig 5.13 Diagram of Physical and digital Realm
- 74 Fig 5.14 CNC Spoon, Version 2, Richlite
- 78 Fig 5.15 Scans from the Visible Human Project website.  
[http://www.nlm.nih.gov/research/visible/visible\\_human.html](http://www.nlm.nih.gov/research/visible/visible_human.html)  
(accessed March 21, 2010)
- 79 Fig 5.16 Translucency of Corian Version
- 80 Fig 5.17 CNC Spoon Version 3: Corian
- 81 Fig 5.18 Corian Material Sample

## Chapter 6

- 82 Fig 6.1 The Suprasternal Notch
- 82 Fig 6.2 Sahara Desert, photograph. Rosa Frei.  
<http://www.flickr.com/photos/rosafrei/4481726116/>  
(accessed Feb, 2009)
- 84 Fig 6.3 Bosphorus. Photograph.
- 85 Fig, 6.4 Mobius strip. Diagram.
- 86 Fig 6.5 Bosphorus. Photograph.
- 86 Fig 6.6 Bosphorus. Photograph.

## Chapter 7

- 88 Fig 7.1 View of North House Interior showing suspended ceiling. Digital Rendering
- 89 Fig 7.2 Still from "Playtime" by Jacques Tati (1967)
- 91 Fig 7.3 Gramazio Kohler- "Structural Oscillations" Installation Venice Biennale 2008  
<http://www.dezeen.com/2009/09/16/pike-loop-by-gramazio-kohler/>  
(accessed March 20, 2010)
- 91 Fig 7.4 n|Edge Installation by Marc Fornes/Theverymany  
<http://theverymany.com/constructs/09-nedg/>  
(accessed April 23, 2010)
- 95 Fig 7.5 View of Voussoir Cloud installation – IwamotoScott  
<http://www.iwamotoscott.com/>  
(accessed March 30, 2010)
- 95 Fig 7.6 Voussoir Cloud, cell type diagram – IwamotoScott  
<http://www.iwamotoscott.com/>  
(accessed March 30, 2010)
- 96 Fig 7.7 Views of Gantenbein Winery - Gramazio Kohler  
<http://www.gramaziokohler.com/>  
(accessed April 15, 2010)
- 97 Fig 7.8 The Longpen – Sygrafi Inc.  
<http://www.longpen.com/businesswriterinfo.html>  
(accessed April 21, 2010)
- 97 Fig 7.9 ETH six-axis robot arm at work.  
<http://www.gramaziokohler.com/>  
(accessed April 15, 2010)

- 97 Fig 7.10 Frank Gehry designs the Springfield Opera House! Still from “The Simpsons” Season 16, “The Seven Beer Snitch”
- 99 Fig 7.11 Frank Gehry’s Catia Process.  
Freidman, Mildred. *Gehry Talks*. New York: Rizzoli. 1999.
- 100 Fig 7.12 Vitra Design Museum (left) and Guggenheim Museum Bilbao (right)  
Freidman, Mildred. *Gehry Talks*. New York: Rizzoli. 1999.
- 102 Fig 7.13 ROM “Crystal” under construction, July 2005
- 104 Fig 7.14 North House Ceiling Panel. Digital Rendering
- 105 Fig 7.15 North House Cutaway view. Digital Rendering
- 106 Fig 7.16 North House Labeling System. Diagram.
- 107 Fig 7.17 North House, Exterior view. Photograph.  
North House, Interior view. Photograph courtesy of Geoff Thun.
- 108 Fig 7.18 North House, Interior view. Photograph courtesy of Jim Tetro
- 109 Fig 8.19 Material Sample: Hunter Douglas GreenScreen Eco
- Chapter 8
- 110 Fig. 8.1 View of North House interior.
- 112 Fig 8.2 Comparison of modular versus flexible growth. Diagram.
- Chapter 9
- 114 Fig. 9.1 Karman Vortices over Selkirk Island -USGS Lansat 1999  
<http://earthasart.gsfc.nasa.gov/vortices.html>  
(accessed April 15, 2010)
- 116 Fig 9.2 “Icebergs Generating Fog” - David Burdeny 2007  
<http://www.davidburdeny.com/>  
(accessed April 15, 2010)
- 117 Fig 9.3 “Wind in an area of Low Pressure” - Theodor Schwenk. Diagram  
Schwenk, Theodor. *Sensitive Chaos*. London: Rudolf Steiner, 1965.
- 118 Fig. 9.4 “Swell, Haida Gwai” -Eamon Mac Mahon 2007  
<http://www.eamonmacmahon.com/>  
(accessed April 10, 2010)
- 119 Fig. 9.5 Diagram of Horse locomotion – E.J. Marey, 1895  
Dagonet, Francois . *E.J. Marey: A Passion for the Trace*. New York: Zone Books, 1992.
- 119 Fig. 9.6 The Sphymograph, E.J. Marey 1863  
Dagonet, Francois . *E.J. Marey: A Passion for the Trace*. New York: Zone Books, 1992

- 120 Fig. 9.7 Ammassalingmiut wooden maps of the East Greenland coast (Whitridge, 224)  
Whitridge, Peter. "Landscapes, Houses, Bodies, Things: "Place" and the  
Archaeology of Inuit Imaginaries." Journal of Archaeological Method and  
Theory. June 2004
- 124 Fig. 9.8 Speed River
- 123 Fig. 9.9 "The slow evolution of a river towards meandering form" - Theodor Schwenk.  
Schwenk, Theodor. Sensitive Chaos. London: Rudolf Steiner, 1965.
- 123 Fig. 9.10 Cross section of a river – Theodor Schwenk.  
Schwenk, Theodor. Sensitive Chaos. London: Rudolf Steiner, 1965.
- 124 Fig 9.11 Speed River Aerial view, Google Maps  
(accessed May 2009)
- 128 Fig. 9.13 The Surface View. Photograph.
- 129 Fig 9.14 "Turbulence" - finished piece.
- 130 Fig 9.15 "Turbulence" - finished piece.
- 131 Fig 9.16 "Turbulence" - finished piece.
- 132 Fig 9.17 "Steam" - digital photograph
- 134 Fig 9.18 "In Praise of Shadows" - Hiroshi Sugimoto  
Brougher, Kerry . Hiroshi Sugimoto. Washington: Hatje Cantz, 2005.
- 135 Fig 9.19 View of digital model.
- 136 Fig 9.20 View of digital model.
- 140 Fig 9.22 Stills from video.
- 141 Fig 9.23 Stills translated into Vector Selections
- 142 Fig 9.24 "Vaporization" -finished piece.
- 143 Fig 9.25 "Vaporization" -finished piece.
- 144 Fig 9.26 Lake Ontario – digital photograph
- 145 Fig. 9.27 Rock Formation in Bolivian desert courtesy of Flickr user dizymac  
<http://www.flickr.com/photos/31222184@N07/4309925057>  
(accessed July 12, 2010)
- 147 Fig 9.28 The Wave Machine. Diagram.
- 148 Fig 9.29 Overlay of cumulative wave data lines. Diagram.
- 152 Fig. 9.31 Wave Machine in Motion.

- 153 Fig 9.32 "Wind + Water" finished piece.
- 154 Fig 9.33 "Wind + Water" finished piece.
- 155 Fig 9.34 "Wind + Water" finished piece.
- 156 Fig 9.34 "Wind + Water" finished piece.

#### Conclusion

- 159 Fig 10.1 "Bird in Space" – Constantin Brancusi, 1928.  
Guggenheim Collection Online.  
<http://www.guggenheim.org/new-york/collections/collection-online/show-full/piece/?search=Bird%20in%20Space&page=&f=Title&object=76.2553.51>  
(accessed July 25, 2010)
- 161 Fig 10.2 "Studies in alternative materialy" Digital Renderings.
- 162 Fig 10.3 "Concetto spaziale" Lucio Fontana, - 1965  
Tate collection Online  
<http://www.tate.org.uk/servlet/ViewWork?workid=4492>  
(accessed July 25, 2010)



*"Piazza"*  
Alberto Giacometti, 1947-48



## Introduction

This thesis began out of a general observation: that we, as individuals within society, are becoming increasingly disconnected from the world around us. Many people seem more concerned with snooping on the Facebook pages of friends who are very far away than they are with talking to the person sitting right in the room with them. When waiting in line at the supermarket it would be rare to strike up a conversation with the person next to you, instead it is more likely that you will both avoid eye contact, and whip out your mobile phones, scrolling in search of some kind of momentary distraction. It is difficult for me to find any empirical evidence to support this, but it is something that I feel very strongly about. As a student of architecture, I have sought to find ways that these changes have impacted on my profession, and I believe that one effect is an increasing over-reliance on new technology and a lack of faith in the world of our daily experience.

We are surrounded by a world of our own making; gadgets, furniture, buildings, cities, all of it made by man. The majority of these spaces and things say nothing to us, they merely fulfill prosaic needs of everyday life, allowing us to go about our everyday lives without disrupting our pattern of thought or stirring our feelings. But from time to time, something reaches through this stratum of normalcy and actually touches us. There are a number of ways that objects and spaces can gain meaning, but I would like to focus my research on the ways that places and objects gain meaning through the careful ways that they are made.

I do not intend to imply that the way things are made is the only way that buildings and objects can speak to us, for often it is a wide range of factors that combine to create a powerful experience (such as past and present uses, history, form, ornament, etc.) But it is clear to me that at times it can have an immensely powerful effect. This is why I have chosen to make this the focus of my research, even though I am aware of and appreciative of the fact that it is but one factor within many that influence our experience.

This notion that certain spaces, objects, and works of art can move us through the way they are made has been difficult for me to describe. Some might use the term “well-crafted” to describe a building that is put together in a careful way. Richard Sennett, in his book *The Craftsman* develops a notion of craft that he defines as “an enduring, basic

human impulse, the desire to do a job well for its own sake” (9). Sennett is careful not to limit his description of craftsmanship to one involving the use of traditional tools, artisanal techniques, or skilled manual labour – for him craftsmanship can apply to computer programming, the practice of medicine, or even parenting.

Another similarly influential discussion of this subject has been made by David Pye in *The nature and Art of Workmanship*. Pye makes a crucial distinction between what he calls “the workmanship of risk” and “the workmanship of certainty” (Pye 7). The workmanship of risk refers to work where the outcome of a given action is not predetermined, that is, it is dependant upon on the judgement, dexterity, and care exercised by the worker. When the workmanship of risk is deployed, there is a constant possibility that the quality of the project will be compromised. This is in direct contrast to the workmanship of certainty, where the quality of a project is exactly predetermined before the project even begins. Pye gives the example of a modern printing press as the height of the workmanship of certainty, while writing with a pen as the example of workmanship of risk.

Pye ascribes a certain value to the workmanship of risk, primarily due to the much-needed diversity that it can bring to a world of mass-produced everything. He is however, careful not to valorize the workmanship of risk, and states what is really important is workmanship that is consistent with the designer’s intention (13). This can just as often mean rough workmanship as it can precise, and all parties involved will know that it was “good workmanship” when it “carries out and improves upon the intended design” (14).

The difficulty of Pye’s definition of “workmanship of risk”, is that all too often it require hand-controlled work, which, Pye openly admits, can be slow, and expensive (9), and in the realm of contemporary architecture, is all but unknown. Somewhat ironically however, the proliferation of mass-customization and CNC machinery may lead to a reintroduction of much of the diversity that Pye was lamenting for, however it will certainly do so without utilizing the workmanship of risk.

To me the word “craft” remains a loaded term – it carries many meanings and associations that can be difficult to fully understand and clearly express. I very much value the craft in my own work and I take pleasure in identifying it in the work of others, but it is difficult for me to say exactly what it is, how it came about, and how to create it again. Furthermore it means very different things to different people, and as an architect, someone who must communicate with a wide variety of people from different backgrounds and with different interests, it is lacking in specificity. For this reason I have chosen to use a matrix of terms to describe what some might call craft. I believe that what makes a building special is a combination of technique, materials, and technology, and that the combination of these elements takes place under the guidance of the intent of the designer.

Chapter I briefly describes a number of circumstances where this very thing occurs: buildings, works of art, and even consumer products where, for a number of reasons, the intentions of the designer are

aligned with a compatible process of shaping matter. In the example of Le Thoronet, a 12<sup>th</sup> Century Cistercian Abbey, one can see an instance where the architecture both symbolizes and reinforces the belief systems of the monks who built it. In the subtle texture of sunlight moving over stone that is roughly cut but carefully laid one can see the virtues of life lived simply, honestly, yet with careful reflection. This effect is achieved through the remarkable harmony that exists between the materials used, the way that they are shaped, and the values of the monks who were to inhabit the abbey. Even though this is pure speculation on my part, I can only feel that to the monks that lived in the abbey, the architecture must have strengthened their beliefs, and that by modifying their earthly world, they were able to draw a stronger connection to their spiritual world.

In order to get a much better insight in the effects that different ways of working can have, I have undertaken a number of projects at different scales and involving various tools and techniques. The projects range from a series of hand carved spoons, to sculptural, physical representations of flowing water, through to the full-scale realization of a suspended ceiling for the North House prototype. In this way I was constantly supplementing my reading and writing with a different kind of research, a research through making.

Chapters 2 and 3 offer brief descriptions of ways that the direct engagement with the material world can have powerful effects. At first this might seem trivial and obvious, but upon reflection, it can offer valuable lessons. In our contemporary society, things are often fuzzy, it is rare to find something that is absolutely right or absolutely wrong, in fact it is seen as admirable when an individual is able to hold two contradictory thoughts in one's mind at the same time. When it comes to subjects such as history, this is a good thing – there is not one absolutely correct version of history, rather a multitude of fragments that each portray a valuable perspective of history. What might seem like a good thing to one person at one time and place might seem horrible to another person, living somewhere else, or at a different time. For architects, computers play a great part in this "fuzziness". The use of computers can, as I will elaborate in later chapters, lead to the over-determination of quantitative information, with more important, qualitative information suppressed. In this way the user of a computer can, either subconsciously or very deliberately, avoid confrontation with certain very important questions, simply because there are certain kinds of information that computers are just not very good at accurately processing or representing.

As a direct foil to this, I decided to find a small place in my life where things could be a little more black and white. I decided, as an ongoing project, to carve wooden spoons. I chose spoons because they are small enough that I would be able to make several of them, and hopefully learn a little bit about the development of skill and craft along the way. They require a mix of functional and aesthetic attention. Because the function of a spoon is relatively straightforward, the requirement of making a spoon that works well as a spoon would not overwhelm other concerns, while at the same time, they do require some degree of functionality in order to be taken seriously. By carving the wood by hand, I was able to get the most

direct experience of shaping the material, from the hardness of ash to the sticky, oiliness of teak. Perhaps most important though, I would be directly confronted by the results of my labour, my successes and mistakes would become immediately apparent to me, and would present me with ever-changing opportunities to correct them. Chapter 2 outlines my intentions with this project and the implications that I feel direct hand-controlled work can have on both the maker and the user of an object.

By continuing to carve the spoons over time, I was able to learn a little about the effects of developing a skill. I was able to build a large base of knowledge, a base of knowledge that is stored in my unconscious. There is a big difference between doing something for the very first time, and doing something again, and again, and again, and this is exactly the experience I sought to gain by continuing the practice of spoon carving. Chapter 3 describes some of the lessons that I have learned through the continued engagement with technique and material.

Chapter 4 takes the form of a visual display of the results of this practice, the spoons are displayed alongside text that frames them within our larger culture. Despite the fact that I have tried to focus on the tactile engagement of carving spoons, I cannot escape the fact they are a much larger cultural artifact, and that they mean many different things to different people at different times.

From the specific material effects afforded by the spoons, Chapter 5 Thickening, looks more explicitly at new technologies that are being currently adopted by architects, specifically parametric modelling software and computer controlled machinery. Often the adoption of new technologies comes with a heralding of their benefits and what is lacking is a proper degree of skepticism and an examination of their weaknesses. The benefits of digital tools to the architectural profession have been well trumpeted by architects who have adopted them and publications that promote them. In order to assess them a little more clearly myself, I have sought to understand some the weaknesses of the computer as tool for designing and representing three dimensional space. For architects, a crucial shortcoming of computers is the muted and rigid way that they process qualitative information, as Juhani Pallasmaa puts it, they “flatten our multisensory experience” (Pallasmaa 12) In response to this and other shortcoming of digital practices, I propose a means of working that incorporates the direct engagement with physical matter as a way of getting back some of the information that computers parse, a way of thickening the design process. Several brief case studies will examine practices of architects who successfully bridge the gap between the efficiencies of digital tools, and the crucial information contained in other ways of working. Following these case studies, and in keeping with my desire to directly engage with the subject matter, is a description of a project which I have undertaken that seeks to put the process of “thickening” into practice.

Chapter 6 is another example of a project that seeks to find a new form through the melding and joining of various sources, in this case that of poetry and the imagination, landscape and the body. Taking inspiration from Michael Ondaatje’s The English Patient, The Bosphorus is a sculptural interpretation of a journey towards a love that can never be

realized. Taking the form a mobius strip and calling to mind the silky, sensuality of a parched desert landscape, it is also an inquiry into the combination of various ways of shaping material and crafting meaning.

Following the earlier discussion on the potential strengths and weakness of new technologies, Chapter 7, *The Question of Computers*, looks a little closer at the differing ways that these technologies are actually put into practice by various architects. Some architects have chosen to make these technologies themselves the main focus of their research while others adopt them purely to provide an efficient solution to a given problem. Those who chose to focus too closely on the means of achieving a objective may quickly run the risk of forgetting what the objective was in the first place, and for architects this is no different. Again, a number of brief case studies will examine the different ways that practising architects are using these new technologies, and the potential strengths and weaknesses of the differing approaches.

Because my research interest is architectural, I also sought out the opportunity to work on projects that were more architectural in scale. The largest of these was the design and construction of a suspended interior ceiling for the North House, which was a project that was completed in collaboration with another graduate student, Alan Wilson. From the outset, the project sought to explore the use of digital fabrication technologies and parametric modelling to create a useful element within a residential setting. As discussed in Chapter 8, much energy has been expended in the exploration of these technologies to create standalone, gallery sculptures and installations, the intent of the North House ceiling research was to attempt to bring these technologies a little closer to the functional reality of a residential setting. As such the ceiling had to navigate a number of challenges relating to the integration of mechanical and electrical systems, the modularization and onsite assembly of the ceiling, and had to meet all applicable building code restrictions.

Chapter 8, *The Staring Contest* places some of these new technologies in a historical context and looks at the ways that culture and technology can reflect each other over time. By juxtaposing the currently emerging techniques of “mass-customization” with an example of more traditional mass-production, one can get a sense of the difference between the Modernism of the 20<sup>th</sup> century, and the as-yet undefined contemporary era that we find ourselves in.

While the many of the projects that I have undertaken in this thesis have had the benefit of certain programmatic requirements, I also wanted to experiment with different tools and techniques of making in a freer, more speculative context. To this end I created a number of sculptural representations of water, as illustrated in Chapter 9, *Hydrophilia*. Water is, by definition, always changing, either flowing or freezing, evaporating or thawing; in nature it would seem impossible to find water that is completely still. In addition to this aversion to stasis, water is also a powerful metaphor and motivator for human activity. We often think of time as flowing like water, and water is seen as a giver, and sustainer of life. Through the use of a combined analogue and digital process, I created a series of wood sculptures that seek to capture essential aspects

of water, and to give those essences physical form. As can be seen by the finished results, the flowing, splashing, twitchy nature of water lends itself well to the intricate accuracy that can be achieved through the careful combination of various means of shaping material, digital, hand-crafted, or otherwise.

It is my hope that by directly engaging in the processes of my study, that is, by getting my hands dirty, I will be better able to understand them, and thus better know how to use them. In addition to my own experience, I have also sought out the opinion of many writers and thinkers on the subject, both to give credence to my assertions, and to provide a counterpoint to my experiences. Despite my own avid appreciation of both digital design tools and hand-controlled ways of working, I have tried my best not to blindly valorize either. If anything, this work of this thesis has taught me that tools and processes must be interrogated. While I believe strongly that process counts and that the tools one uses can strongly impact ways of thinking and working, they are not the be all and end all, especially when the end result is architecture.







# 1 | Transcending

The spaces we inhabit and the objects that surround us are often made in a way that betrays the narrow set of forces that control their manufacture. Concerns such as financial profitability, economy of materials, speed of assembly, uniformity of production are often manifested as the primary drivers that shape the world that surrounds us.

I do not mean to argue that the above-named forces are not important, but merely that they should not be the only criteria upon which decisions are made. It would be foolish to ignore conventional notions of profitability and value, just as it would be foolish to ignore those things that can bring joy, happiness, or a deeper understanding of our place in the world.

There exist however, certain buildings, works of art, and even products that allow us to step outside of the realm of our daily lives, to believe we are something that we are not, to feel transported to another place outside of our earthly bodies. The experience of such things or places can challenge our conceptions of who we, and what we believe to be possible in our world.

I will argue that frequently when this does occur it is because, rather than being controlled solely by a rather pedestrian set of criteria, that the way in which these projects are made is aligned with a poetic ambition. Furthermore, it is not enough for the designer to merely have the poetic ambition, the designer must also understand the myriad processes necessary to complete the project, and ensure that their ambitions are achieved.

This can be achieved in a number of ways, but the primary means can be summarized as a combination of technique, technology, materiality, and intention. These terms in and of themselves might not seem significant, for it would be impossible to create anything without using some form of tool (technology) in a specific way (technique) to shape some form of material towards a particular goal (intention). However in

all of the examples I have chosen we can see a unique convergence of these forces such that the projects are able to transcend the boundaries of what we would consider normal in our daily life.

In the case of the Bruder Claus Chapel, a very powerful space has been created, using relatively simple means. The actual technology utilized is inconsequential, however the materials used and the precise way in which they are manipulated has resulted in the creation of a building that is indelibly linked to its site and context. Yet despite its rootedness, it is also capable of transporting visitors into an otherworldly place, a fitting memorial to a religious figure whose prayer and devotion allowed him to



Fig 1.1  
Humber River Pedestrian Bridge (left) -  
Montgomery Sisam Architects  
Pünt da Suransuns (right) -  
Jürg Conzett Eng.

escape the confines of his earthly body.

For a more specific description of why I consider these projects special, I will now compare the example of the Pünt da Suransuns footbridge to a similar project, the Humber River Pedestrian bridge (a more detailed description of the Pünt da Suransuns can be found in the following section).

As a piece of public engineering, the Humber River Bridge is a very successful project. Its structural system is elegant and efficient and the experience of crossing it on foot or on rollerblades is very pleasant. Its designers even made an attempt to pay respect to the historical significance of the site by incorporating native symbolism into the design, such as the abstracted thunderbird that appears as cutouts from the panels between the two main arches. Its design and construction required the skillful use of a wide range of technological tools, and their careful deployment has led to the creation of very successful project that has come to act as a marker for the Western end of the Martin Goodman trail.

The Pünt da Suransuns footbridge is successful in many similar ways, and yet manages to add a somewhat indescribable quality. Its structural system is no less elegant and its design and construction must have required equally sophisticated engineering and fabrication tools. What sets the Pünt da Suransuns apart is its use of material, by using locally-quarried Andeer gneiss, the bridge is indelibly linked to its site and to the history of the Viamala. Furthermore, the stone is not merely added as a cladding or decoration, it is embedded into the structural

concept of the bridge.

When one crosses the Humber River using the footbridge, one does so in a thoroughly modern way, gently and effortlessly held aloft by a crisp, white machine, and the experience of doing so could not be further removed from that of the natives or early settlers to whom this site was so important. To cross the Pünt da Suransuns, is to feel the coiling path of the Viamala stretched 40 metres across empty space. The deck of the Humber River footbridge presents a perfectly flat plane, while the drooping profile of the Pünt da Suransuns presents a much more delicate, tenuous relationship to nature. The native symbolism of the Humber River bridge could easily be replaced or removed entirely, and the bridge would be largely the same, but if the stone were removed from the Pünt da Suransuns, not only would it lose its crucial connection to its site, the bridge itself would tumble into the Hinterrhein River. Its success can be seen as a result of the powerful interaction of materials, with the technology and techniques used in its making.

In my thesis work I often have taken a particular focus on the role of technology in the practice of architecture, this is because I feel that technology is changing the way architects think, act, and view the world. However, I also know that technology is but one force with which we are able to shape our world; technology must be used in a certain way, and towards a specific end. These brief case studies are a way for me to broaden my focus and to identify the ways in which architects and designers have been able to successfully transcend the forces of profitability and economy that all too often govern our work. In a way they are a declaration of an alternate set of values, and as such give me something to strive for in my future work.



## Bruder Claus Chapel - Peter Zumthor

In a field outside the southern German town of Mechernich, lies a small chapel erected by local townsfolk in memory of Nicholas von der Flüe, also known as Brother Klaus. Brother Klaus lived between 1417 and 1487, according to legend he survived for 19 years without any food other than the Holy Eucharist, for much of this time he lived in a cave, wearing only a thin tunic.

The chapel was commissioned by a husband and wife who had lived and farmed the nearby countryside for their whole lives. They decided to build the chapel in “thanks for a good and happy life” and sought out Zumthor when they learned that he had won a competition to design a museum for the Archdiocese of nearby Cologne (Galilee 72). Zumthor was intrigued by the project, partly because Brother Klaus was a favourite saint of his mother and also because the clients themselves wanted to be very involved with the actual construction of the chapel. This desire to involve both the clients and local specialized craftsmen led to what Zumthor calls an architecture of basic elements “air, water, earth, fire ... joined by light and sound” (Baglione 91).

The construction of the chapel began with the formation of a void; a teardrop-shaped space was formed by carefully arranging 111 poles to create the inner formwork. The poles were actually trees cut from a nearby forest, and they lashed together to create a teepee-like form, with an open oculus to the sky. Over the course of the next two years, rammed concrete was placed onto this formwork, one layer per month, each layer 50 cm thick. Once the walls had reach their final height of 12 meters, the inner form was set ablaze, smouldering for three weeks until the wood had shrunken away from the now-charred walls. Finally, the floor was poured, four tons of lead were melted on site, and ladled by hand into place.

Stepping inside the chapel one is transported to an otherworldly space, soaring somewhere above a molten sea, swimming under a glowing sky. Water pools in a depression in the lead floor, the charred walls lean inwards and intense light draws one’s gaze upwards. The form of the space recalls the protective embrace of a mother’s womb, while the light brings to mind the stark darkness a cave or an underground tomb. All the while, traces of burned tree trunks and patterns of flowing metal provide a reminder of the earthly world from which this space of dreams was entered.

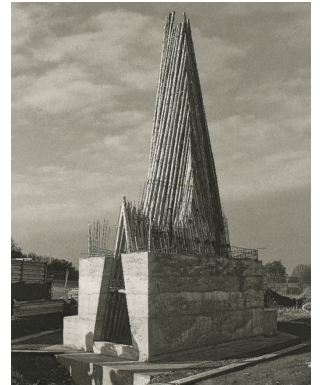


Fig 1.3  
Construction photo showing internal void  
within layered concrete form.

Fig 1.2 (facing page)  
Interior view of chapel.



## Morphinas in Bronze - Commonwealth Design

Existing somewhere between abstract sculpture and functional ornament, the Morphinas in Bronze door handles occupy extreme and somewhat contradictory positions with respect to their design and construction. They were designed and produced by Commonwealth, a New York-based studio whose recent projects have melded cutting edge tools such as digital modelling and rapid prototyping and with more traditional craft techniques such as slip casting porcelain and casting bronze.

Partners Zoe Coombes and David Boira named the piece “Morphinas” after a painting by the Catalan artist Santiago Rusiñol. As Boira describes it, Rusiñol’s painting lies at the heart of an artistic debate between two rival movements: *Modernisme*<sup>1</sup>, with its espousal of the decadent and voluptuous, and *Noucentisme*<sup>2</sup>, with its call for austerity and order (Fichtner, 31). The handles were originally designed for the entrance to an art gallery, an ornamental flourish to mark the portal to a neutral display space.

If their form is somehow inspired by both the austere and the voluptuous, then their construction involved a similar marriage of extremes. The handles were modeled using 3d drawing software and then printed using selective laser sintering (SLA), a rapid prototyping technique. The SLA forms were then used to create wax duplicates of the originals and finally, were cast in bronze using a lost wax process, a combination of contemporary digital techniques with ancient metallurgic craft. It is difficult to imagine that these forms could have been created without the use of digital tools, but it is the materiality of the bronze that brings them to life.

Organic in form, yet unlike any earthly animal, the Morphinas exude a sensual tactility, and invite the hand to caress, grip, and pull. They have the appearance of the bones of an alien life form, evoking a sense of wonder and feelings of desire.

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<sup>1</sup> *Modernisme*, a Catalan movement which included writers, musicians, architects, and designers had many parallels with Art Nouveau and Jugendstil, existed roughly from 1888 to 1911. (Rodgers)

<sup>2</sup> *Noucentisme* a cultural movement that influenced all areas of artistic activity in Catalonia between 1908 and 1923, *Noucentisme* encouraged a return to order and normality after the radicalism, bohemianism and individualism that had characterized some of the major figures of modernism. (Solà-Morales)



Fig 1.5  
“La Morphina”  
Santiago Rusiñol, 1894



Fig 1.6  
SLA originals (right) and wax duplicates.



Fig 1.7  
Bronze silicate being poured.

Fig 1.4 (facing page)  
La Morphinas Door Handles





## Pùnt da Suransuns - Jürg Conzett Eng.

Stretching 6 kilometres long and up to 300 metres deep, the Viamala Gorge has long been an obstacle on what would otherwise be the most direct route between Lake Constance and Milan. An important route since Roman times, the disdain that travellers once held for the gorge can be seen in the translation of its Latin name – in English Viamala means “evil road”. Despite its treacherousness, many important figures have walked its trails, in 1788, Goethe travelled to Italy, crossing the Viamala.

What was once a hindrance is now a sought-after destination, hikers come from across the world to see the drama of the Gorge and walk its historic trails. Beginning in the mid 1990s, the Swiss Government began building a number of bridges crossing the Gorge, their design of which was given to Jurg Conzett, an engineer known for sensitivity to context and history. The Pùnt da Suransuns, is the third bridge to have been designed by Conzett to span the Viamala Gorge.

Pulled taut like a rubber band between two sides of the rocky gorge the Pùnt da Suransuns appears impossibly thin, an abstract line connecting two points in space. Structurally, the bridge uses a stress ribbon system, and hangs like a catenary between its two abutments.

It is only when one gets closer that it becomes evident that the bridge is made of stone, slabs of locally-quarried Andeer gneiss, cut to a mere 60mm thick. By pre-stressing the underlying steel ribbon, the stone slabs are placed into compression, where stone has its greatest strength; additionally the weight of the stone aids stability, and minimizes movement when the river floods. Perhaps most importantly though, the use of stone ties the bridge to its site, it is as if the footpath itself has been stretched across space, from one bank to the other.

The bridge is completely synthetic, a mark made by man on the natural landscape, yet because of its structural and material purity, it stretches across the river in perfect harmony.

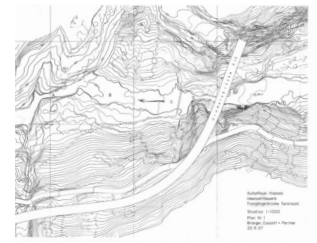


Fig 1.9  
Topography of the Viamala Gorge.

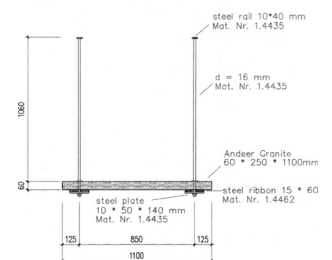
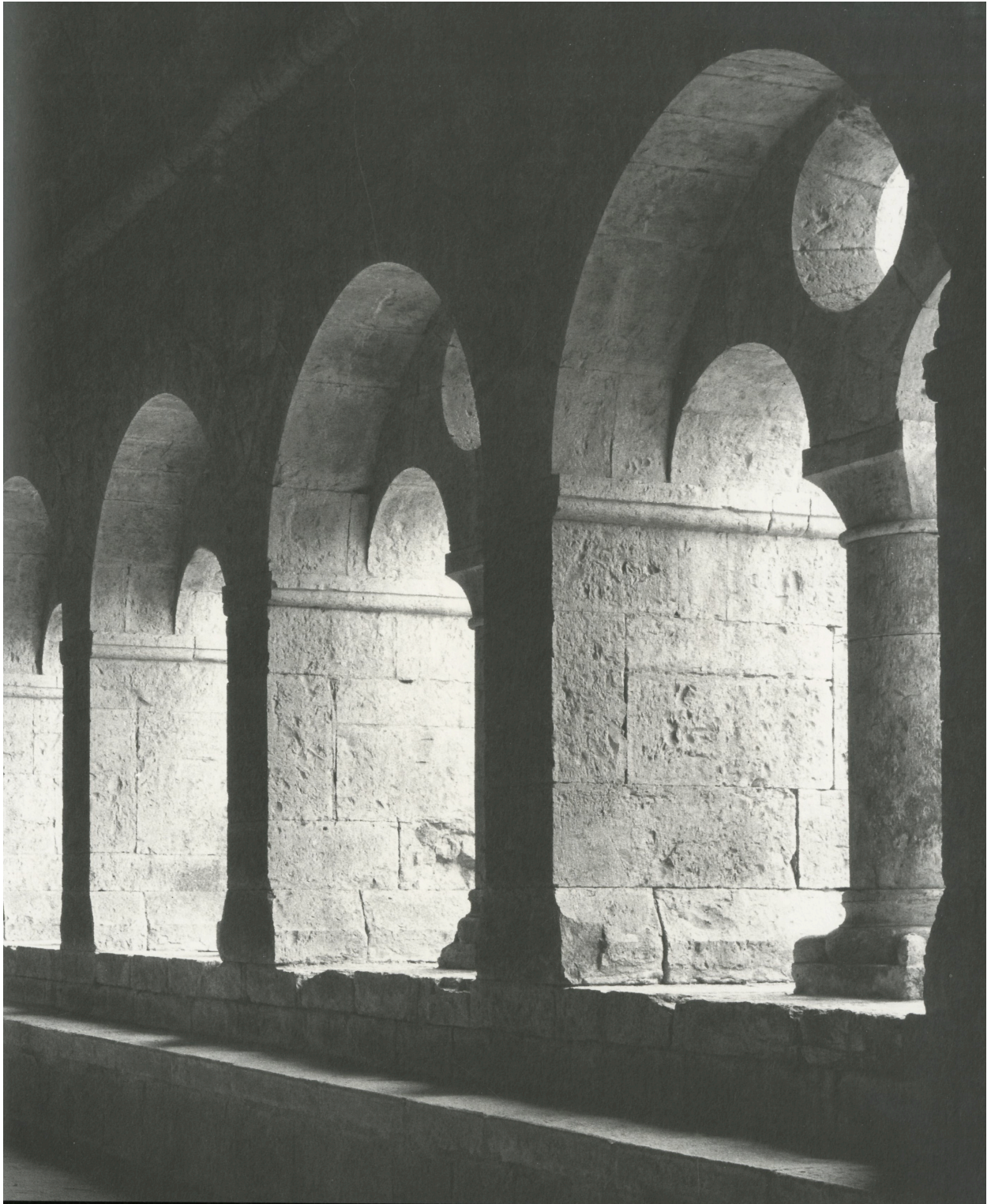


Fig 1.10  
Section through footbridge

Fig 1.8 (facing page)  
Pùnt da Suransuns



## Le Thoronet Abbey

*"There is no virtue more indispensable for us all ... than humble simplicity"*

St Bernard of Clairvaux

The Cistercian Order of monks was founded in 1098 in reaction to what was seen as the superfluous practices of the Clunian Order. Through a strict asceticism and a life of poverty, its followers sought a return to the original Rule of St Benedict (Anonymous Monk, 148).

Le Thoronet was constructed between 1160 and 1190, and represents the height of Cistercian architecture. Consistent with Cistercian beliefs, the architecture is restrained, simple, and built to last. The complex is built almost entirely of stone, and the stone used is locally-quarried limestone, rooting building to site. The stone is remarkable in the way that it is worked, whether cut roughly or smoothly, a high level of skill and attention to detail is consistent throughout.

The effect of this workmanship is brought into sharp contrast through the movement of sunlight across the surfaces of the stone. The thick walls cast deep shadows and the variation in texture of the different surfaces brings life and richness, confirming the beauty inherent in nature, and reinforcing the values of the monk's simple, humble way of life.

Due to the use of stone and its simple vaulted form, the church at Le Thoronet has unique acoustics with a very short reverberation time. Because of this, the monks must sing slowly and in perfect unison, otherwise the consequence is "acoustic chaos" (Pawson, 153). What in other circumstances might be seen as a fault of the space, here is perfectly consistent with the Cistercian's careful, measured way of life, and unity with each other and with their faith.

In the architecture of Le Thoronet, we see more than just picturesque stone buildings, we see Cistercian values written in stone

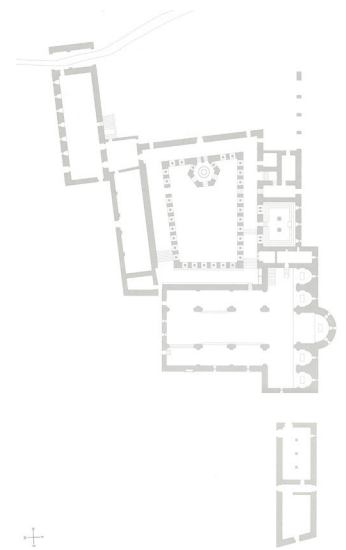


Fig 1.12  
Plan of Le Thoronet

Fig 1.11 (facing page)  
view of Collation Gallery, Le Thoronet



## iPhone - Apple

The name says it all, a merging of self (i) with artifact (phone), a pure expression of the users' identity through the use of a functional product. The iPhone has been a runaway success for Apple, in less than three years, over 50 million iPhones have been sold in over 80 countries.

The construction of the iPhone betrays nothing of how it was made or what it does – no fasteners, hinges or tool marks detract from the pure sleekness. There are no gaps or joints, it is, above all, seamless. The touch interface is variable and its customization rewards fluency. In your hand it feels solid and well-built, an investment in hardware that serves to deliver content, while at the same time conveying status upon its user, and signalling membership into a somewhat exclusive club.

Several observers and critics of product design have noticed and commented on the similarity of Apple's recent design language and that of Braun electronics during the time that Dieter Rams oversaw the company's design studio (1961 – 1995). Rams' was known for a careful attention to detail and consistency, as well as geometric purity and a desire to remove superfluous design gestures. Rams famously stated "Weniger, aber besser" which can be translated into "less, but better".

For Rams, "less, but better" led to a consistent design language that attempted to communicate quality through a richness of materials and a focus on the essential elements of a given product, it was a design that had a rational justification and attempted to appeal to intellect rather than emotion. It also had an ethical dimension, material could be saved by removing superfluous details, and by eliminating elements that were purely an expression of fashion, items would not need to be discarded when fashions changed.

For Apple, this design language seems to mean something different. Unlike Braun, Apple is a content provider as well as a producer of hardware. In addition to computers and electronic gadgets, Apple sells movies, television shows, music, and a whole host of software applications ("apps"), that can do just about anything you can think of. To this effect, the seamless, monolithic beauty of a Apple product means that its physical presence will not dominate the experience of the user. This means that your iPhone will do much more than just look nice, it can find you a restaurant reservation, bring you the latest hot single, translate a foreign sign; your iPhone (and by extension, Apple) is your guide to a new, plugged-in lifestyle.

In this light then, it is hard not see the iPhone for what it really is; it may seem to be all about you, but really it is the exact opposite, it is all about Apple. With an iPhone in your hand, you are able to step outside of your normal existence, and to locate yourself in the contemporary world, one where the solution to all of your needs and desires is just a swipe and a tap away.

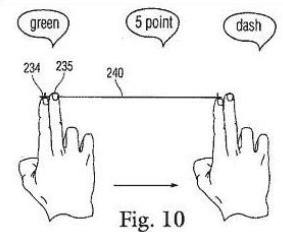


Fig 1.14  
Drawings from Apple's US Patent  
Application 20100060608 for a  
gestural interface system

Fig 1.13 (facing page)  
iPhone, by Apple



## *plywood sculpture - Tapio Wirkkala*

The striking forms of Tapio Wirkkala's plywood sculptures bear a more than passing resemblance to figures both natural and mathematical. Evoking the flow of water in a stream in his native Lapland, or the flight of a bird diving down through an up current of ocean air, there is a definite sense of motion captured, yet there is also an abstract purity, an evidence of a distillation of his natural observations.

Wirkkala may be best known for his design for a Finlandia Vodka bottle or his glassware for Iitala, but he had a long and varied career, designing furniture, products, even the Finnish banknotes at one point in time. That he became an icon of Finnish design should come as no surprise, for he directed his considerable talent towards projects that resonated with the important role that nature played in the Finnish psyche. He spent a large part of each year in Lapland, the Northernmost part of Finland – in a cottage that he built himself. Through sketching, photography, and carving, he created experimental works that often formed the basis of later projects (Periainen 199).

Wirkkala is also known for his hands-on approach to design and his close collaboration with the craftsman who worked to produce his designs. He would often begin a project with extensive sketching, followed by the creation of many hand-carved prototypes. In the case of his designs for glass he would often carve the moulds that the glass blowers would use himself, and then meet with them to develop each specific glassblowing process.

In his plywood sculptures we can see the combination of this close observation of nature and the careful understanding of materials – the forms and the material complement each other perfectly. Plywood was originally developed as an more efficient alternative to solid wood products, it has greater dimensional stability and can be made in sheets much larger than the trees from which it is made. Wirkkala's use of plywood, however, exploits none of these traits – instead it is the layered striations of the laminated veneers that stand out. These alternating light and dark layers create a regular linearity against the which the curving forms stand in contrast, an opposition that elevates the material and accentuates the form.



*Fig 1.16  
Tapio Wirkkala's hands at work*

*Fig 1.15 (facing page)  
plywood sculpture by Tapio Wirkkala*

**2 JUIN 2000**



## date paintings - On Kawara

On January 4th, 1966, Japanese conceptual artist On Kawara covered a small canvas with paint, and carefully painted "JAN. 4, 1966" in white paint in the centre. Since then Kawara has painted over 2 000 of these so-called "date painting" (also referred to as the "Today Series").

He follows a very strict routine; first the canvas is covered in 4 coats of paint, each of which must be allowed to fully dry. The colour of the paint varies, most of the paintings are varying shades between black and dark grey, others are bright red or orange. Kawara has never given the reasons behind the colour selection, he rarely if ever gives interviews, and he never explains his work. Next he outlines the text of the date using the language of the country he was in on the day the painting was made – the JUIIN on the painting selected here indicates that he was living in a French speaking country at the time. A frequent traveller, Kawara rarely stayed in one city or country for more than a few months at a time. Finally the letters are filled in with white paint, carefully done with the precision of a printing press. Each painting is stored in a cardboard box, and for sometime Kawara would include a newspaper clipping from the day it was painted (he no longer includes the newspaper clipping). Perhaps the most important part of the process, if the painting is not completed before midnight on the day it was started, Kawara will destroy it.

Born in 1933, he lived through the second World War, and was living in Japan when the United States dropped atomic bombs on the cities of Hiroshima and Nagasaki. These events are thought to have had an important impact on Kawara, perhaps influencing the two themes that run through all of his work: time and human mortality.

Like all conceptual artists, Kawara walks a tightrope – there is a delicate balance between the underlying idea and its physical representation. Mark Kingwell put it succinctly when he wrote:

*If the works are visually beautiful and compelling, if they excite a prehensile wonder that cannot be translated into or reduced to words, they reward our interest but violate the artist's intentions. If the work fades and the ideas obtrude, on the other hand, then the work risks self-annihilation, disappearing in a puff of zero-degree smoke.*

Through his insistence on the physicality of the artist committing a specific act within a predetermined timeframe, Kawara avoids this pitfall – his art cannot exist on a conceptual level alone – he, and only he must complete each date painting before midnight on the day it was started. We live in a world that is often difficult to understand, and impossible to explain. Through the repetition of a simple act, that of putting down paint in a carefully prescribed way, On Kawara is able to categorically prove the fact of his existence, and leave a meaningful record of his impact on the world.

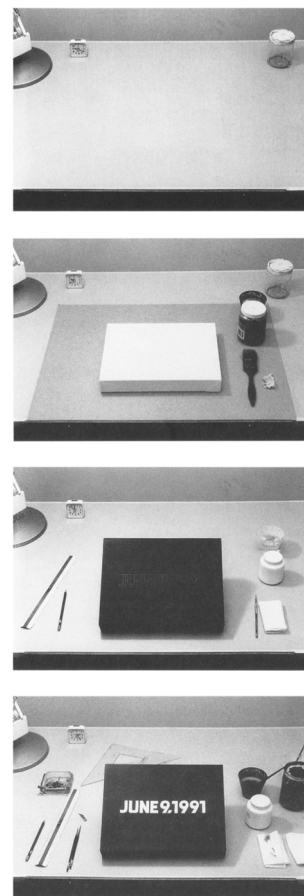


Fig 1.18  
One of On Kawara's date paintings in progress, photos taken at (from top) 9:21 AM, 9:40 AM, 11:51 AM, 2:25 PM

Fig 1.17 (facing page)  
date painting, On Kawara



### 3 Standard Stoppages - Marcel Duchamp

*I have forced myself to contradict myself in order  
to avoid conforming to my own tastes.*

Marcel Duchamp

The metre is the base unit of length in the International System of Units (SI). Originally intended to be one ten-millionth of the distance from the Earth's equator to the North Pole, its definition has been periodically refined and since 1983, has defined as the distance travelled by light in vacuum in  $1/299,792,458$  of a second. The definition of the metre (as well as all SI units) can be seen as an attempt to create a purely rational system of measurement, one based repeatable empirical quantities rather than variable properties. This is in contrast to human-referenced systems such as the Egyptian cubit, which was based on the length of the forearm from the elbow to the tip of the middle finger and is thought to be the precursor to the present day inch, foot and yard. The rise of the metric system can be seen as a victory of analytical, egalitarian ways of thinking over more personal, idiosyncratic practices.

Marcel Duchamp's work *3 Standard Stoppages* takes the metric metre as its starting point, but then subjects it to a chance operation. A working note of Duchamp's describes his idea for this enigmatic work: "A straight horizontal thread one meter long falls from a height of one meter onto a horizontal plane twisting as it pleases and creates a new image of the unit of length." (MOMA). The threads were glued to canvas in the precise positions they landed in. Duchamp then traced their contours and had them cut out of strips of wood, the wood strips bear a resemblance to a ruler, and can be hung on wall or stored in box similar to one that would be used to store drafting equipment. Duchamp claimed to have used the curves of *Stoppages* while painting the forms of the bachelors in his later work *The Bride Stripped bare by her bachelors, Even...* (Naumann 3).

Duchamp's *Stoppages* does two things: on one hand it is a not-so-subtle critique of the autocratic nature of standardized systems of measurement and their insistence that one single method of measurement is ideal for all tasks. More importantly however, it allowed Duchamp to incorporate the element of chance into his work, albeit in a somewhat controlled, contrived way. For Duchamp (and all artists who followed him) art did not have to rely on deliberate actions or skilled technique, rather it could be a product of the artist's intellect. Rather than being limited by the extent of his skill, his experiences, and his imagination, by tapping into the infinite possibilities of chance in everyday life, Duchamp was able to create works of art that even he could not anticipate.

*Fig 1.19 (facing page)  
3 standard stoppages, Marcel Duchamp*



*Spoon #1*  
*Walnut, 30cm x 6cm*

## 2 | What Does a Spoon have to do with Architecture?

*This is the first spoon I have ever carved, the first thing I have ever carved. Through the making of this spoon, I had to learn how to hold a knife, how to make a cut, how to sharpen the blade, how to visualize a form, and when to stop. In order to know where to begin I visited a few websites, watched a few videos, and jumped right in.*

Carving a spoon is an exercise in reduction; with each stroke, the knife subtracts wood, carving out space. Force is applied through the hand to the knife, and the wood offers resistance. Each stroke immediately and permanently affects the wood, the thoughts and intentions of the carver become tangible, and he or she is directly presented with the results of their effort.

Despite the use of various practised strokes, each movement is unique, and the meeting of hand, knife, and wood can never be repeated. The carver must have an image of the spoon in his or her head, and the accuracy or inaccuracy of each stroke must be tested against this image, and against the wood as it yields to the carver's touch. In this way the final design is arrived at through a conversation between material, skill, and intention, with a constant dialogue flowing in all directions.

The resistance of the wood varies with species, wetness, age, and the part of the tree from which it was harvested. Cutting through wet poplar is like scooping soft ice cream, whereas dry cocobolo yields itself very reluctantly and requires short, firm strokes in order to remove the thinnest of shavings.

Spoon #1 was carved from a thick plank of black walnut (*juglans nigra*), and the spoon was located within the plank so as to incorporate a strip of sapwood directly into the bowl of the spoon. The sapwood is the newest growth on the tree and hence is found on the outside of the trunk. The sapwood is the part of the tree that is most alive – it delivers the the moisture from the roots to the leaves and stores the energy created in the leaves (Hoadley: *Understanding Wood*). Perhaps it is due to this animate nature that the sapwood yields so easily, as the difference in texture

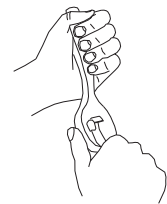
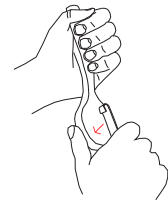
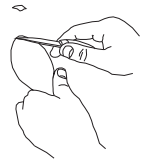
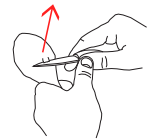
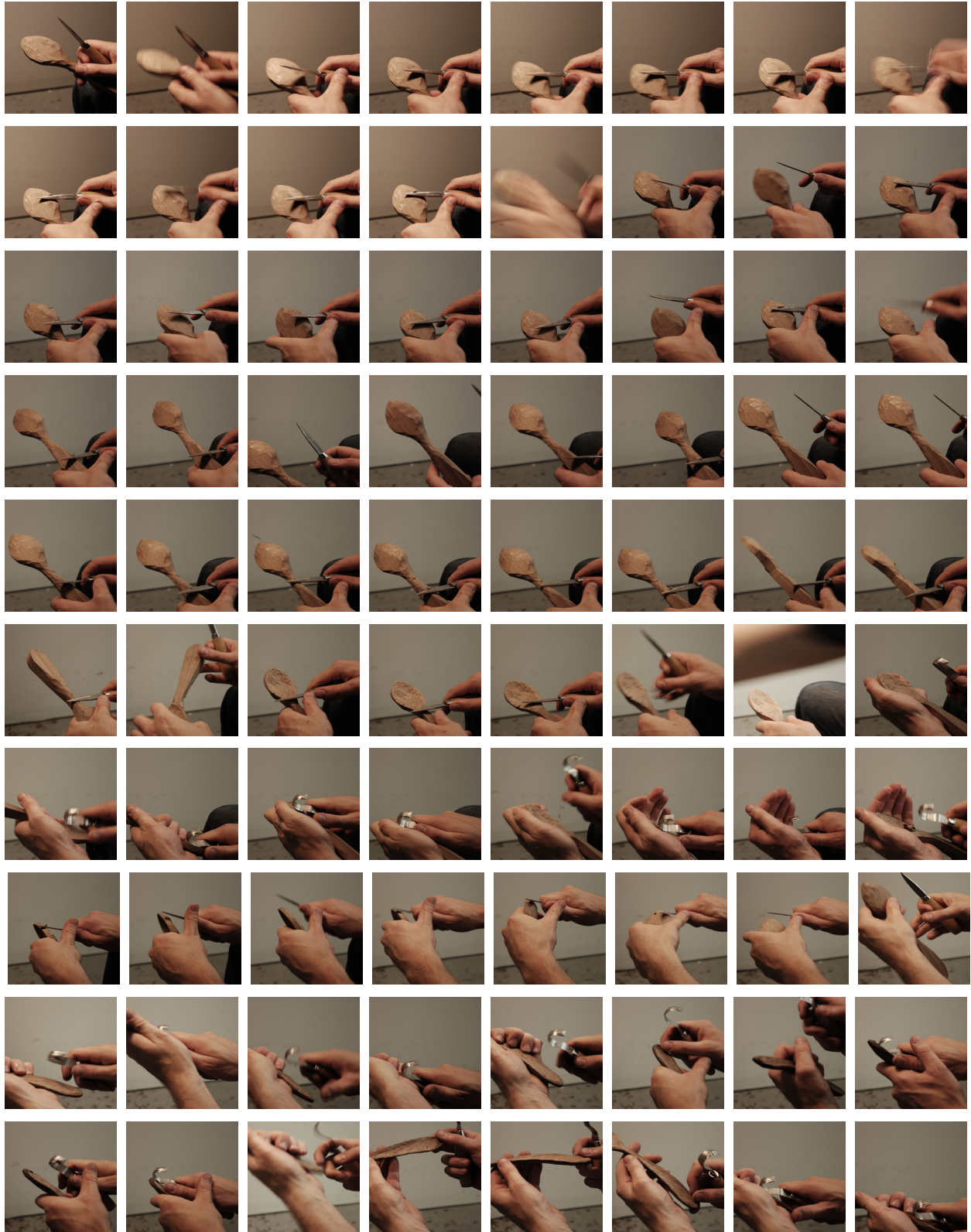


Fig 2.2  
Spoon Carving Techniques  
above: thumb guided stroke  
below: carving the bowl with a hook knife



*Spoon # 1  
in progress*

between heart and sapwood can be felt directly and immediately through their resistance to a blade's edge.

The strength of the wood constantly dulls the edge of the blade, and the carver must control its retreat by frequently honing and polishing. This constant dulling and frequent honing means that a carver is always listening to his or her tools, the blade speaks in terms of its ability to slice, cleave, and scrape. It also means that a carver is effectively rebuilding his or her tools as they are used, with the style of sharpening determining the resultant blade edge, impacting the way that knife cuts, and thus the finished surface of the spoon.

Two things must be accommodated, the hand of the user, and the volume of matter to be scooped, stirred, served, spanked, flung, or measured by the spoon's bowl. From this simplicity of program, a diversity of form emerges. Spoon #1 was intended to be used as a general purpose cooking spoon, for stirring soups and mixing sauces, for this a wide, deep bowl was carved and reassuring bulge was left at the end of a long handle for the hand to grip. Spoon #3 was intended as a tea scoop, and its deep round bowl and short handle with thumb grip attest to this function.

Once the carving is complete, the step of finishing remains. Some species, such as teak, have natural oils that will preserve the wood, but most require some form of finishing to prevent the wood from excessive drying and to protect it from water and staining. Finishes can range from a gloss lacquer, which creates a new mirrored finish on top of the wood to light oils, which can penetrate the surface. For this first spoon I chose walnut oil finish as it is light and fragrant, non-toxic, and easy to re-apply. The oil darkens the wood and makes the grain pop visually, and provides a satisfying final transformation.

Carving a spoon, like many hand-directed forms of work, is a meeting of the most cerebral and the most tactile. This intense process of interaction is stored in the wood, 10 years from now when someone reaches for a spoon that I have carved, they will feel the touch of my hand through the smooth wood. When I carve a spoon, I have the hand of the user close in my mind just as I ponder the wood, the blade, and the movements of my own hands.

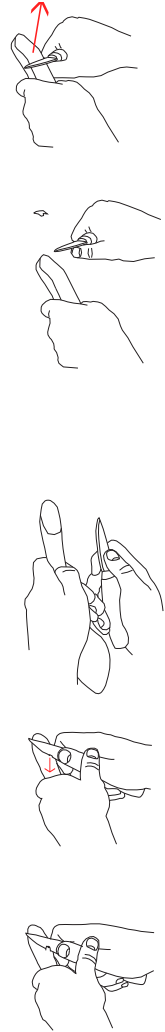


Fig 2.4  
Spoon Carving Techniques  
above: large, roughing stroke  
below: back-scraping to smooth the  
handle



*10 Spoons*  
*materials and dimensions variable*



### 3 | Embedding

*Not long after carving my first spoon, I decided to continue carving spoons throughout my thesis studies. The carving became a sort of live laboratory for me to further investigate the meaning of craft, the workings of the hand, eye, and mind, the accumulation of skill, and the engagement with matter.*

Because wood is a natural material, it has grain and irregularities, just as marble or any other naturally formed matter. This material property of “grainyness” provides both challenges and opportunities for anyone who works with it. As David Pye puts it “The delight which has always been felt in things made of wood and marble rests mainly on the contrast between the regularity of their design and the diversity of the material” (Pye 30). But to anyone who has worked with wood, this “diversity” can be anything but a delight, as grain must be constantly considered and planned for. Whenever ripping, planing, and especially carving wood, the interaction between the tool and the wood must be carefully scrutinized so as to minimize splitting and tear-out.

As a novice woodworker, I am always struggling to understand the grain in a piece of wood, peering at it intently, turning it this and that before finally deciding (not entirely confident that I am correct) how to make a cut. This is in contrast to a more expert carpenter, who can pick up a piece of wood, look at it once, and decide right away how to cut it cleanly. The expert never knows for sure, for often a piece of wood can hide knots, checks, and swirls under a smooth surface, but he or she is able to quickly make a very educated guess by intelligently assessing a complex number of variables, and comparing those variables to a set of patterns that is stored in a lifetime of experience.

The difference between a novice and an expert woodworker was succinctly described during an introductory seminar on wood turning that I attended led by master turner, Kurt Hertzog. Hertzog described the

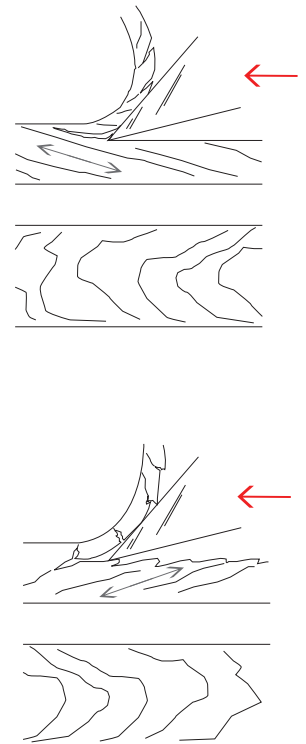


Fig 3.2  
Cutting with wood grain  
When the grain of the wood slopes across the board (as it typically does), the board should be oriented so that the fibers are rising ahead of the line of cut (above). If the fibers slope down ahead of the cut, the blade will dig under the grain and leave a rough, torn surface (below).  
Redrawn by author from Hoadley 2000



*Carving tools*

development of a novice into an expert as the progression through four distinct stages of skill and knowledge. The four stages are as follows:

- 1)unconscious incompetence
- 2)conscious incompetence
- 3)conscious competence
- 4)unconscious competence

What Herzog is describing is a process that is common amongst woodworkers, artists, athletes, musicians, chefs, - in fact, just about anyone who repeatedly does a complex task with their hands will undergo a similar path of development.

In the first stage, unconscious incompetence, the student does not know what they are doing and is unaware of their shortcomings. This can be seen in the novice woodworker who puts a piece of wood into a surface planer with the grain in the wrong direction and is surprised to see tear-out across the surface of the board. With some instruction and a little practice however, they soon reach a stage of conscious incompetence where the student still lacks the knowledge of how to work with the material, but is aware of the fact that orienting the board differently will have very different effects on the resultant cut. As the student gains skill, the level of conscious competence is reached, where the student has acquired the knowledge to understand the implication of different courses of action, but must still consciously consider them before acting. Finally, after the student has absorbed instruction and practised technique, when the tool falls readily to hand and the body moves easily into position, when they know what to do and can do it without thinking about it, they move to a stage that can be described as unconscious competence.

This final level, unconscious competence, is further described by Richard Sennett as “embedding”, that is, “the conversion of information and practices into tacit knowledge” (Sennett, 50). The embedding of knowledge of complex tasks allows those tasks to be carried out without dominating the attention – freeing the mind to focus on other things. As Sennett puts it, “In higher stages of skill, there is a constant interplay between tacit knowledge and self-conscious awareness, the tacit knowledge serving as an anchor, the explicit awareness serving as critique and corrective” (ibid 50). It is interesting to note that it is not separation of mind and body that occurs. Just because the mind is not constantly, consciously focussed on the task at hand, this does not mean that the focus is elsewhere, rather, the mind is able to broaden its focus, to take in a greater scope of information, and assess a more complex set of variables, while not neglecting the immediate task.

Sennett is careful to identify the term “tacit knowledge”, which he describes as “a realm of skill and knowledge perhaps beyond human verbal capacities to explain” (95). It is knowledge that is clearly held by the craftsman but that she or she is not able to articulate using words.

Juhani Pallasmaa further developed this notion of tacit knowledge though his conception of “embodied thinking” (Pallasmaa 107). There is a certain physicality to the experience of architecture that precludes it

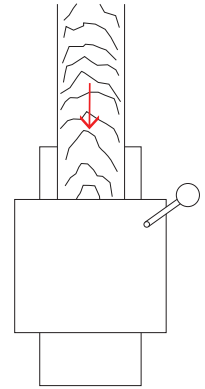


Fig 3.4  
Thickness Planing  
To minimize tear-out, the board should be oriented with the grain “flames” pointing against the direction of travel.

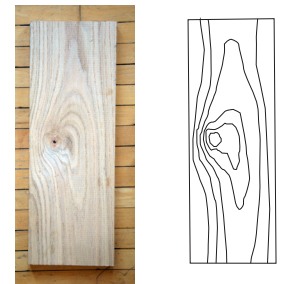


Fig 3.5  
Its not always that simple.  
Knots in wood complicate matters and mean that there is not always one simple and/or best solution. Planing this board in either direction will still produce tear-out.



*Hua Chi's feet, embedded into the wooden floor of the monastery.*

from ever being a fully theoretical practice. Our bodies feel in complex and sensitive ways that our mind cannot always fully comprehend - these body-feelings are stored as "embodied wisdom", a form of wisdom that is called upon by the painter, the sculptor, and the architect.

In the creation of a building Pallasmaa argues, an architect must call upon "operative and instrumental knowledge" (such as understanding of program or building envelope design) as well as "existential knowledge moulded by their experiences of life" (119). This complexity describes Pallasmaa's notion of embodied thinking, that we must think both with the knowledge of our minds and the wisdom of our bodies.

Hertzog's description of the four stages of development and Sennett's notion of embedded knowledge are both consistent with the ten-thousand-hours theory of expertise described by David Levitin and others. The ten-thousand-hours theory posits the claim that in order to become expert at something, one must practise for an extended period of time, with the number of ten thousand hour being given as a benchmark that recurs across many differing fields. Ten thousand hours translates into practising three hours a day for ten years, which as Sennett puts it, is a typical training regimen for young athletes seeking to excel in their sport, but the number could equally be translated into the gruelling conditions of a 3 yr medical residency, or a seven year medieval goldsmith apprenticeship (Sennett 172).

There are two important points to consider here, the first is that the development of tacit knowledge is a process, it is something that happens as one practices and hones a skill over an extended period of time. The second point is that something special happens when a process becomes embedded into our subconscious, we become better at enacting what it is we have practised, but we are also able to expand our field of vision. The development of these characteristics can both be said to be integral aspects of the development of one's craft, or, as I prefer to term it, the development of craft within one's self.

To me this discussion of embedding is really about breaking down the barriers between one's self and the world around you. Through sustained activity our experiences of the physical world can become embedded within our bodies, and by extension, our selves become more rooted in the world of our experience. An extreme example of this is the story of Hua Chi, a Buddhist monk living in Qinghai province, China. Hua Chi has prayed in the exact same spot for over twenty years, kneeling and stretching out over 1000 times per day. Over time the action of his feet has carved deep recesses into the wood, over 1" deep where the balls of his feet rest (Duncan).

Hua Chi is praying to ensure a smooth transition into the afterlife, but he has clearly made his mark here in this world. The younger monks look up to him and revere the carvings he has left on the temple floor. While his impact on the temple is clear to see, the impact



*Fig 3.7  
Learning when to Stop  
This was my second spoon, it was shaping  
up nicely until I applied the oil finish, and  
a precarious thin spot was revealed!*

*Fig 3.8*  
*Black Walnut material sample, sanded*  
*and oiled on one face*

of Hua Chi's devotion on his life is, of course much harder to quantify, but it is hard to wish him anything other than success for his labours.

In my own experience with carving spoons, I remain far, far, below the threshold of ten thousand hours. I have carved 8 spoons, each one taking somewhere between four and eight hours each, meaning that I will need to carve at least 2 492 more spoons to approach the threshold of expert. I have reached a point where I no longer need to be ever-vigilant that I might cut myself, I am better able to visualize where to cut next, and most importantly, I am beginning to understand how to work with the wood grain so as to get the most out of its natural beauty.





*Fig. 4.1*  
*10 Spoons - materials and dimensions variable*



# 4 | Ten Spoons



*Fig. 4.2*  
*Spoon #1: cooking spoon - walnut, 32 cm*

The English word "spoon" derives from the Viking "spon", meaning chip of wood, while the German "Löffel" comes from the Old high German "Laffen" meaning to slurp. Both the Greek and Latin words for spoon are derived from cochlea, meaning a spiral-shaped snail shell.



*Fig. 4.3*  
*Spoon # 6: tasting spoon -spalted maple, 32 cm*

This spoon was carved from spalted maple, the unusual patterns are the result of a white rot attacking the wood. The rot is accompanied by veins of dark brown or black staining.

Creating spalted maple is an inexact science, the rot can be encouraged by burying the wood underground, piling it with sawdust, or leaving it in a dark, damp space. Once the rot has advanced to the desired stage, the wood must be dried relatively quickly, otherwise the rot will continue until the log has decayed completely.

Although wood with decay is usually considered defective or even worthless, in the case of spalted maple, it is a sought-after feature and can create beautiful patterns and unexpected textures.



*Fig. 4.4*  
*Spoon # 7: sugar scoop - cherry, 12 cm*

*Dal cucchiaio alla città*<sup>1</sup>

-Ernesto Nathan Rogers

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<sup>1</sup> trans: "from the spoon to the town"

In a 1946 editorial for *Domus* magazine, Rogers famously stated that a designer could use the same principles to design a spoon as to design a city, and everything in between.



*Fig. 4.5*  
*Spoon # 8: jam spoon - teak, 29 cm*



In its previous incarnation, this spoon was part of a patio chair - the piece of wood that it was carved from was given to me by a carpenter who builds and repairs teak furniture.

Teak (*Tectona grandis*), is a very hard, dense wood, and contains natural oils that give it durability even without the treatment of oil or varnish. Because of this it has long been highly sought after for use on boat decks, in window frames, and patio furniture.

When cut, it releases a slightly spicy odour, and it blunts tools quickly. When sanded, the oils combine with the saw dust to make a gummy paste that clogs the sand paper. It is almost as if the natural oils in teak that make it resistant to decay and pests have also been evolved with the tools of the woodworker in mind.



*Fig. 4.6*  
*Spoon # 10: sauce spoon - holly, 18 cm*

There is an old German saying: “to throw away one's spoon”, meaning to die, and another which dates from the Middle Ages: “to shave someone over the spoon” which means to cheat someone; less skillful (rural) barbers used a spoon to stretch the wrinkled skin of old people to facilitate a smooth and bloodless shave<sup>1</sup>.

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1 *Jasper Morrison, Book of Spoons*



*Fig. 4.7*  
*Spoon # 4: serving spoon - walnut, 24 cm*

Because these spoons are intended for cooking, serving, and eating food, a non toxic finish is required to seal the wood and prevent it from drying out too much. I have experimented with a number of finishes, but as of yet I have not found one that is perfect.

Some carvers recommend olive oil or corn oil, but I avoided these options as they can go rancid if the spoon is not used often enough. Mineral oil forms a good finish and will not go rancid, but as it is a petroleum product, I find it to have a rather unpleasant odour.

Walnut oil is fragrant and light, but evaporates rather quickly. By mixing walnut oil with melted beeswax, a thick, waterproof paste can be made - this leaves a smooth finish that seals the wood and is pleasing to touch. The only drawback to the beeswax/walnut oil mixture is that it is susceptible to heat, making it inappropriate for a spoon that will be used for cooking or serving hot foods.

Most recently, I have been sealing my spoons with tung oil, it lacks the pleasant odour of walnut oil, but seems to penetrate better and form a longer-lasting finish. At this point in time it is the best option that I have, but as I continue to carve, I will keep exploring other methods.



*Fig. 4.8*  
*Spoon #2: soup spoon - walnut, 20 cm*

“Never,” says Andréani’s French guide to etiquette, “leave your coffee spoon in your cup when you lift it to your lips.”

About the use of the soup spoon, Miss Manners (Judith Martin) was much more emphatic. In her seminal text Miss Manners’ Guide to Excruciatingly Correct Behavior, she writes:

*Now, about that spoon. Please hold it parallel to your mouth. It is the side of the spoon that should kiss the mouth, not the oval tip. The soup is gently and quietly poured from the soup spoon bowl, over its side, into the mouth. It is not inhaled. If you knew how often people do dreadful things to soup, kind caring soup, you would weep. And even as the tears rolled from your cheeks, your faithful soup would expand in response.*



*Fig. 4.9*  
*Spoon # 9: rice paddle - white ash, 26 cm*



When I carve a spoon, I typically begin by cutting a blank (the rough shape of the spoon) out of a solid piece of wood using a bandsaw. Next I sand the blank using a belt sander to smooth any rough edges the band saw may leave - at this point the blank looks like a bulky, blocky spoon. Following this, I carve the remaining wood away using a knife, this is where the spoon really takes shape, and usually takes the longest amount of time.

This spoon is carved from white ash (*Fraxinus americana*). Ash is a relatively dense and hard wood, making it ideal for floorboards and baseball bats, but also tough to carve by hand. After 30 minutes of carving, I had barely scratched the surface, and my knife blade was dulled considerably.

Reflecting upon my feeble efforts, I decided to return to the belt sander to remove some more of the excess wood. Using a belt sander I can remove in seconds what would take minutes or hours using a knife, but what is sacrificed is fine control - it is akin to the difference between using a hammer and chisel and a dental scraper.

My spoons would typically be described as “carved by hand” but in reality, a variety of tools, mechanized or otherwise, are involved in their making. While it may be tempting to idealize the notion of using only hand tools, to do so would be foolish. To spend an hour removing wood with a knife that could be removed in seconds with a belt sander (or an axe, chisel, or chainsaw) only prolongs the process of preparing the blank, and does little to change the final spoon. The key is to identify the transformative effects of each stage in the process, and to carefully deploy them as needed.



Fig 4.10  
From block to spoon.  
Step 1 (top) - block of wood with outline of spoon drawn in pencil  
Step 2 - Cut outline using bandsaw  
Step 3 - Smooth spoon blank with belt sander  
Step 4 - Spoon finished using knife and sandpaper



*Fig. 4.11*  
*Spoon #3: tea scoop - walnut, 15 cm*

The “wooden spoon award” is typically given to the last-place team at the end of a season of competition. The “honour” of such a prize is frequently noted in British sports such as Rugby Union or in inter-university rowing.

Rarely, however, is an actual wooden spoon awarded.



*Fig. 4.12*  
*Spoon #11: ice cream scoop - teak, 20 cm*

There is a Trappist monastery near Zundert in the Netherlands where all the monks eat with wooden spoons. The Abbey Maria Toevlucht is a Trappist monastery and follows the Rule of St. Benedict, which preaches a humble, simple way of life.

On the surface, the fact of the monastery using wooden spoons might seem insignificant, but for the fact that in the 21st century, wooden spoons are actually a luxury item. A wooden spoon takes longer to make and does not last as long as a stainless steel spoon, or for that matter a plastic one. Luxury is, of course, a contradiction to the Rule, and for the most part, the life of a monk is a life of work, study, and prayer.

But in many ways the spoons provide a link to the past, and if they can be seen as an indulgence, one cannot help but think that even St Benedict himself would approve.



## 5 | Thickening

Surgery is the most invasive form of medicine – the surgeon must slice through the flesh of the patient, enter inside their body, and perform the necessary procedure. Afterwards, the wound must be sewn back up, and the healing process is doubled – both the original affliction must heal as well as the damage done by the surgeon. Over time, as surgery increased in complexity and moved deeper into the body, larger incisions needed to be made, inflicting even more damage to the patient in the quest for healing.

One solution for this difficulty is the advent of laparoscopic surgery, also known as keyhole or minimally invasive surgery, which involved the insertion of long, hand-operated instruments through a small incision. Laparoscopic surgery offered the great advantage of minimizing the damage needed to reach the site of the surgery, but is not without complications: often the instruments are very difficult to use, as a small movement of the surgeon's hand is translated into a large movement at the end of instrument. In many cases the movements of the surgeons hands operate in a 180 degree relationship opposite to that of the instrument, meaning that if the surgeon wants to move the end of a scalpel to the right, he or she must move their hand to the left (Fried & Gill, 141). The surgeon's view inside the patient is also mediated through a small camera inserted into the patient which tends to flatten the image the surgeon sees, decreasing depth perception (ibid).

Not surprisingly, computer controlled robots have been introduced into the operating room (OR) in an attempt to overcome some of these difficulties; robots excel at making precise, repeatable motions, and sophisticated software can translate large movements of the surgeon's hand into small movements of a robotic tool, while at the same time eliminating natural hand tremors and unintended movement. But the rush to integrate robots into the OR has not come without its unique set of complications, the technology as it currently exists is prohibitively

Fig 5.1 (facing page)  
CNC Spoon Version 3 – Corian



Fig 5.2  
Open heart surgery

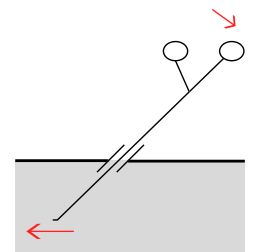


Fig 5.3  
The Fulcrum Effect  
To make the instrument tip go in one direction, the handle of the instrument must be directed in the mirror image directions.  
redrawn from Gerald M Fried



Fig 5.4  
da vinci Standard Surgical System  
The operating surgeon sits at left.

expensive as well as physically large and cumbersome, however given the pattern of technological progression in just about every other field, these shortcomings will likely be overcome in time (Lanfranco 18). More troubling would be digital surgeons are the built-in difficulties that a computer-controlled tool inherently carries, that is, that the primary interaction between the surgeon is no longer between the surgeon's hand and the patient's flesh, now all of the surgeon's movements must be translated into computer code that can control a robot arm, and all of the tactile feedback and resistance that the patient's body offers must likewise be registered by a digital sensor, translated into computer code, and then sent to the surgeon as a form of "haptic feedback". This lack of haptic feedback is an inherent weakness to all robotic surgery systems, and one that must be alleviated before their widespread adoption can take place (Lanfranco 17).

Given the difficulties that the medical community faces in its utilization of computer-controlled equipment, it is not surprising that architects have seen mixed results as well. The benefits of digital design and fabrication tools have been expounded by many architects (see chapter 7, *The Question of Computers*), and it is clear that they have a role in the field of architecture, but difficulties remain and ways to overcome these shortcomings need to be identified.

Perhaps one of the biggest difficulties of working with computers is that they are, by definition, removed from the physical environment of the world we live in. In order to process any information, a computer must translate it into binary code. Whenever we interact with computers we must use an interface capable of making this translation into the binary, and whenever we read information from a computer, it is always a representation of data that is stored in the form of ones and zeros. The problem then, is that through this process of translation, something is inevitably lost, Juhanni Pallasmaa describes it as a "flattening":

*Computer imaging tends to flatten our magnificent, multisensory, simultaneous and synchronic capacities of imagination by turning the design process into a passive visual manipulation, a retinal journey*

(Pallasmaa 12)

Pallasmaa fairly accurately describes one of the primary weaknesses of computers, but this is not to say that they should be removed from the design process entirely. Rather, I will propose that architects need to be aware of these weaknesses, and, while keeping these shortcomings in mind, find ways to integrate them into a design process, rather than making the computer the sole focus of the design process.

There are three main areas that are problematic for computers and critical for architects: scale, materiality, and texture. Anyone who has spent more than a short amount of time working with Autocad (and similar digital drafting programs) can speak to the difficulties of scale – it is all too easy to zoom from millimetres to infinity in just an instant, not to mention the temptation to zoom in and draw way too much detail, detail that when printed to a fixed scale will be illegible. These difficulties can be alleviated somewhat by adding scaling elements to digital drawings, such

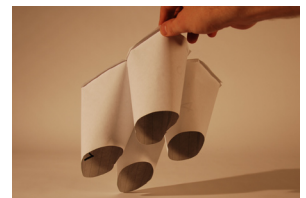
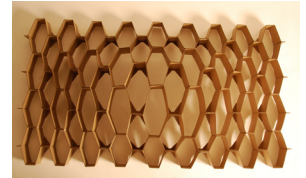


as handrails, trees and people, or by frequently printing and sketching in detail by hand.

Often however, it will not be possible to ascertain the proper scale of an architectural element merely by interacting with a digital representation. A relevant example of this was a difficulty faced by the author in the design of the North House ceiling (See Chapter 7 Epilogue). The ceiling was made up of over 4 000 individual cells, knitted together to create a three-dimensional textile. The cells varied from 6.5 cm to 16 cm in diameter based on the desired level of visual density in any one part of the ceiling. Changing the range of cell sizes had a dramatic impact on the number of cells, which impacted drastically on the character of the space, the translucency of the ceiling, and of course, the amount of time required to fabricate it. Making each cell 2-3 cm smaller was as easy as a few mouse clicks, but resulted in the total number of cells increasing from 4 000 to over 6 000. However due to the resolution of a computer screen, it was difficult to ascertain the resulting change to the character of the space. The only way that this difficulty could be overcome, as well as communicated to the rest of the team, was through the construction of a large number of full scale prototypes

Even as digital rendering programs such as V-Ray and Maxwell Render make photorealistic rendering even easier and faster, the accurate and compelling representation of materials in digital drawings remains difficult and time consuming. What is relatively easy to achieve is a rendering with lots of detail, realistic shading, and soft shadows, devoid of colour, material or texture, and this is increasingly the style of choice among architects and students alike. A quick survey of competition entries and design drawings from recent publications will only serve to reinforce this statement, and a small selection of such illustrations can be seen in figure 5.6. More and more it is common to see renderings that are starkly white, with little information on what materials the spaces are constructed with. In addition to the lack of visual interest in these drawings, there is also the very real possibility that working with tools that tend to lead designers to draw in this way will also lead them to think in a certain way, and that materiality will begin to be erased from the spaces they design just as it has been purged from the drawings they create. It has been said that to a man with a hammer, everything looks like a nail, perhaps to an architect with a computer, every project looks like an empty, minimalist whiteness.

Not only is it still difficult to represent how materials look, it is much more difficult to represent how they work. All of the most commonly used drawing and modelling programs, such as Autocad and Rhino3d lack the capacity for material intelligence – no matter how long they span, beams do not sag, glass can be made in impossibly large sheets, and concrete can be formed into complex forms that are unfeasibly thin and perfectly smooth. In the virtual world of digital design, matter is infinitely malleable. Similar to the difficulties of representing materials, the real concern here is that the thinking of architects and designers will be influenced by the tools that they use, and that the physical reality of their materials they use will slip further away from their consciousness.



*Fig 5.5  
North House Prototypes  
various prototypes at 1:1 testing scale,  
materiality, and texture*

Yet another difficulty facing architects who utilize primarily digital based means of practice is that CAD programs such as Autocad and Rhino 3d do not allow for a development of skill in the same way that, for example, hand drafting or especially hand sketching (or, for that matter, any hand guided activity) offers. A line drawn by a novice Autocad user is identical to a line drawn by an expert draftsman with thousands of hours using the program (indeed, these two expert and novice lines would be indistinguishable from lines drawn by a monkey, a fact that is not lost on intern architects who often refer to themselves as “cad monkeys”).

On the surface this might not seem like a shortcoming, one could argue that a line drawn in Autocad need not have the same variability, the same expressiveness as a line drawn by hand, that in fact, all lines should be identical, repeatable, so that the information they contain might be presented consistently. But what of the draftsman? Is there not something lost when so much time is spent engaging with a medium that is essentially unresponsive, lacking in tactility, and muted in its stimulation? There is powerful evidence that development of skill in the hand (or other parts of the body for that matter) has a corresponding effect on the mind, yet digital tools offer little in the way of developable skills. The impacts of the development of skill on the mind is discussed further in Chapter 3 Embedding.

Richard Sennett summarizes many of these issues in his book “The Craftsman”. Sennett warns of the “over-determination” of CAD programs, whereby through their absolute precision, computer programs can make their operators believe that they have a better understanding of a project than they really do. This precision applies to both the way computer measure space and the way they physically represent it, as Sennett puts it, “what appears on screen is impossibly coherent, framed in a unified way that physical sight never is” (41). In this way, a project can seem to be much more complete, much better resolved than it really is, fooling architects just as often as clients.

The disconnect between material reality of architecture and the drawings that architects often make is explored by Jonathan Hill in his article “Building the Drawing”. Hill writes about a fundamental shift in the role of the architect that was brought about by the increased importance placed on the drawing during the Italian Renaissance. As he puts it, prior to the Renaissance, architects worked along side the other craftsmen as a construction supervisor, but that “from the 15<sup>th</sup> century to the 21<sup>st</sup>, the architect has made drawings, models and texts – not buildings”. Hill draws a connection between the Renaissance emphasis on drawing, and a privileging of the intellect over the physical, the idea that “intellectual labour is superior to manual labour” (ibid, 14). The implication of this is that architects began to put greater faith in ideas and in drawings, believing the conception of a project in the mind of an architect to be a fully formed thing, and that the ideas they held could move directly from mind to matter (ibid, 15).

Just about any architect with a little bit of experience and a just a tiny bit more honesty can see the fallacy in this way of thinking, that often what you think in your mind, does not directly correlate with what gets built



Fig 5.6  
“White-Out”: evidence that the influence of rendering programs is leading to a reduction in the representation of materiality in architectural design

in the real world. Typically the process of realizing a project is long and arduous, and the physical realization is far removed from the idea that may have given birth to it. The continued difficulty however, is the faith that architects place in drawings, and in particular ones created by computer. As a means of testing their designs, Hill proposes that architects “build the drawing”, using some form of computer aid manufacture (CAM) to “align thinking, drawing, and making” (17). In this way, drawings (and their physical analogues) can serve as ways to develop and test ideas, rather than merely represent them.

Pallasmaa, Sennett, and Hill all bring up the necessity for architects to engage with physical, material tools in their design process, be it hand sketching, building physical models, or utilizing some form of computer controlled machines to physically output their virtual designs. In fact, there are several architects currently practising who are following just this sort of model. William Massie, an architect currently teaching at the Cranbrook Academy of Art, is one such example. Since forming his practise in 1993, Massie has explored various means of using computer controlled machinery to build experimental architecture at 1:1 scale. Massie was educated during a time when computers began their steady rise to prominence, but whereas many of his classmates and peers focussed their energy on more conceptual aspects of digital tools, Massie focussed on the direct utilization of computers to control laser cutters, plasma cutters, and milling machines, purchasing a number of these tools for his own research purposes.

Not surprisingly, Massie is critical of the ways in which many of his peers have embraced the more “virtual” side of computers: “Once again we see the institution of architecture dealing with arguably the most important spatial technology (the computer) in only a visual way” (Massie 55). As an alternative to this focus on the visual, Massie has embraced the physical and has focussed on the use of computer controlled machinery to create large-scale, highly customized, three-dimensional structures. Many of his projects feature CNC cut rib structures that describe a three-dimensional volumes, covered in a flexible skin such as plywood or plaster (see figure 5.8). Massie has also developed ways of feeding construction information back into his digital models, an example of which is his development of complex joints, inspired by dovetail joints in woodworking, that both facilitate the use of smaller sections of flat-stock material as well as provide a new form of ornament and material expression (see figure 5.9).

Massie is perhaps unique for his hands-on approach and his willingness to mix high-tech CNC techniques with Home Depot materials and a DIY mentality. The strengths of this approach can be seen in the Owens House, a single family home sited in the Montana countryside and completed in 2002. Although the house might seem somewhat modest by the standards of today’s digital experiments, it has a fair amount of complexity and customization given its budget of \$145 000. The curving exterior walls were made possible by CNC cutting a template for the foundation out of plywood and then bending standard Styrofoam molds to fit. The molds were then filled with concrete onsite by the contractor. Massie was even able to CNC cut windows out of the Styrofoam molds



Fig 5.7  
*An Inconvenient Truth: it is impossible to tell the difference between a line drawn in Autocad by a monkey from one drawn by an architect*



Fig 5.8  
*American House 08  
William Massie Architect*

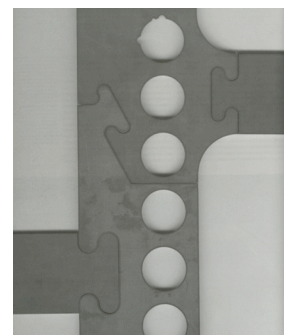


Fig 5.9  
*Plasma jet cut steel connections  
William Massie Architect*



*CNC Spoon  
Version 2, Richlite*



before they were put in place. The cost of the exterior walls, including materials and installation was estimated to be less than \$40 000, as Massie points out “it’s usually forming the concrete that’s costs a lot, not the concrete itself” (Hay 84).

Another benefit to the use of the CNC cut foundation template was that the entire template could be pre-assembled and easily moved around the site to fine tune the house’s final location. This allowed the house to be precisely placed so as to frame distant mountain views and to appear from a distance as if it is sitting right in the middle of the two lane highway.

Massie’s approach to the use of digital tools is significant for three reasons: 1) he is applying digital design and construction tools to actual projects with specific real-world problems (as opposed to more theoretical works,) 2) he has allowed his digital practises to be informed by actual material properties and construction techniques (for example the dovetail joints or the use of flexible plywood strips to describe doubly curved surfaces), and 3) he is highly involved in the construction of his projects whether that means overseeing and assisting the work of conventional contractors, or actually fabricating the projects himself. The benefits of this approach can be seen in his work, of all the architects currently exploring digital practices, his work stands out in that he is able to actually achieve the “more for less” promise of computer controlled production (a promise that too often goes unrealized). His work is also materially and formally inventive and for the most part has avoided falling into the trap of self-similarity that some of his peers have. One could easily argue however, that he has lost his way somewhat with his recent *American House 08* (see figure 5.8), with its overly-adorned surfaces, superfluous curves, and \$750 000 price tag, but this does not in any way discredit his earlier work.

Bill Massie is cited here for his innovative use of computer

Fig 5.11  
(left) Exterior view of Owens House – William Massie Architect  
(right) Plywood foundation template and curved Styrofoam molds



Fig 5.12  
 Prototypes and Models  
 Renzo Piano Building Workshop

controlled machinery, but perhaps it is not necessary to put so much emphasis on the use of specific technologies in and of themselves. If the issue is one of architects being distanced from the material reality of their work, then an example of an architect who successfully avoids this trap can be found in Renzo Piano, and the work of his firm, Renzo Piano Building Workshop. Piano is significant for his use of a circular design process that involves working with sketches, computer models, physical prototypes, without a prescribed order of progression. As Piano describes it:

*Creativity is craftsmanship. The tools may include a computer, an experimental model and mathematics. However it is still craftsmanship – the work of the mind, the work of the hand. It involves a circular process that draws you from an idea to a drawing, from a drawing to an experiment, from an experiment to construction, and from construction back to an idea again.*

(Murray 116)



Fig 5.13  
 Menil Collection  
 Renzo Piano Building Workshop

As Piano is quick to point out, he came to architecture with a background in construction, his family has been in the construction business in Genoa for generations. The name of his firm is telling as well, Renzo Piano Building Workshop, implies that it is a place where buildings are actually *made*, rather than just *designed*.

This notion of a “building workshop” is literally seen in the presence of a substantial workshop within Piano’s various studios (he currently has offices in Paris and Genoa) – the workshops produce both design and presentation models as well as full-scale mockups and prototypes. Skilled craftsmen run the shops, bringing knowledge and experience into the office that architects may not necessarily have. The walls of the workshops are covered in models and prototypes, and provide a very visible record of past work and potent source of inspiration.

While it may be true that his buildings are often less-than formally inventive, they are often very carefully detailed and rich in materiality. Both of these strengths combine to bring a very human quality to Piano’s work, something that is often lacking in many of his contemporaries (for example, Norman Foster, or perhaps Zaha Hadid.)

An often quoted example of Piano’s skill at developing details can be seen in the sun shading “leaves” of the Menil Collection, a project completed in 1986, a time in which Piano was partnered with engineer Peter Rice. The leaves are carefully calibrated to block direct sunlight from entering the galleries, while at the same time allowing diffuse and reflected light (a strategy Piano has frequently returned to throughout his career.) The leaves also have the effect of trapping hot air near the ceiling, allowing for slow-flowing air to be introduced from the floor and collected at roof level, an efficient solution for controlling temperature and humidity (Buchanon 146). In addition to these functional benefits the leaves also help to soften the gallery spaces. Despite the relentless way in which they are deployed and the rigid rectilinear design of the building, there is a certain organic quality to the form of the leaves, and the softness of the light they introduce. The precise design of the individual leaves was tested with many full-scale models, as well as highly detailed scale models that could be placed on site (see figure 5.14).

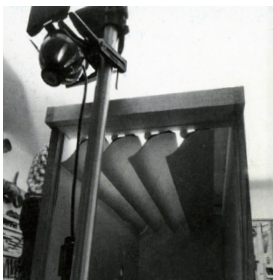
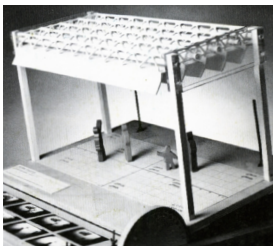


Fig 5.14  
 Menil Collection Scale model, full-scale  
 Mockup

In terms of materiality, one can look to the exterior screen of the recently completed New York Times building. The screen is made up of 3-inch diameter ceramic tubes which partially shade the building from direct sunlight as well as reflecting diffuse light into the interior. Even though in reality it may lack the crisp whiteness and dematerializing effects of the initial renderings, the screen nonetheless reflects the changing light conditions in a subtle way that is very different from the glass, concrete and stone that make up much on New York's skyline.

Piano's success in this regard can likely be attributed to the process of building physical models, both in the office and onsite as mockups before construction (this is of course, a luxury that not all architects can afford, many of Piano's projects are for large institutional clients, and come with large enough budgets to accommodate both extensive prototyping and rich materiality.) But it is also due to the careful and measured use of computers, in a recent interview with *Architectural Record* Piano had this to say about the impact of computers on the design process:

*You may find yourself in the position where you feel like you're pushing buttons and able to build everything. But architecture is about thinking. It's about slowness in some way. You need time. The bad thing about computers is that they make everything run very fast, so fast that you can have a baby in nine weeks instead of nine months. But you still need nine months, not nine weeks, to make a baby.*

Despite the fact that his office must rely heavily on computers, clearly, the computer is not king. Models, sketches, and prototypes all play an important role, and can be revisited throughout the design process. One key aspect of this is that the artifacts (models, sketches, prototypes) do not merely serve to describe or illustrate an existing design, they also explore, provoke, and challenge them, and are continuously under interrogation (Ishida 4.)

Despite the challenges they bring, it seems as if computers are here to stay, and if this is true, then the difficulties of working in a digital environment must be confronted. As has been suggested by several of the above-quoted sources, one possible way to escape some of the more problematic aspects of digital design is through the making of physical artifacts. If, as Pallasmaa says, "the computer flattens", then fabrication thickens. To make a physical artifact is to confront materiality, and all the opportunities and challenges that it entails. On the embedded material knowledge inherent in physical material things, Dennis Shelden, chief technology officer of Gehry Technologies had this to say:

*A simple sheet of paper is incredibly knowledgeable about its nature, and in many ways the digital counterparts – with all their gigaflops and megapixels – fall far short of that kind of intrinsic knowledge in the world ... A sheet of paper guides the designer – even as the designer guides the paper – in ways that are natural, direct, transparent, and yet at the same time very much constrained towards its solution.*

(Kedan 185)



Fig 5.15  
New York Time Building, day and  
night views  
Renzo Piano Building Workshop

Returning to the example of robotic surgery, and in light of the above discussed examples, it is clear that for a number of reasons, that the computer cannot replace the human hand. Designers (like surgeons) gain immensely from a direct, tactile encounter with their work, one that stimulates their entire body (not just their eyes and mind.) Sometime in the future, it may be possible for digital design programs to seamlessly integrate material intelligence, and for computer interfaces to gain tactility and intuitive feedback systems, however, at this point in time, both of these essential qualities are cumbersome and change seems a long way off. In the mean time (and perhaps even, permanently) it would seem that a hybrid approach combining digital tools and physical sketching, model making, and prototyping is likely the best way to reap some of the benefits of digital tools, while also being conscious of their shortcomings. Architects, designers, and even surgeons must remember, that when it comes to quantitative information, computers are very powerful, but when it comes to qualitative qualities of the material world we live in, the human hand, eye, and mind have no technological equal.

### Epilogue – *Material Transformations*

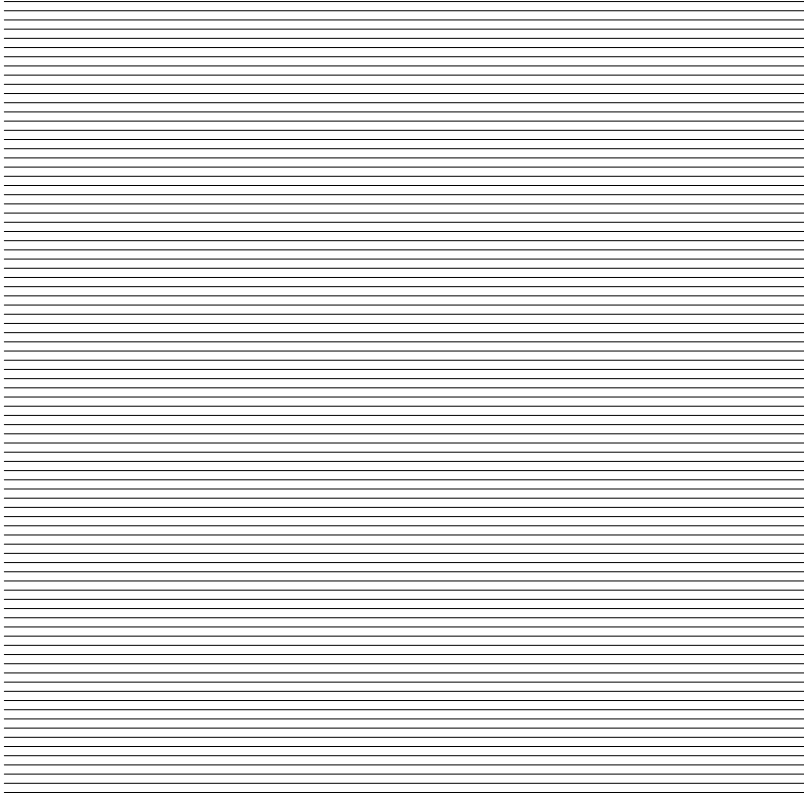
This essay has been interspersed with images of a project entitled *Material Transformations*. The project is an attempt to liquify the boundary between the virtual and the material worlds. It was born out of an interest in finding ways of working that could combine hand-controlled ways of shaping material with digital drawing tools and computer-controlled machinery. Building upon the work of the hand carved wooden spoons, this project introduces the use of digital modelling software and a computer controlled router into a workflow that is still largely controlled by hand.

The preceding essay outlined the importance of direct engagement with physical matter to a designer and this project continues this line of thinking with an explicit focus on more intuitive ways of designing, manipulating, and inputting three-dimensional forms. It is relatively easy to create free-form flowing shapes using digital software, but at this point in time it is still somewhat difficult to do with accuracy and precision. Often in order to fully understand the digital form, it is necessary to see it physically – either through 3d printing or milling operations. In recent years the ways to input data into a digital environment (such as 3d scanners, Wacom tablets, motion capture systems, temperature, noise, and proximity sensors, etc etc) has grown just as quickly as ways to export it (3d printers, laser cutters, cnc machines, digital projectors, etc). Add to this the growing practice of blending digital ways of working with traditional techniques (see Chapter I – *Morphinas in Bronze* for example) and one can easily see that there is now a dynamic, growing, and increasingly fuzzy boundary region between the digital and the physical realms. Whereas not too long ago there weren't very many readily available input devices apart from a mouse and keyboard and not too many output devices apart from a monitor or a keyboard there now exists a growing range on either side of

Facing Page: Fig 5.16  
Increasing "fuzziness" of the boundary  
between digital and physical realm.

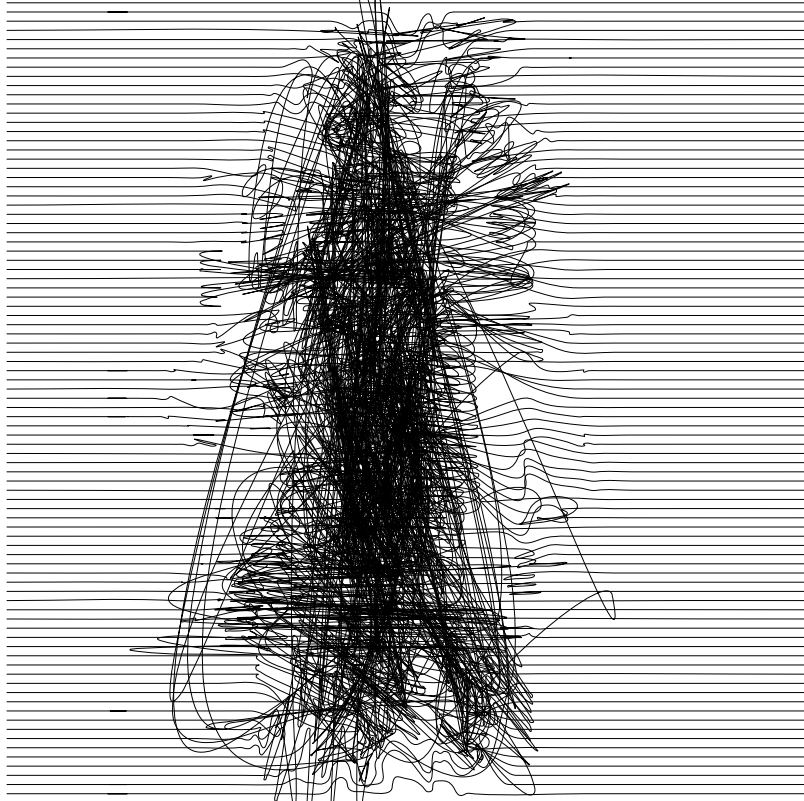


virtual



material

virtual



material



*CNC Spoon*  
*Version 2, Richlite*

the spectrum<sup>1</sup> (see figure 5.16).

This boundary zone represents an opportunity for designers, primarily in the realm of mixing the physical and the digital. More sensitive input devices mean that designers can find more intuitive ways of digitizing data, while minimizing the losses that come with a transition into ones and zeros. Similarly the proliferation of varied and affordable output devices means that the distance from a digital artifact to a physical one is much shorter, increasing the opportunity for designers to confront their designs in a physical, material way. As with any technology, it is always important to understand the limitations not to become overly focussed on its implementation, but I believe that a fluency with such techniques will be of great benefit to future designers.

I began by carving a spoon out of a soft and easily workable material, Styrofoam insulation. The Styrofoam could be easily carved with a knife and sanded with sandpaper. Due to the pliable nature of the material I could work quickly and finish a spoon in about 15 min (for comparison, the wooden spoons of Chapter 4 took between 4 and 8 hours each.)

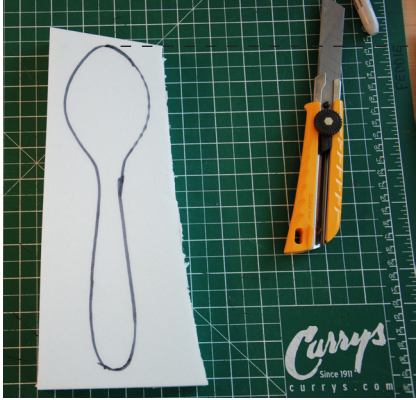
Once I was satisfied with the result I experimented with various ways of digitizing the form. There exist several 3d scanners which can achieve this, and these scanners have been featured prominently in the design process of architects such as Frank Gehry (see Chapter 8), however at this point in time 3d scanners remain very expensive and I was unable to gain access to one. I did however, construct a rudimentary 3d scanner using a computer webcam and a laser level, based on a prototype developed by the David Laserscanner company, ([www.david-laserscanner.com](http://www.david-laserscanner.com)), however I was not able to produce a 3d scan that accurately reflected the form of the hand-carved spoon. The scanner did produce some very interesting results, but they was more in the form of a sort of digital static, and were not immediately useful to me.

As an alternative to using a 3d scanner to obtain a digital representation of the physical form, I considered the way that Rhino3d actually creates 3d shapes. There are approximately 4 or 5 different ways to create a describe a three-dimensional shape using Rhino, one of which is the loft command which creates a surface by connecting a series of cross-sectional curves. To obtain digital curves that described the physical spoon that I had carved, I sliced the spoon into sections using a hot wire cutter, and scanned the resulting sections on a conventional flatbed scanner. Using the selection and stroke tools in Adobe Photoshop I could easily automate the process of outlining the slices which were then be imported in Rhino3d, lofted, and finally, exported as tool paths that could be used to control the CNC milling machine in the Architecture workshop.

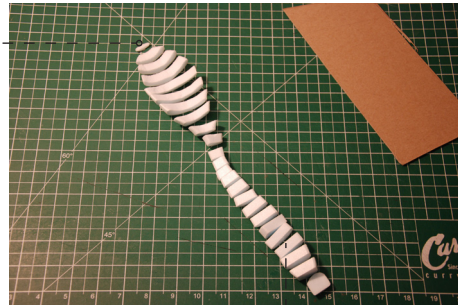
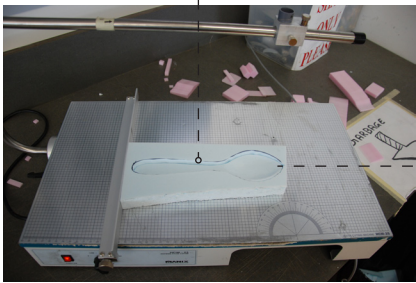
This technique has an interesting parallel with the Visible Human Project, a medical research project run by the United States National Library of Medicine. The Visible Human Project involved the

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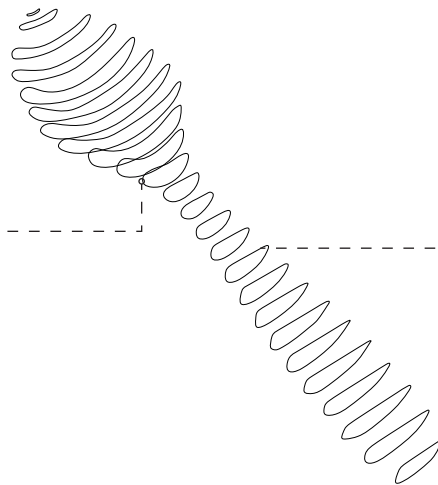
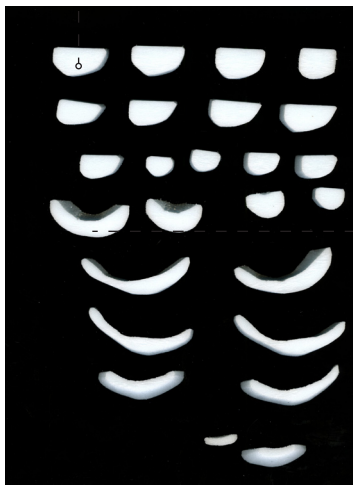
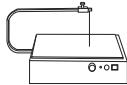
<sup>1</sup> Evidence of this can be seen in the fact that 3d printers are now less expensive than laser printers were in 1985!



1) Carve by hand



2) Slice into Sections

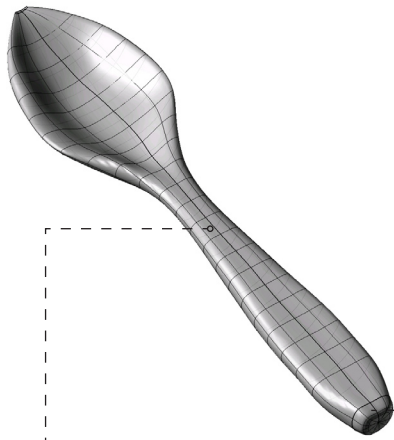


3) Scan Sections



4) Auto-trace and arrange Sections

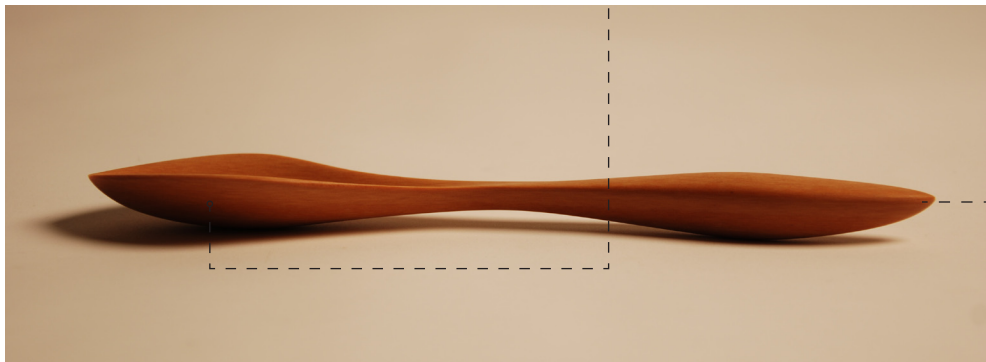
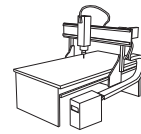




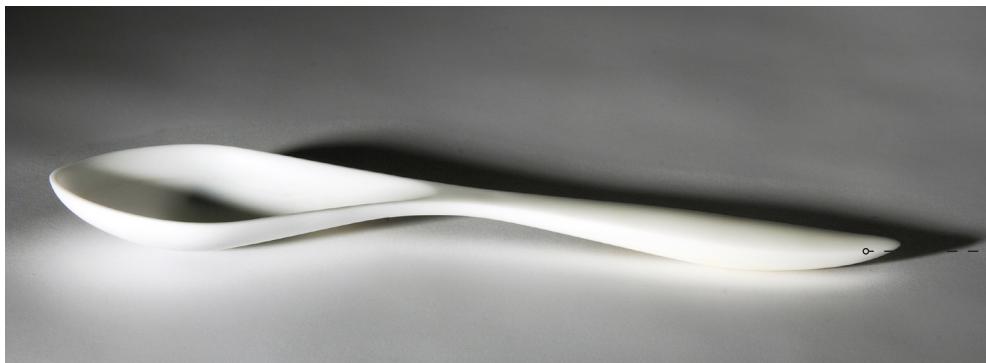
5) Loft into Surface



6) Carve using CNC Milling Machine



7) Version 2 Richlite



8) Version 3 Corian

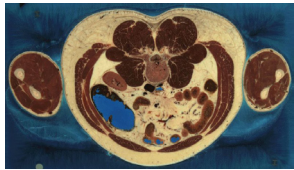
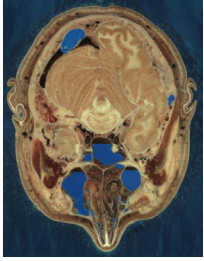


Fig 5.19  
Scans from the Visible Human Project

sectioning and scanning of a frozen cadaver so as to facilitate anatomy visualizations. Beginning in 1993, the frozen body of a male convict was incrementally sliced in 1 mm thick layers, a high resolution scan of the the body was taken in between each slice. The data has since been used to create detailed digital 3d models of the human body and has been used to successfully identify several errors in medical textbooks<sup>2</sup>.

The first version cut on the CNC machine was cut from Richlite, a dense panel material formed of layers of paper treated with phenolic resin. The hardness of the material meant that the form was quite true to the digital version, and after sanding and finishing with tung oil, the spoon is smooth, hard, and durable. The process of slicing, scanning, and lofted resulted in a form that was quite close to the original, hand-carved spoon, but was somewhat softer, similar to a piece of glass or driftwood that had been gently scrubbed with sand on a sea shore.

This softening effect gave a nice flowing connection between the handle and the bowl of the spoon, something that was not prominent in the original design, but it also distorted the form somewhat and gave slightly inconsistent thicknesses in some areas. In order to get back some of the crispness of the original design, I revised the 3d model in Rhino, modifying some of the lines that were used in the lofting operation.

The final version of this round of prototyping was cut using this new 3d model, again using the CNC milling machine, this time using Corian as the material. The pure whiteness of the Corian brings a cool softness to the design, and it is somewhat translucent near the edges where the material is thinnest. This final version bears a curious relationship to the original hand-carved one; it has been transformed into something new by several operations and material changes, yet the two are linked by virtue of being integral parts of the same process.

The process of slicing the model and scanning the resultant slices worked rather well, apart from the unavoidable drawback that you need to destroy your first prototype in order to transition from physical artifact into digital model. Perhaps the most exciting aspect of this project was the unexpected transformations that occurred in the transitions between physical and digital and when moving between different materials. As it stands, this project represents the timid first steps into a new field of working that I hope will be richly productive in the future.

Fig 5.20 (facing page)  
Version 3: Corian

Fig 5.21 (following page)  
Translucency of Corian Version

Fig 5.22 (following page)  
Corian Material Sample

2 For more information on the Visible Human Project, see [http://www.nlm.nih.gov/research/visible/visible\\_human.html](http://www.nlm.nih.gov/research/visible/visible_human.html)











## 6 | The Bosphorus

*There was that small indentation at her throat we called the Bosphorus. I would dive from her shoulder into the Bosphorus. Rest my eye there. I would kneel while she looked down on me quizzical as if I were a planetary stranger.*

Count Ladislaus Almasy recalling his lover, Catherine Cliften,  
quoted from Michael Ondaatje's *The English Patient*

*Fig 6.1, 6.2 (facing page)  
Top: The Suprasternal Notch  
Bottom: The Sahara Desert*



The project is an exploration of the body as land. A scorched desert landscape is re-imagined simultaneously as both a soft, silky, welcoming hollow, and a dry, barren, potentially life threatening plain. The form of a mobius strip is used as a symbol of continuity, an endless surface, a slow, sensual path to nowhere.

The piece was inspired by a photograph of the desert and the text of Michael Ondaatje's *The English Patient*. The story of the *English Patient* is one of a beautiful love that can never be fulfilled - two lovers meet and one of them tragically dies before they can truly be together. The memory of their love affair lives on in the mind of the scorched English Patient, a memory that is beautifully painful to recall.

The image of the desert is one of sensual softness, however lying just under this tempting image is the knowledge that the desert is among the deadliest, least hospitable parts of the earth.

This project is also an inquiry into the combination of digital fabrication techniques and hand craftsmanship; a tactile, material exploration. The piece was created by laminating laser cut profiles and then selectively hand sanding the resulting shape until one side became smooth and the other remained rough, infusing the piece with a level of tactility commensurate with its poetic ambitions.

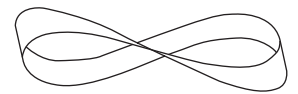


Fig. 6.4  
mobius strip

Fig. 6.3 (facing page)  
finished piece



*Ask a mariner what is the oldest known sail, and he will describe a trapezoidal one hung from the mast of a reed boat that can still be seen in rock drawings in Nubia.*

*Pre dynastic.*

*Even today caravans look like a river... Water is the exile, carried back in cans and flasks, the ghost between your hands and your mouth.*

The English patient, recounting the landscape of the Bedouin who rescued him from the wreckage of his burning plane.

*Fig. 6.5 (facing page)  
finished piece*





## 7 | The Question of Computers

In 1965, Christopher Alexander wrote a short article entitled “The Question of Computers in Design”. Despite the fact that it was written in 1965, a time when the use of computers by architects was rare, it contains some insights that are still relevant today, a time when architects rarely do anything without the use of a computer. A computer, Alexander argues, is “essentially the same as a huge 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.” The conclusion of this argument is that unless the problems faced by architects are so vastly complex and can be precisely defined so that they could be solved by an army of such clerks, there is no point in turning to a computer to solve them. In his most biting criticism Alexander states:

*Adults use tools to solve problems that they cannot solve without help. Only a child to whom the world of tools is more exciting than the world in which those tool can be applied, wanders about wondering how to make use of his tools.*

In his description of the workings of computers, Alexander is quite accurate, as of 2010 artificial intelligence still seems a long way off, and computers are only capable of performing very specific tasks requiring specific inputs. However, in a time when the use of computers is essentially a foregone conclusion, how relevant is Alexander’s analogy of a wandering, tool-loving child? Surely, now that nearly every aspect of our lives is saturated with technology, we have moved past this stage of techno-worshipping infancy?

For some time now, a large, and seemingly ever-growing group of architects and architecture students have become increasingly fascinated with parametric modelling tools and digital fabrication techniques. Now that enough time has passed for these tool and practices to have gained some acceptance and to have been tested in a wide variety of applications, an interesting situation has developed in regards to their use and application.

*Facing Page: Fig 7.1  
View of North House Interior showing  
suspended ceiling*



*Fig 7.2  
Still from Playtime by Jacques Tati  
(1967) - an army of mindless clerks or  
the inner workings of a computer?*

To some architects, the use of such tools has become commonplace and assimilated as a necessary part of everyday practice. Yet at the same time, to others they are new, cutting edge, and ripe territory for exploration. This divide offers insight into different ways of viewing technology; for some exploring the means of solving a problem can be just as important as actually solving it, whereas others are just seeking the best tool for the job. While it may seem that these two positions are diametrically opposed to one another, this essay will attempt to argue that both are valid, and in fact necessary, for the whole field of architecture. Furthermore, by examining the way these tools are used, insight might be gained into the way that their use shapes the architecture that they create.

As mentioned above, digital design tools and CNC manufacturing are not exactly new anymore, and enough time has elapsed for these tools to now be evaluated in terms of their actual utility and practical impact on the design process, not just on novelty and gee-whiz factor. But it seems the gee-whiz factor with some of these technologies is fairly powerful and unusually long-lasting; this can be seen in the publications put out annually by high profile architectural schools around the globe. Now that the novelty, at least to some critical eyes, is beginning to wear off, some chinks in the armour of the digital devotees are appearing. Kenneth Frampton had this to say about the output of some of these investigations:

*the studios of these schools indulge in aestheticized morphing exercises that, while brilliantly contrived and graphically seductive, are invariably unspecific as the substance of the project, not only in terms of site, materials, structure, and environmental performance, but also with regard to the basic raison d'être underlying the supposed function or programmatic address of the work in hand*  
(Frampton 35)

As Frampton outlines, there is clearly not enough focus on *what* these projects accomplish and *why*, with nearly all the attention being focussed on the *how*.

For further insight into the work of this burgeoning genre, I have compiled a survey of projects that, among other things, have sought to explore and express the digital aspects of design and construction. Images of these projects can be seen in the overleaf on the following two pages. Looking at a number of projects such as this from a distance, a few patterns emerge. For example, there has been much effort by a wide range of practitioners looking at ways with which to approximate doubly curved surfaces using only flat sheet materials<sup>1</sup>, and to create small, infinitely variable modules that “morph” across these surfaces. These morphing modules are often aggregated to form canopies, screens, and partitions of varying visual opacity. As complex and beautiful as the outputs of these investigations may be, there is often little in the way of reasoning as to why they were undertaken in the first place, and what, if any, the useful outcomes are. A similar grouping could easily be gathered of projects

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<sup>1</sup> See “Tessellion” by Skylar Tibbets, “Maximillians Shell” by Ball Noguees, and various projects by Marc Fornes/Theverymany

that seek to create new urban planning solutions by synthesizing vast data streams in parallel with observation of natural systems<sup>2</sup>, or a number of other research interests.

When taken as a group, the work of these architects begins to show some of the pitfalls of an approach that values the implementation of technology over other architectural concerns. The work is often site-less and divorced from concerns such as program, context, occupants, or in some cases, any practical application whatsoever. As more and more practitioners waded into the fray, there is a growing self-similarity to the projects, the search for unexplored research niches has brought an increase in specialization and a corresponding increase in the complexity of the rhetoric required to justify the projects (see for example the work of Marc Fornes, figure 8.4). Due to the innovative nature of many of these projects, there is often a significant investment in material research, software development, and the implementation of specialized manufacturing processes, the challenges of which can help to explain why many of these projects seem one-dimensional when considered as works of architecture. But perhaps it is unfair to regard many of these works as architecture, *pre se*. Rather they seem to occupy a sort of frontier of architectural research, in that they share many of the concerns of architects, but are not always explicitly meant to perform as buildings.

There is also the undoubtable effect of experiencing a sculpture or installation that is so unlike anything else we have experienced, something that is present in many of these works. For much of recent history, architecture has been dominated by flat surfaces, often of regular consistency. There is a certain sense of awe and wonder that comes from visiting a space that is so opposed to this paradigm, immersive spaces marked by variety, transparency, and double curvature. However a large part of the wonder and awe we might feel from such experiences relates to their novelty, and if when the novelty wears off, there is little of substance behind it, then the work's relevancy will be short-lived indeed.

This is not to diminish the importance of this work, for it is no doubt beneficial for all architects to see the work of those who are constantly pushing the boundaries of what is possible, but rather to acknowledge the specific role that such practices can have, within the greater realm of the architectural community. I also do not mean to argue that every project must always have an immediate practical application, I believe that design can be a form of research, and not all research must have immediate applications. There is, however, a valid concern that, driven by the excitement of breaking new ground and faced with the challenges mentioned above, these architects will lose sight of some of the vital concerns that make architecture what it is, and that help to separate it from sculpture, set-design, fashion, and other allied arts. Just as scientists need to validate their work outside of the controlled conditions of research laboratories, so too do the digital frontiersmen need to consider their



Fig 7.3  
Gramazio Kohler  
"Structural Oscillations" Installation  
Venice Biennale 2008

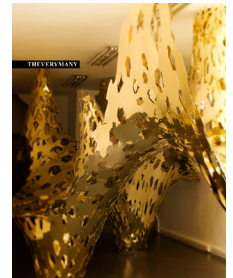


Fig 7.4  
n|Edge Installation by Marc Fornes/  
Thevermany:  
"looking at tessellation beyond triangle  
and quadrilateral arrays"

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<sup>2</sup> See *Morph-Ecologies*, 2006 Michael Hensel editor; *Techniques and Technologies in Morphogenetic Design*, 2006, Archim Menges editor



*Dunescape*, 2000  
PS1 Young Architects Program  
SHoP Architects



*Playa Urbana*, 2002  
PS1 Young Architects Program  
William Massie



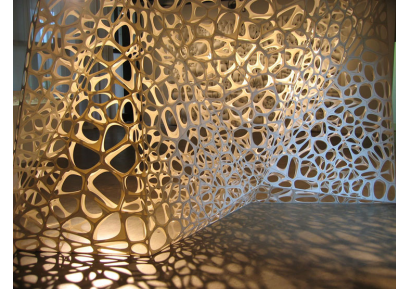
*Honeycomb Morph*, 2004  
Banvard Gallery  
Matsys



*Rip Curl Canyon*, 2006  
Rice University Art Gallery  
Ball Nogues



*BEATFUSE!*, 2006  
PS1 Young Architects Program  
OBRA Architects



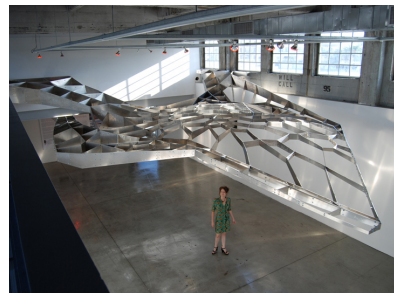
*C-wall*, 2006  
Banvard Gallery  
Matsys



*Swoosh*, 2007  
AA Summer Pavilion



*Liquid Sky*, 2007  
PS1 Young Architects Program  
Ball Nogues



*Dragonfly*, 2007  
SCI-Arc Gallery  
Emergent



*[C]space*, 2008  
AA Summer Pavilion



*Voussoir Cloud*, 2008  
SCI-Arc Gallery  
Iwamotoscott



*nEdg* 2009  
Galerie Roger Tator  
Marc Fornes/theverymany



*Puppet Theatre*, 2004  
Harvard GSD Courtyard  
Pierre Huyghe, Michael Meredith



*untitled* 2005  
Serpentine Summer Pavillion  
Alvaro Siza



*Maximilian Schell*, 2005  
Materials and Applications Gallery  
Ball Nogues



*Bonewall*, 2006  
Storefront for Art and Architecture  
Urban A&O



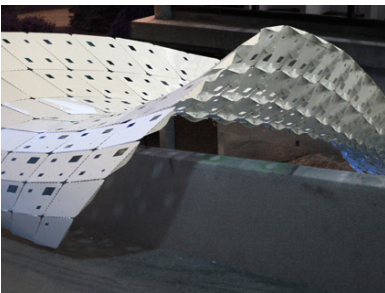
*Voromuro*, 2007  
ICA Boston  
Office DA



*Hover*, 2007  
Howeler+Yoon Architecture



*Merletti*, 2008  
SCI-Arc Gallery  
Atelier Manferdini



*Tesselion*, 2008  
Philadelphia University Architecture  
Skylar Tibbets



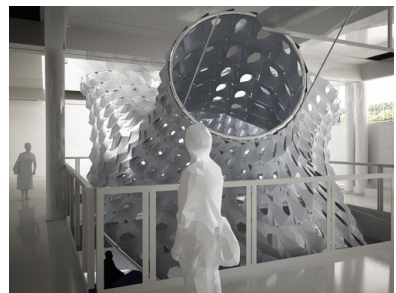
*untitled* 2008  
SCI-Arc Gallery  
Andy Ku



*Reef*, 2009  
Storefront for Art and Architecture  
Rob Ley + Joshua Stein



*Driftwood*, 2009  
AA Summer Pavilion



*Aorotic Arch*, 2009  
California College of the Arts  
VRO

role within the practice of architecture at large if they want their work to remain relevant to it.

Perhaps the biggest danger that these practices pose is to architects and students who may adopt the fascinations of the frontiersmen as their own, and might blindly overestimate the importance of such concerns by seeing their proliferation in media as validation. This, however is speculation, and as such, could be applied to many of the multitude of things that occupy the imagination of the architect.

While the bird's eye view afforded by a survey of work such as the preceding two pages can be useful for identifying trends and large-scale patterns, it is lacking the specific insight that a more focussed examination can afford. To that end I will now present the work of two firms whose work, although very different in many ways, shares a similar focus on the implementation of new technology.

IwamotoScott is the professional firm of Lisa Iwamoto and Craig Scott, a practice that is, according to their website, "committed to pursuing architecture as a form of applied design research." Both partners hold teaching positions at major universities and the work of their firm is blurred with their academic pursuits such that it would be difficult to distinguish between the two.

In 2008, the studio completed the installation *Voussoir Cloud* in the SCI-Arc gallery. This paradoxical title describes the ambitions of the project very well, a *voussoir* is wedge shaped piece that makes up an arch or vault and is typically made of stone or another dense material – yet here they are made of paper-thin wood laminate. By scoring and folding the wood sheets, the properties of the individual cells are transformed from flexible to rigid, and it is this transformation, Iwamoto says, that formed the genesis of the project. Rather than begin with a vaulted form and then seek out a way to make it using lightweight materials, IwamotoScott began with a material investigation, and a compatible form emerged. As Lisa Iwamoto describes it: "We noticed that by curving the seams, it began to take on a vaulted geometry ... the challenge was to digitally model it and replicate it physically." (Buxton 20). This is not to say that the act of folding paper was the sole genesis of the project, for a quick glance at the firm's portfolio confirms that new technologies such as CNC manufacture and parametric design tools have figured prominently in the firm's work for some time, rather that a process of material investigation was highly present among a number of other interests.

This practice of material investigation is one that IwamotoScott has pursued in other projects as well, notably the *IN/OUT Curtain* (2005) and *One Kearny Lobby* installation (2010), both of which also utilize folded, lightweight wood laminate to create three-dimensional translucent forms. Following a series of initial material experiments, IwamotoScott was able to develop four different cell types with either zero, one, two, or three curved edges. Each type had differing degrees of compressive strength and nested with its neighbours in a specific way (see figure 8.6). The cells with zero and one curved edge nested tightly and were used to form the bases and ribs of the vaults, while the cells two and three curved edges formed the less-dense infill sections of the vaults (Moreno).



The final form of the vaults and the density of the cells was developed in close collaboration with structural engineers Buro Happold. After IwamotoScott provided a preliminary model showing their desired vault form and cell distribution, Buro Happold was able to perform digital stress analysis to determine the most efficient form and to identify areas that would need a greater density of cells. According to Buro Happold engineer Tim Reiner: “This process ensured we were creating the most efficient form possible, which would experience a minimum of bending forces, the lack of bending meant we could construct the structure from relatively thin, weak material. It’s just the paper - no internal ribs, no columns” (Buxton 20).

In the example of *Voussoir Cloud* then, we have the case of a material transformation which has led to the development of a lightweight, self-supporting structural system. But perhaps the most compelling aspect of the project is the filtration of light, both through the openings near the top of the vaults and through the glowing cells themselves. It is undeniably a beautiful space. This visual beauty is compounded by the knowledge of the structural/material gymnastics at work here. The form of the vaults is somewhat similar to that of crypt beneath an ancient Gothic cathedral, but the materiality and sense of lightness could not be further from this. At the same that you are dazzled by its beauty, you become aware that there is more to this than just appearances.

Yet despite these successes, it is not without some of the flaws that beset similar digital technology-driven pieces - one of which is that it is

Fig 7.5  
View of *Voussoir Cloud* installation

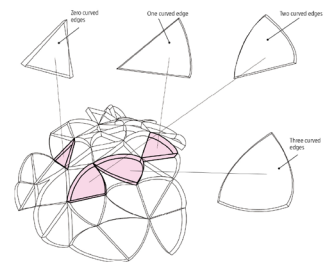


Fig 7.6  
Diagram of cell types and locations



Fig 7.7  
Views of Gantenbein Winery  
Gramazio Kohler

(in this incarnation at least) a gallery installation, requiring the physical walls of the gallery for support and the conceptual space of the gallery to remove it from many “real world” architectural concerns. Also, due to its cellular nature, it required an army of student volunteers to assemble, something that few architects have at their ready disposal.

As a relatively young firm, IwamotoScott does not have a lot of built work. They do however have a number of projects either in planning or under construction, and it will be interesting to see how their research efforts manifest themselves in their more substantive work. Another practice on a similar trajectory is Gramazio Kohler, a Swiss firm that has produced innovative work focussed on the implementation of CNC robots into construction processes. Utilizing a six-axis CNC controlled robot arm to precisely place small modules such as brick or wood blocks, they are able to create massively complex, three-dimensional assemblies out of modest materials. The work of the firm is being undertaken in parallel with research studios undertaken by its principles at the Swiss Institute of Technology in Zurich (also known as the ETH).

The use of a six-axis robotic arm is particularly interesting in that the robot itself resembles a human arm and hand, but one of super-human strength and precision. Robots similar to this have fully permeated the manufacturing processes of various industries<sup>3</sup>, but to date are extremely rare in the construction of buildings. Various attachments can be added to the end of the arm, from welding and painting tools, to terrifying circular saw blades. The project I would like to discuss involves the use of a gripping tool that works somewhat like an inarticulate yet highly controllable human hand.

In 2006, Gramazio Kohler was approached by Bearth & Deplazes Architects to design a facade for a winery building that was already under construction at the time (see Fig. 8.7). For Gramazio Kohler it was an

<sup>3</sup> Even Margaret Atwood has harnessed such machinery, she now uses a miniature version of a robot arm known as the Longben to remotely autograph books, see figure 8.8



opportunity to put into practice some of the experiments that they had been conducting at the ETH. Gramazio Kohler developed a variable pattern of brick laying that allowed daylight penetration while blocking direct sunlight, but also (most importantly) creating a graphic image of large spheres (or grapes) created by the subtly shifting shadows of the overhanging brick edges.

While the light effects and the three-dimensional variability of the facade are no doubt beautiful to behold, one cannot help but wonder how amazing the space could have been had the brick-laying robot been used for more than just the facade infill panels – complex three-dimensional vaults that respond to programmatic and performative needs could form a structure which could merge with the facade in a unity of construction. As it currently is, the grid of the concrete structure appears like a massive cage, framing and restricting the facade into a bas relief.

What is also interesting to me is the role of the robot arm in this project – I am somewhat ambivalent about what exactly its significance is. Given enough time (and extensive drawings and templates) a skilled brick layer could conceivably replicate the facades of this building without the use of any robotics – clearly the robot would be much faster, but would it necessarily be better?<sup>4</sup> For the architect there are benefits to a process whereby skilled robots could operate directly through communication with their computers, (ie without the need for drawings or specifications,) but would not a vital link in the chain of the building industry be lost? Gramazio and Kohler have been involved in intensive collaboration with a brick manufacturer as they develop the programming that powers installations such as the Gantenbein Facade, but once these programming parameters are known, will all collaboration between skilled tradesman and architect end? The possible futures of such robots in the construction industry are cause for both great excitement and grave concern.

One real danger that can be seen in the work of IwamotoScott and Gramazio Kohler is that a focus on the “lighter” elements of architecture, such as screens, canopies, surface treatments, etc., can come at the expense of other, more lasting elements, and can appear as architectural “one-liners”, or surface decoration for banal spaces (conversely, one could also argue that these “lighter” elements could be used sparingly to revitalize rundown spaces in an economical way). For an examination into the ways that architects can utilize technology to shape the more elemental aspects of their work, I will next turn to the work of two much more established architects.

From the relative obscurity of the two firms discussed above, I will move to the work of Frank Gehry, arguably the most famous architect currently practising anywhere in the world. Gehry’s famous Guggenheim museum in Bilbao and the ensuing economic revitalization of the once-depressed Spanish city has likely changed the way that museums, cities, and the general public view architecture. The work of Frank Gehry is so iconic he has long been a household name. Gehry (and his design process)

<sup>4</sup> To be fair, Gramazio and Kohler have also investigated processes which lie outside the capability of any human, such as placing blocks larger than 100 kg.



Fig 7.8  
The Longpen at work

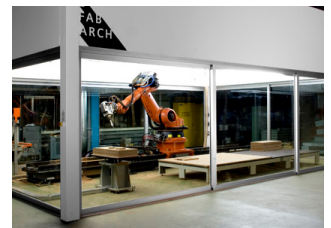
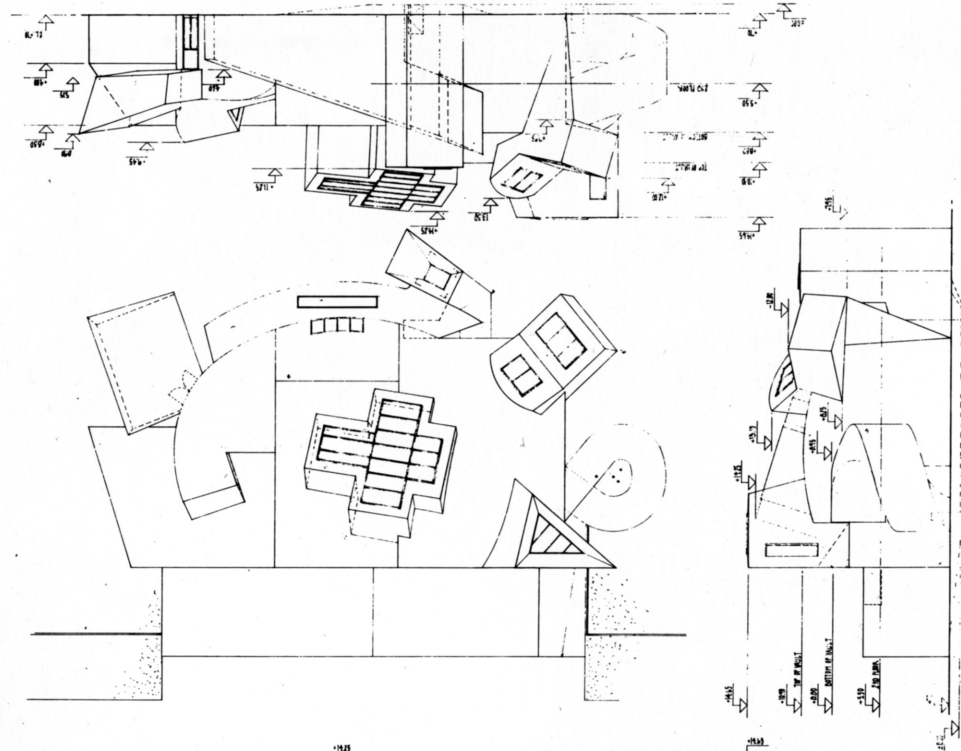


Fig 7.9  
The six-axis robot arm of the ETH at work.

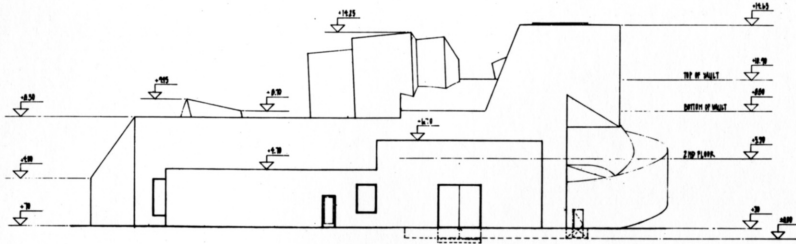


Fig 7.10  
Frank Gehry designs the Springfield Opera House!

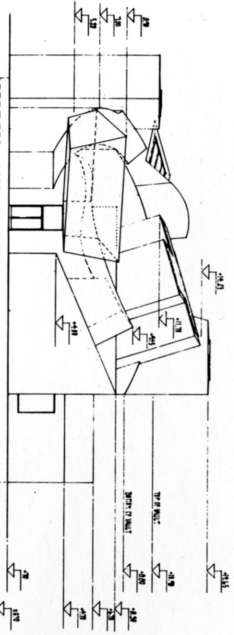
EAST ELEVATION



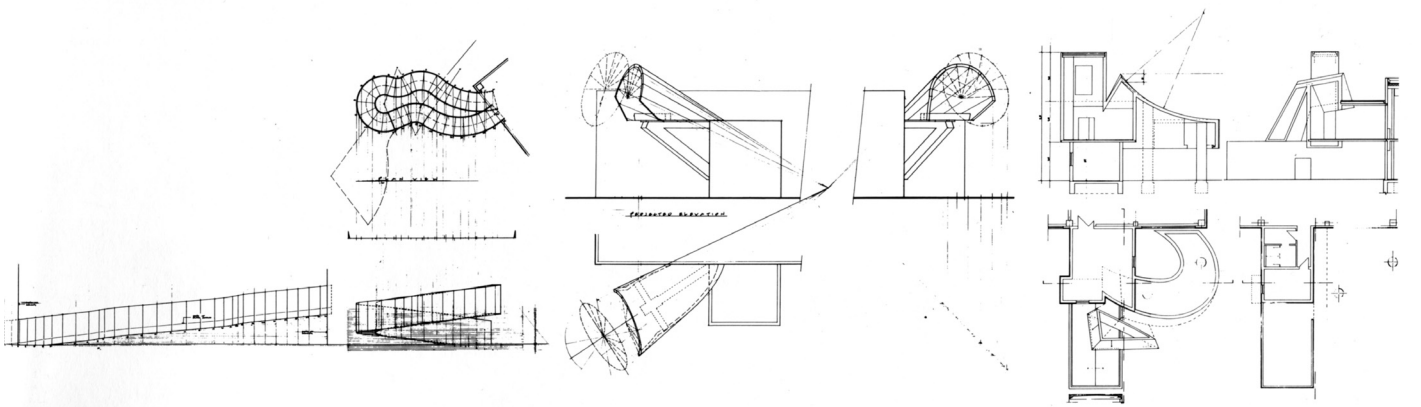
SOUTH ELEVATION



WEST ELEVATION



NORTH ELEVATION



has even figured prominently in an episode of the television show *The Simpsons*. Although the “Bilbao Effect” may never be repeated, that has not stopped many other cities and institutions from trying, and it has undeniably changed the way the general public views architecture.

In addition to these effects on society at large, Gehry has had an arguably more important effect on the working methods of architects around the world, this is due to his integration of advanced software into his idiosyncratic design process. While many people had never heard of Gehry before the completion of the Guggenheim in 1997, Gehry had in fact been designing buildings with incredible three-dimensional complexity for some time before that, a notable example being the Vitra Furniture Museum (1987-1989). The Vitra Museum, although somewhat tame compared to what came after it, has a curving exuberance that in 1989 must have seemed radical. To this author, what is most impressive is that it was built without the use of any three-dimensional modelling software. In fact, as can be seen in the drawings of the project, it was detailed using descriptive geometry, much of it drawn by hand! As can be seen in figure 8.10, this meant that in order to describe a three-dimensional form, it had to be projected into two dimensions and shown from multiple viewpoints, a time-consuming process and one that did not allow for flexibility in the design once the working drawings were started.

Frank Gehry’s design process has been well documented by many sources. It centres around the creation of highly expressive, indecipherably scribbly sketches, and the creation of large, roughly-constructed models. Gehry is known to work for quite some time in this method (sketching and modelling), until for whatever reason a project “feels right,” at which point a more detailed design can develop. While his method of working is highly personal and has been likened by some to that of a sculptor, Gehry also has a keen interest in construction, often experimenting with materials and choosing to express rather than conceal the different methods with which a building is put together. This interest can be seen in Gehry’s most recent work such as the wood-framed *Galleria Italia* at the AGO Renovation and can be traced back to the renovation of his own house in 1978. When Gehry sculpts models out of paper, one gets the impression that he sees them as an analogue to actual buildings made of real materials. This distinguishes him from some of his contemporaries who see buildings as much more plastic, and less materially complex.

Shortly after the completion of the Vitra Museum, Gehry’s office began looking for new ways to describe the geometries of his projects, and the tool they turned to was CATIA, a three-dimensional modelling software originally developed for the aerospace, automotive, and ship-building industries. For Gehry’s office, CATIA provided a way to accurately describe three-dimensional forms as well as a platform that could be shared across the project team. Information could be shared between architects, engineers, contractors, and fabricators, all from the same model. Rather than having to flatten three-dimensional forms into two-dimensional representations, the precise geometry could be shared, eliminating much of the difficulty in understanding and communicating these forms while also allowing the accuracy of computer controlled

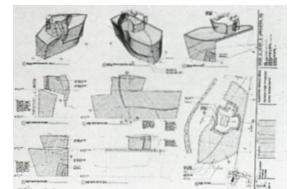
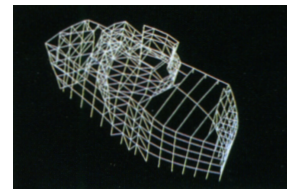
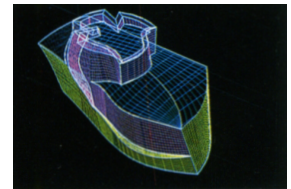
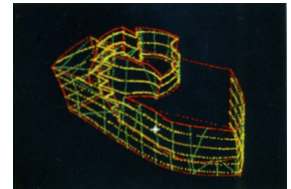
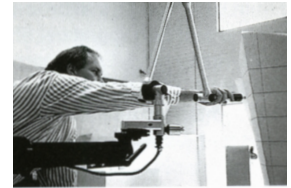


Fig 7.11  
 Frank Gehry’s Catia Process (from top)  
 1) Digitizing Physical Model  
 2) Collection of 3d points  
 3) Points rationalized into surfaces  
 4) Primary steel structural framing  
 5) 2d Cladding drawings created from 3d model database  
 6) Finished building

Facing Page: Fig. 7.10  
 Drawings of Vitra Design Museum -  
 Gehry Partners



Fig 7.12  
Vitra Design Museum (left) and  
Guggenheim Museum Bilbao (right)  
Gehry Partners

machinery (CNC) to be fully utilized. Gehry's office also uses CATIA as an analytical tool, examining design proposals for complexity and thus costliness, nearly in real time, as Gehry puts it:

*When I create curved shapes on the little models, we have a gadget that digitizes them... with our new equipment, shapes can be transferred to the computer in fifteen minutes, and now we know how much its going to cost per square foot to build those shapes ... we can rationalize all these shapes in the computer and make a judgement about the quantity of each shape to be used.*

(Friedman 50)

This brings to light a key component of Gehry's design process, that even though his office is a world leader in the development and utilization of technology, Gehry still works in much the same way as he always has, creating expressive (and scribbly) sketches and rough paper models. However, through the use of advanced software and 3d scanning equipment, Gehry and his colleagues are now able to nearly seamlessly translate these paper models into three-dimensional digital geometry. (See figure 8.11 for a simplified description of Gehry's work flow.) While the introduction of CATIA may not have changed Gehry's process very much, the difference in his completed building, is quite clear and can be seen by comparing the Vitra Museum to the Guggenheim in Bilbao. For all its curving complexity, the forms of the Vitra Museum are largely straight extrusions of curves meeting with tilted planes – there is little in the way of concavity or convexity. This is in direct contrast to the forms of Bilbao, which bulge and swell in three dimensions, somewhere in between a swimming fish and a billowing sail, and give the impression of complete

freedom of form, and a sense of living movement.

Gehry, then, seems to have been able to capture the best of both worlds, the direct intuitiveness of hands-on model making and the powerful, information-rich realm of the digital. Perhaps it is by fortuitous chance that the digital tools that have evolved are compatible with his design process. If anything, the tools he uses have been crafted around his way of working rather than the other way around (as is likely the norm when architects appropriate technology).

I would like to point out at this time that I am not seeking to valorize Gehry in any way – Gehry has managed to construct quite a few regrettable building in his time. One highly publicized example being the Stata Center at MIT whose leaks, cost overruns, and functional failings have been well documented<sup>5</sup>. This is in addition to number of buildings where his sculptural flourishes exist largely in uninhabitable facades, leaving the rest of the building uninspired and often somewhat low-rent (see the Hotel Marques de Riscal in Spain<sup>6</sup>, among others). As mentioned above, it is Gehry's work process that I am interested in, though I do have to admit that when he is successful, his buildings can be fantastic, such as, for example the Guggenheim in Bilbao, and on a much smaller scale, the wonderful, noodly interior/exterior staircases of the AGO in Toronto. It is moments like the AGO staircases, and the atriums of the Bilbao, that one feels a sense of moving, free flowing space, space that is shaped by some external squeezing, pulling and stretching.

Similar to Frank Gehry, Daniel Libeskind is an example of an architect who, by virtue of the complex nature of work being undertaken in his office, has been required to utilize sophisticated digital tools. Yet despite a reliance on these tools both in design and construction of his projects, they do not at any point define the work of his firm. Throughout his career Libeskind's work has focussed on a sort of poetic expression through built form, his buildings often have a very compelling and unique narrative that explains the symbolism inherent in his forms. The sharp angularity of Libeskind's addition to the Royal Ontario Museum (ROM), dubbed the *Crystal*, illustrates this point – in Libeskind's official rhetoric its form is described as being inspired by the ROM's crystal collection, (this despite the fact that it bears a striking resemblance to several of Libeskind's other works, such as the Denver Art Museum or the Berlin Jewish Museum, neither of which boast crystal collections).

Due to the extreme complexity of the form, the project could not have been realized without the use of myriad digital applications and CNC manufacturing processes. Seeing the building during its construction phases clearly illustrates the complexity inherent in all aspects of its construction – the steel frame alone is massively impressive, with three-dimensional connections formed by members meeting at extreme angles (see fig. 8.13). In an article describing some of the technological wizardry required to achieve such a form, Terri Meyer Boake states:

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<sup>5</sup> For a description of MIT's problems, see *Architecture of the Absurd*, by John Silber, 2007.

<sup>6</sup> The interiors of this luxury hotel were generously described as "workmanlike, although corporate in places" by Penny Lewis in an article appearing in *Blueprint* in Nov. 2006.



Fig 7.13  
ROM "Crystal" under construction,  
July 2005

*Although it may appear heavy and oversized, the large eccentric forces on all of the non-vertical members put enormous deflecting loads on the unbraced system. The angled members had to be sized much larger than standard vertical columns to prevent increasing sag in the structure.*

The steel frame then, betrays a weakness in Libeskind's design process. By utilizing computation primarily as a means of constructing sculptural forms, rather than allowing the intelligence of computational systems to refine the forms based on a certain level of efficiency, the result is complexity, redundancy, and a very expensive structural steel frame that is almost entirely hidden by vast expanses of drywall. It is difficult to know for sure, but it would appear that Libeskind's design process lacks the direct feedback of Gehry's, and that there is not the same free flow between digital and physical artifacts<sup>7</sup>. In the case of the *Crystal's* complex, three-dimensional form, the inefficiencies required to construct it appear as a very complex and expensive answer to a question that no one asked. I am reminded of the fortune cookie proverb, (quoted here from Stan Allen's essay *The Digital Complex*) which states: "Do not confuse what is valuable with what is merely difficult" (Allen 86).

Daniel Libeskind is a bit of an easy target in this regard, in part because of the way he chooses to frame his work with a less-than-consistent rhetorical stance. Another factor may be the meteoric rise his firm experienced after the completion of the Berlin Jewish Museum, which brought an onslaught of projects, speaking engagements, and teaching positions around the world. This flood of work, paired with an inability to say no, may have led to a situation where the maestro was stretched a bit thin. But one must also question the role of technology in his work.

<sup>7</sup> This is confirmed both by anecdotal conversations I have had with students who have worked for Studio Daniel Libeskind and by time I spent sharing studio space with the team designing the ROM Crystal. The models that were constructed (both physical and digital) were used more to represent the design than to explore and develop it.

Again, I would like to return to the ROM *Crystal* project. It was completed behind schedule and over budget (largely due to the complexity of the steel structure and a global rise in the cost of steel), it has received mixed reviews from architectural and cultural critics, and has even been criticized by some of the ROM's curatorial staff. The building has been described as difficult to navigate (Nuttal-Smith), unforgiving to its exhibits, and cold and unwelcoming to visitors (Lau). Given all the well-documented problems with the building, does it do anything right? Well, as a matter of fact, it does. The new addition has attracted a wealth of publicity, donations, and visitors, and, perhaps most importantly, it has given the ROM a new identity (the longevity of these benefits, particularly in terms of attendance, however, remains to be seen). The successes of ROM can largely be attributed to its iconic form and its feats of technological bravado. These successes, then, are primarily symbolic while the effects of the new construction on the actual visitor experience debatable. In this way we see Libeskind (and his clients) as dazzled by the wonders of what technology can do, but largely disinterested in the reasons it would be deployed in the first place. It is important to note that this fascination differs from that of IwamotoScott, in that Libeskind is much more focussed on the end result of what technology can do, whereas IwamotoScott is much more engaged with the process of how the technology can be used. The outcome, however, is somewhat similar, projects that privilege the use of technology over other, often much more important concerns.

As a way of concluding, I would like to return to Christopher Alexander, and to the "Question of Computers," a question to which I have found no definitive answer. I originally planned on structuring this essay by identifying 3 groups of architects: (1) those who were fascinated by technology and made it the focus of their work, (2) those whose work was concerned with other subjects, but were nonetheless strongly influenced by technology and were perhaps blind to its effects, and (3) those who managed to integrate technology into their practices in a thoughtful way, as a tool with which to solve a problem, to paraphrase Alexander. Not surprisingly, it was fairly easy to find architects whose work fit the first and second categories, but it was the third category that was the most difficult to identify. This perhaps is the central point I am trying to make, that just about every architect (indeed every person) who uses technology is influenced by doing so, sometimes in unexpected ways. In the experimental work of firms like IwamotoScott, we can see a very real engagement with structure, material, and space, but also the possibility that too great a focus on innovation can come at the expense of other architectural concerns. In the work of Gehry and Libeskind (and to some extent many other "starchitects"), we can see how hubris can combine with the freedom afforded by technological advances to distract both the architect and the client from the central goals of a project. As I hope I have illustrated, there are serious problems that face both the architects who focus solely on the means of design just as there are for those who choose to focus merely on the end result. In light of this, architects who chose to use any form of technology would be well advised to be vigilant of

its drawbacks and limitations, lest they find themselves in the position of Alexander's wandering, tool-wielding child. Ultimately, this conclusion is not surprising, for a tool is never just a tool.

## Epilogue – North House Ceiling

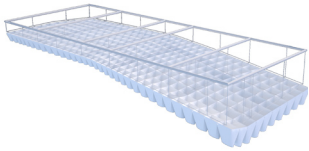


Fig 7.14  
One of forty individual ceiling panels.

This essay would not be complete without a description of my experience working on the North House Ceiling. North House was conceived of as a 5 year research project investigating the state of the art in solar powered housing. Central to the project was the construction of an 800 square foot prototype house that participated in the 2009 Solar Decathlon in Washington DC. A team of faculty and students from the University of Waterloo, Ryerson University, and Simon Fraser collaborated to design and construct the house. The ceiling was developed within the framework of the North House prototype and was developed as an independent research project led by myself and Alan Wilson, another graduate student at the University of Waterloo.

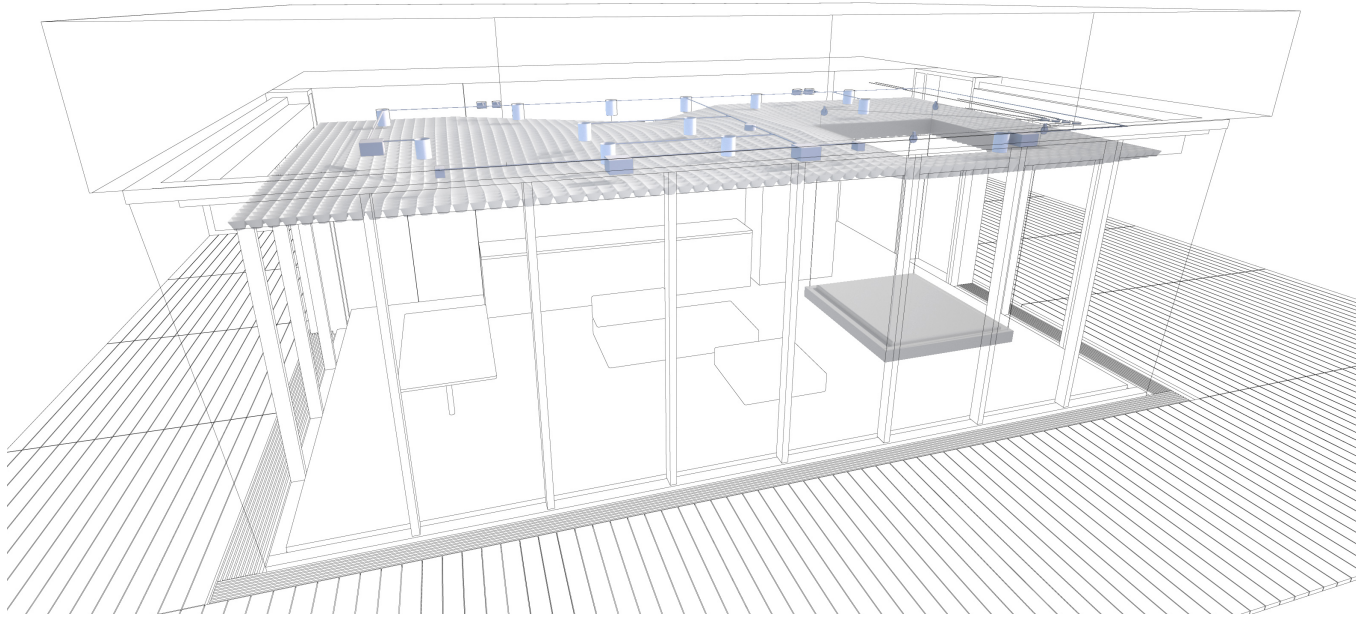
The original program was to create a continuous suspended ceiling that would conceal the surface-mounted lighting, electrical, and controls and at the same time act to soften and diffuse light that passed through it. From the beginning there was also an ambition that the ceiling would provide the opportunity to explore new material and fabrication techniques as well as to create a unique spatial and aesthetic effect. The North House was, above all, a research project and the ceiling was used as a way to engage with emerging technologies and experiment with their possible applications within the context of a residential setting.

The primary functional goal of the ceiling was to conceal the surface mounted lighting, electrical, and controls equipment. Mounting this equipment directly to the underside of the structural insulated panels (SIPs) that formed the roof greatly eased installation and disassembly, and eliminated the need to remove any insulation from the roof, as would have been the case had they been concealed within the panels.

The ceiling acts as both a functional and aesthetic element within the design of the interior living space of the North House. Faced with a competition requirement that limited the floor area to 800 square feet, the strategy for the design of the interior was to create a large, flexible space that accommodated a variety of uses in one area. By creating a continuous surface of varying heights, the ceiling acts to subtly differentiate the different areas of the living space, as well, the curvature of the surface helps to direct views outwards, furthering the connection to the outdoors and the feeling of spaciousness.

The translucency of the fabric and the angled surfaces of the cones also helped to diffuse and soften the light that was emitted from the surface mounted LED downlights. By varying the size of the cells in plan, as well as their depth, the ceiling could be tuned to provide varying degrees of light spread, again helping to subtly differentiate space rather than rigidly separate it.





The interior layout and sectional dimensions of the house were already finalized before work began on the ceiling, because of this the overall form of the ceiling was somewhat predetermined, leaving its materiality and the precise method of manufacture as the main variables to be developed. The selection criteria of the material was surprising demanding, we were in search of a material that was lightweight, translucent, flexible, flame spread-resistant, and could be cut with a laser-cutter. The actual assembly method was determined by the workability of the chosen material, as well as our desire for a flexible cellular pattern.

One of the greatest difficulties were identifying a material that all of the necessary criteria, in particular the difficulty of finding a material that had a UEL flamespread rating. There were a number of paper and lightweight plastic materials that met our desired workability and visual characteristics, but did not come close to the flamespread rating we required. This was ultimately met by using a fabric sourced from HunterDouglas, a material that is typically used to create roller shades. Another difficulty was fitting the ceiling and its mounting hardware underneath. Around the surface-mounted equipment that it was meant to conceal, around the perimeter of the space we had less than three inches within which to the ceiling could safely fit, and at one point in time it seemed like a new surface-mounted control box was being added on a daily basis.

Both of these challenges came as a direct result of the ceiling being installed in an actual functioning building – one that both needed to function both as workable residential prototype, and one that would be visited by thousands of people per day during the two weeks of the Solar Decathlon. These requirements brought a certain amount of rigour to the project that it would not otherwise have had to face, and brought it closer to the realm of real architecture and away from purely research.

There were two significant surprises that the completion of the

*Fig 7.15  
Cutaway view showing ceiling  
and some of the concealed service  
equipment.*

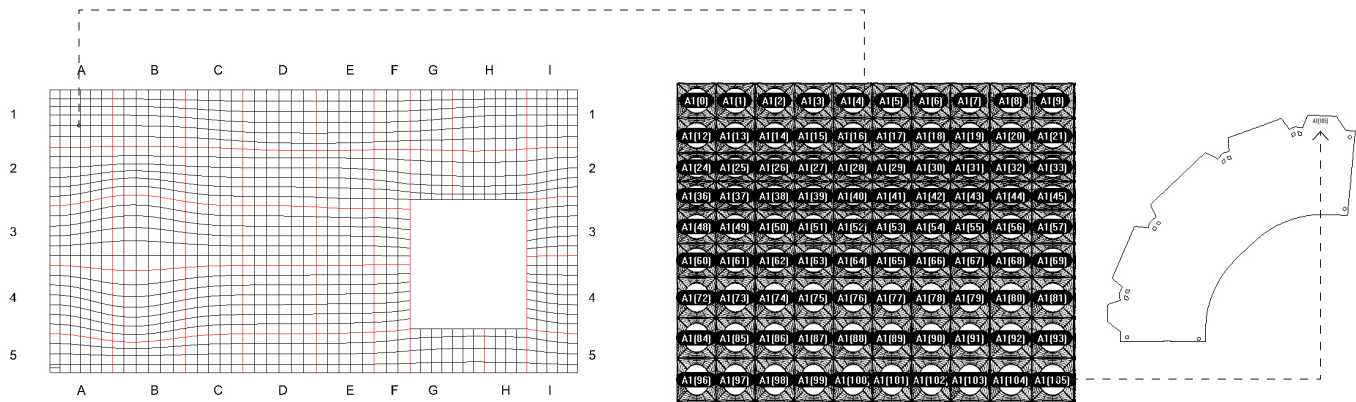


Fig 7.16  
 Labeling system, from array of ceiling panels (left) to arrangement of cells in each panel (centre) to individual label on each cell.

ceiling brought about – the first is the unexpected softening effect that the thick fabric surface had on the space. It is an effect that truly needed to be experienced to be comprehended, but within a house that was otherwise finished in planar surfaces of wood and glass, the ceiling brought much needed visual and acoustic softness, both in its form and its materiality.

The other major surprise was the time-consuming nature of the assembly and the vast amount of labour required to complete the project. As outlined in chapter 4, it was difficult to assess the impacts that small changes in the cell size would have on the assembly time, but after working with a team of other students for over a week straight folding and zip-tying over 4000 individual pieces, it is more than clear to me! I am very grateful to the many volunteers who helped to make the ceiling possible, it truly would have not have happened without their help.

In addition to the many, many small innovations and lessons that were learned from this project, there are two that stand out as important. The first is the seemingly endless supply of complications that ensue when a project like this is undertaken at fullscale, and the second is the value of cross-disciplinary, which emerged as a very powerful antidote to the former problem.

Due to the exploratory nature of this project, there were many parameters of the design that were not finalized until very late in the project, many of these stemming from the previous-mentioned difficulty in sourcing a material.

One such example of this was how exactly we would put the whole thing together - in particular the folding and fastening of the 4000+ individual cells. One early idea was that we would be making the cells themselves out of a lightweight plastic material, the cells could then be held together with zip ties. When we couldn't find a suitable plastic material, this had to be abandoned. We then moved to using a fabric which we thought could be sewn using sewing machines - a team of 3-5 students sewing for 8 hours per day could probably do the whole ceiling in a week. This of course presumed we could find volunteers who could skillfully operate a sewing machine.



After abandoning the proposition of using an army of student seamstresses, we experimented with using snap fasteners, originally used to close shirts and jackets. The snaps allowed for easy assembly by unskilled (and possibly unattentive) volunteers, but were determined to be too obtrusive in appearance, leaving us at a loss.

We had originally ruled out using any adhesives as being too messy, but upon hearing that the massive glass pieces of the facade were going to be fastened with special adhesive tape and that a consultant from 3M was giving advice on the project our interest was peaked. A brief meeting with the adhesive expert from 3M led to the recommendation of three different products, none of which had been used to fasten fabric before. Fortunately we had found a solution, and it had come from a rather unexpected place (although in hindsight it might seem like a logical progression of events.)

This sharing of expertise was evident in several other areas of the ceiling development and became a driving strength of the North House project as a whole. Although there was rarely a shortage of unexpected difficulties, there was often someone somewhere on the team to provide the necessary expertise to develop a solution.

Even though many of the lessons that I have learned working on the North House ceiling can be seen as project-specific and not necessarily transferable to later work, lessons such as these can be applied to any project - to expect that unanticipated difficulties will develop, and to look to a wide network of expertise to find innovative solutions.

*Fig 7.17*  
*left: Evening View, Exterior*  
*right: Interior View*



*Fig 7.18*  
*Interior View*

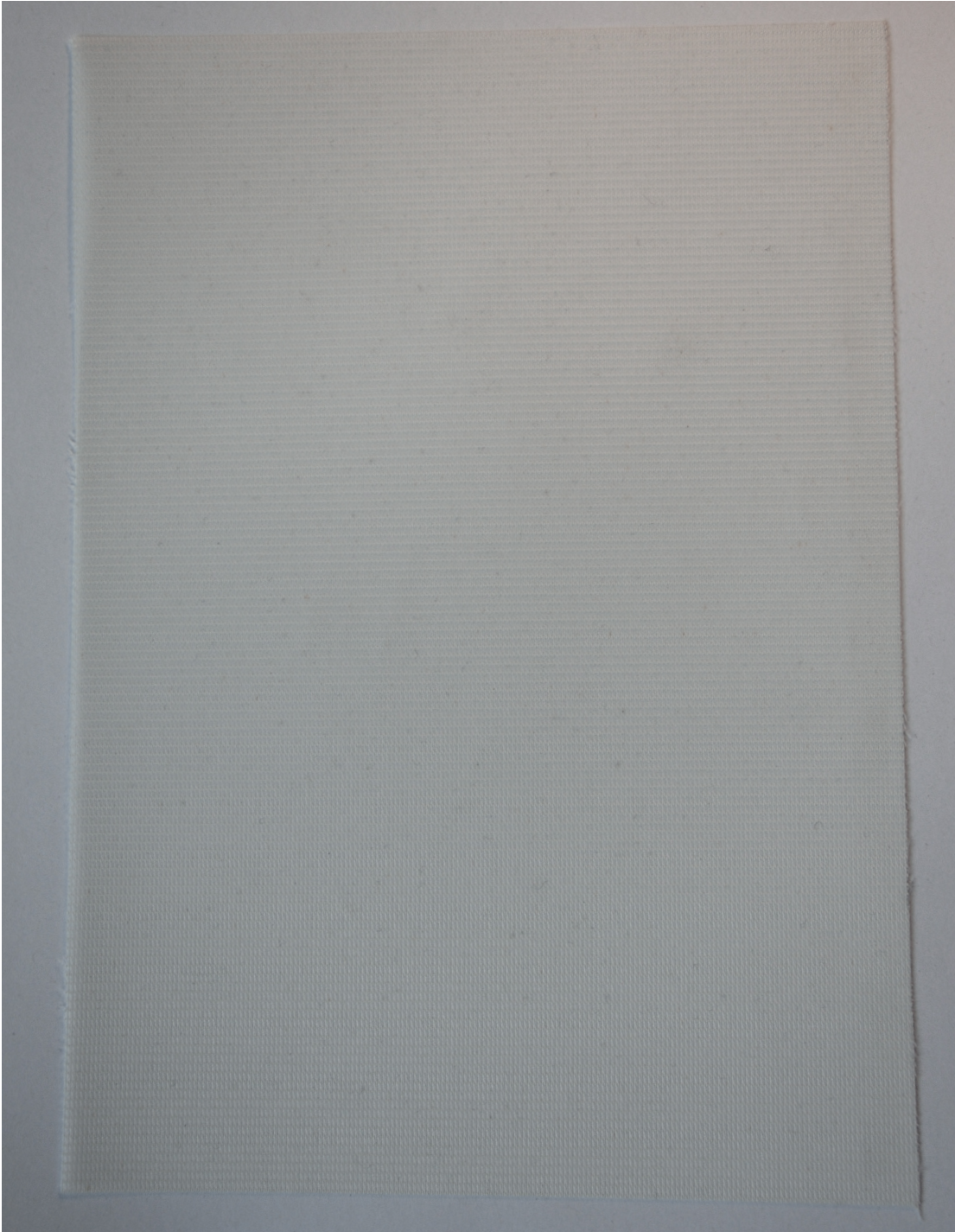


Fig 7.19  
Material Sample: Hunter Douglas GreenScreen Eco



## 8 | The Staring Contest

Like two warring tribes staring at each other across a narrow stream, the Baulthaup BI kitchen and the North House ceiling sit in uneasy contrast with each other. Below sits the kitchen; with its gas dampened drawer closers and integrated equipment, it accommodates all the rational functions that a kitchen requires, and presents them with ultra-refined smoothness, all planes and clean corners. Above droops the ceiling, and no one is exactly sure what it is supposed to do – it diffuses light, it dampens sound, it defines space, but more importantly it hangs down like a soft sea anemone, subtly drawing attention to itself with its bulges and tentacle-like openings.

The kitchen is an example modernist industrial production at its finest – once setup, an assembly line could manufacture them continuously until the world's supply of Corian and Medium Density Fibreboard were exhausted, and each one would have the exact same level of perfection and refinement. It is easy to install, easy to operate, and easy to keep clean. Its form reflects the tools with which it was made and the philosophy behind its design, a philosophy that can be traced back to the origins of modernism and the writings of Le Corbusier<sup>1</sup> and Adolf Loos<sup>2</sup>. It holds that through the use of modern technologies and economies of scale, a better life can be made available to the masses. A corollary of this thinking is a certain kind of top-down design approach that can easily stray into the area of uniformity, rigidity, and insensitivity.

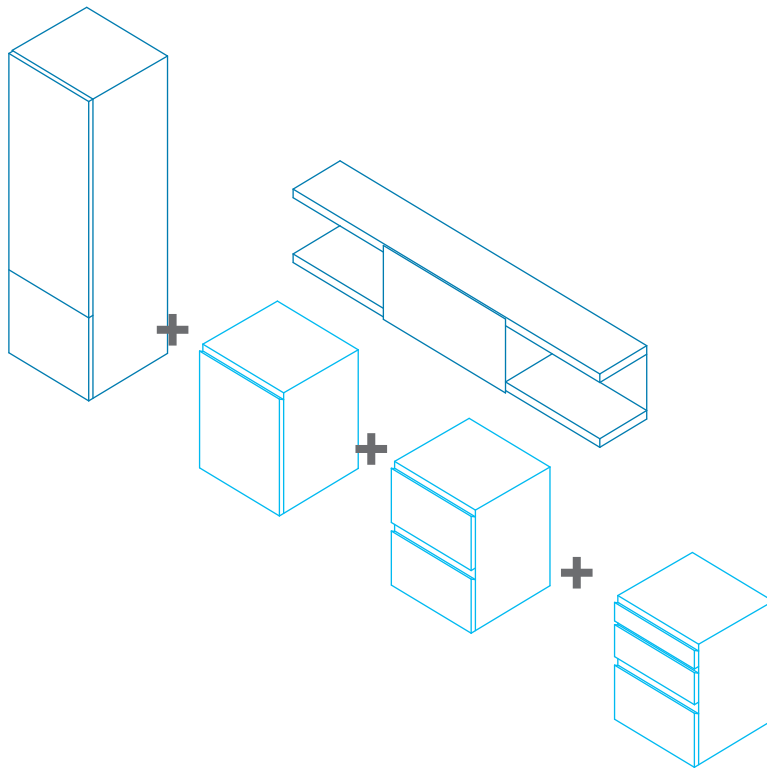
The ceiling is quite another thing entirely. By combining computer controlled machinery and hand assembly, its manufacturing

*Fig. 8.1 (facing page)  
View of North House interior.*

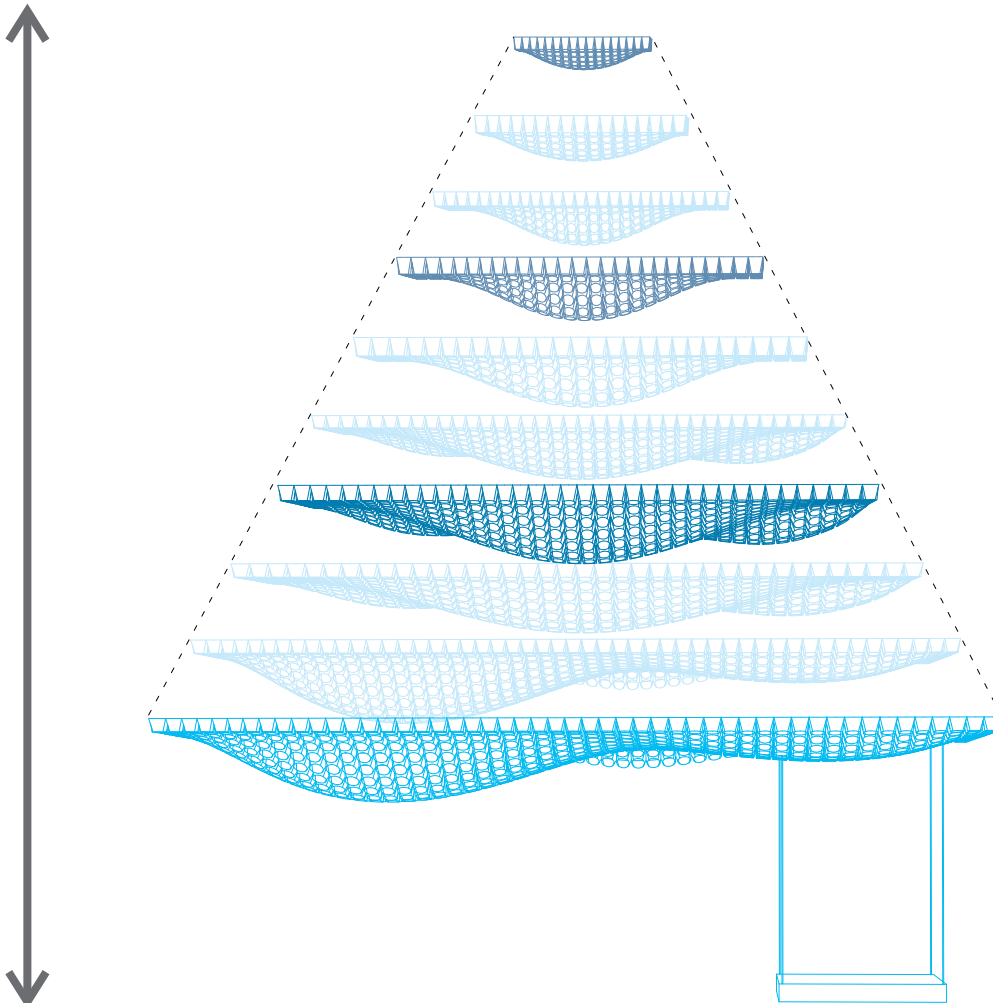
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<sup>1</sup> In the chapter "Mass Production Houses" in *Towards a New Architecture*, Le Corbusier justifies his theories on the basis of technology, economics, health, and above all morals – for him the only way to satisfy all these aspects is through the creation of "the mass production spirit"

<sup>2</sup> Although he describes the wasteful nature of ornament in his essay "Ornament and Crime", Loos expounds much greater energy making an argument against it on terms of moral and intellectual evolution: "lack of ornament is a sign of intellectual strength".



Bulthaup Kitchen  
Growth through discrete,  
modular components



North House Ceiling  
Growth through flexible, non-  
standard customization



process allows for continuous variation, and, provided the supply of cheap labour holds up, an infinite number of versions could be produced, each unique, each one tailor-made to its owners' specifications. Theoretically, if one were able to reduce the labour required for its assembly (in this task it is not far fetched to imagine a robot hand replacing many human hands), then this system of design and construction could begin to approach the ideals of mass customization as promoted by Stephen Kieran and James Timberlake<sup>3</sup>. While the idea of every man living in a bespoke house tailor-made just for him may sound appealing, is it really necessary? And does difference necessarily bring individuality? Faced with an excess of variation the human mind begins to read difference as noise, cancelling it out in a search for an understandable level of input.

It is interesting to note that the kitchen, in its current application, has strayed quite far from how early industrialists might have imagined mass production taking its course. Despite the economies of scale inherent in being produced on an efficient assembly line, it remains prohibitively expensive and out of reach to all but the wealthiest clients. A small part of this expense can be explained by the materials used and the high quality fittings and attachments, but most of it is likely due to the ability that high-end manufacturers such as Bulthaup have to charge just about whatever they want for the products they sell. Thus price is more a function of marketing than economics or engineering.

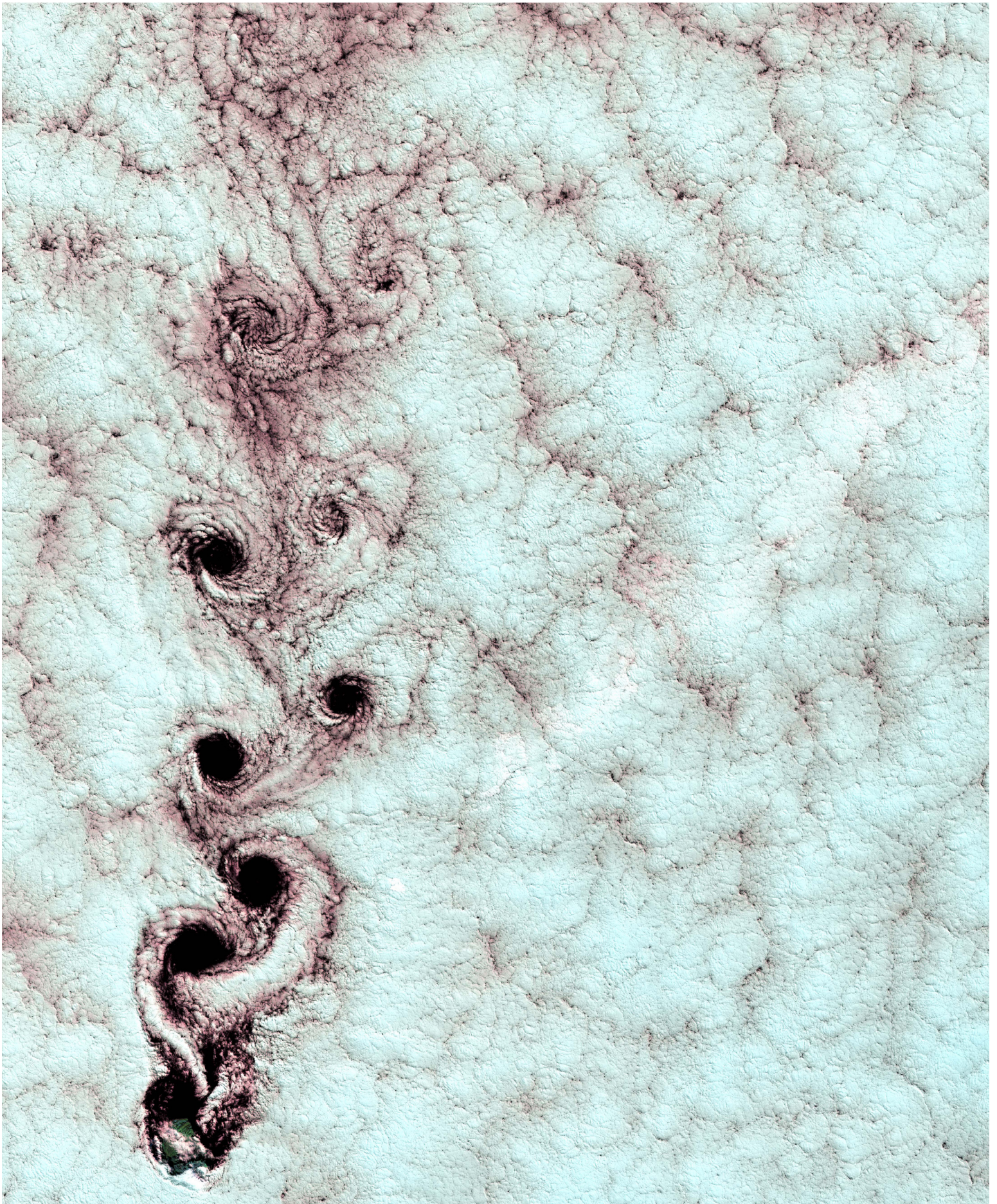
It is also interesting to speculate on how exactly the phenomenon of "mass customization" will play out. If the example of mass production is any hint, then it won't likely proceed exactly according to plan. Indeed, the Bulthaup kitchen itself is likely made primarily with computer controlled machines that have the flexibility to introduce much more variation than we are currently seeing. But just because the machines are capable of non-standard outputs, does not at all mean that the materials that feed them come in non-standard sizes, or that the means of packaging and shipping the outputs can efficiently accommodate constant variation in size, or even that easy-to-use design tools exist to program them. It seems that even though many of the tools of the mass-customization movement are already in place, the reality of non-standard production matching the efficiency of mass production remains a ways off.

In this photograph it appears that we have two very different projects with very different ideologies, but once you dig a little deeper, it seems they do have more in common than was originally thought.

*Fig. 8.2 (facing page)  
Comparison of modular, incremental  
growth versus flexible, non-standard  
growth.*

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<sup>3</sup> Kieran and Timberlake argue that through the use of process engineering and manufacturing methodologies, the architect could overcome the typical governing formula that states that  $Quality \times Scope = Cost \times Time$  moving to one where  $Q \times S > C \times T$ . Not only will this fulfill clients' mandates and desires, it will lead to a new and more central role for the architect in the design process.



*Fig. 9.1 - Karman Vortices over Selkirk Island  
USGS Landsat 1999*

## 9 | Hydrophilia

*The oceans of the earth feed the clouds, the clouds precipitate and freeze,  
and the melt-water feeds the rivers of the earth, which in turn run to the  
sea. Water behaves like being: endlessly changing, yet ever the same.*

Timothy Stock

Water, by its very nature, is ever changing - in our natural world it oscillates between solid, liquid and vaporous forms. It is essential to our survival, an average human body is approximately 60 percent water, and without water, a healthy adult will not last longer than three days. Much of our geography has been shaped by the movement of glaciers, and the subsequent erosion that their thawing brought about. Proximity to water sources has shaped settlement patterns, and the potential calamity of rising sea levels due to global warming promises to shape them once again. Throughout written history, water has also permeated literature, as a metaphor of purity, of the passage of time, and as a symbol of life itself. And yet, water is much more complex than this.

In his wide-ranging book *Sensitive Chaos*, Theodor Schwenk traces a coherence between all living things and finds in water recurring patterns that shape lifeforms from the scale of fibres in the human auditory nerve up to the swirling patterns of planetary solar systems. Although his observations are based on scientific methods, Schwenk's ultimate purpose is not merely to precisely and accurately document water, but to change the way that man looks at water. Schwenk outlines how historically man had a much more complex relationship with water. Whereas now we consider water mainly for its economic value, it once held a more spiritual, holistic value:

*"People experienced the fluid element to be the universal element, not yet solidified but remaining open to outside influences, the unformed, indeterminate element, ready to receive definite form; they knew it as the 'sensitive chaos'" (Schwenk 9)*



*Fig 9.2 - "Icebergs Generating Fog"*  
*David Burdeny 2007*

Schwenk's appreciation for water is not purely spiritual, he also values it in the most physical, practical way, but his aim is to reconcile the spiritual with the physical, to take a much more holistic view of the world. As he puts it: "A way of thinking that is solely directed to what is profitable cannot perceive the vital coherence of all things in nature." (Schwenk 10) By merely viewing water (or any other aspect of our world) as purely a commodity, we risk causing untold long-term damage for relatively small short-term gains<sup>1</sup>. Through a detailed study of water in all its changing forms Schwenk can help us to wonder at the interconnectedness of life and cause us to think of the ramifications of our actions outside of our immediate viewpoint.

It is in this spirit of observation and reflection that the work of this chapter is based. While I may not share Schwenk's spiritual beliefs in their entirety, I do believe that there is an inherent, compelling, and elusive beauty in the form of flowing water and that it is a beauty that can be observed throughout our natural world.

Theodor Schwenk is far from alone in his description of a world where all living things are united by water. In his novel *Siddhartha*, Herman Hesse describes the journey of a young man towards enlightenment. After a life filled with many adventures and experiences, from the physical to the intellectual and spiritual, the protagonist Siddhartha, still seeking enlightenment, finds himself before a river. By looking upon it he grasps that the river holds many mysteries, the most powerful of which being that "the river flowed and flowed, flowed ever onward, and yet was always there, was always the same yet every moment new!" (Hesse 107). At that moment Siddhartha decides to stay by the river, to become a ferryman, and to seek to understand the mysteries of the river.

In time, as he listens to the voice of the river, and reflects upon the events of his life, Siddhartha slowly begins to see a profound harmony in the world, and comes to the realization that time as we know it does not exist. In listening to the river, in seeing it "everywhere at once – at its source, at its mouth, by the waterfall, by the ferry crossing, in the rapids, in the sea, in the mountains – everywhere at the same time" (ibid 112). Siddhartha comes to see that all of time, all of life, exists simultaneously, for him there is no past or future, only present.

While I cannot pretend to have achieved enlightenment in the way of Hesse's Siddhartha, I do feel that our Western notion of time is a limited one. I see the value of the cycles of water as a metaphor for a more sophisticated conception of time and possibly even life itself. Perhaps because of the emphasis our materialistic society places on monetary value, we have difficulty seeing time as something other than a scarce commodity, and a signifier of worth. There must be an escape from the expression: "time is money". By stepping outside of our egocentric notion of time, we can at least try to see that time also exists on a much longer scale than that of our own lives, and in ways that may not be wholly comprehensible

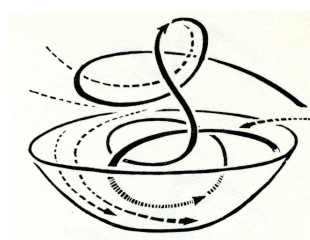


Fig. 9:3  
"Wind in an area of Low Pressure" -  
Schwenk

1 Examples of the tragedy of narrow thinking abound throughout human history, from the collapse of the cod stocks off of Newfoundland due to over-fishing, to the near-elimination of all old growth forests throughout North America.



*Fig. 9.4 - "Swell, Haida Gwaii"*  
Eamon Mac Mahon 2007

to us.

Schwenk and Hesse both sought a higher spiritual understanding through an observation and contemplation of water, but my interest in water does not stop there, for I am also drawn to the physical and material properties of water in motion as well. This project is a product of close observation of movement over time and in that respect, is very much inspired by the work of Eadweard Muybridge and Etienne-Jules Marey. Muybridge and Marey were pioneers in the study of motion and their work led to many important breakthroughs. A noteworthy early example being the discovery of the answer to the “galloping question”, whereby in 1877 Muybridge provided conclusive proof that when a horse gallops, all four of its hoofs leave the ground at once. Perhaps much more important than any single discovery however, was the illumination of information that was all but invisible to the naked eye, as Francois Dagonet in his description of Marey’s work put it: “a world now emerged that could not be grasped by looking” (Dagonet II).

The human eye has a tendency to smooth things out, whereas the world of motion as described by Marey was anything but smooth, it was often twitchy, jolting, and dynamic in its rhythms. The innovation of Marey was to develop apparatus that could record such movement without introducing interference or losing detail, to strip away all other information and reveal “the ‘trace’ ... nature’s own expression” (Dagonet 63). This idea of an essential “trace”, is one that I have pursued in these investigations – while I do not purport to have found the one and only “trace” in each piece (or that there could be only one trace), it was nonetheless a guiding principle in the work.

The techniques of Muybridge and Marey, are influential as a starting point however, for in each of the three projects I has gone one step further than my 19<sup>th</sup> century forebears. Whereas the work of Marey and Muybridge typically concluded with a series of individual still frames or lines tracing movement, I have attempted to put the data together into a new artifact, one that steps out of the world of two-dimensional representation.

Just as Muybridge and Marey faced specific challenges in their quests to observe and record movement, the intricacy of water also has inherent complexities that I believe make it appropriate to investigate these phenomena using digital technologies. The challenge, of course, is making a transition from physical observation to digital data, and back to a physical representation without losing the very qualities that I am seeking to capture. These project do, however, provide an opportunity to experiment with much more subtle and unconventional means of inputting data into a digital platform. I believe quite strongly that our current ways of interacting with computers is extremely limiting (ie, keyboard, screen, mouse) and that in the future we will develop much more intuitive and sensitive means of interaction. In the meantime, however, these experiments in utilizing data gleaned from the analysis of still and video images provides a hint of alternate ways of working.

The finished pieces display a certain kind of abstraction due to the translation from physical observation to material representation. In their

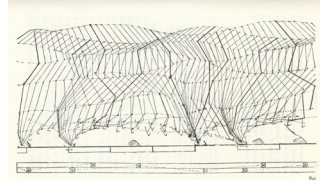


Fig. 9-5  
*Diagram of the movements of the right anterior and posterior limbs of a horse at walking pace*  
- E.J. Marey 1895

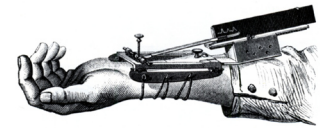


Fig. 9.6  
*The Sphymograph, an early instrument to measure and transcribe the human pulse*  
- E.J. Marey 1863



Fig. 9.7  
 Ammassalingmiut wooden maps of the  
 East Greenland coast (Whitridge, 224)

indirect relationship to the world of their inspiration, they are not unlike the intuitive maps made by Inuit travellers as described Peter Whitridge. Whitridge describes maps that were often drawn in the air or in snow, and occasionally carved into tusks, or planks of wood. These maps were often used as mnemonic devices to aid in story telling or in the verbal description of routes. What is particularly interesting is that the scale of the maps was often flexible in terms of physical distance, but constant in terms of the time required to travel between points on the map, proving a kind of hierarchy of information, and ultimately creating a map that is much more useful to an Inuit traveller than one which was perfectly consistent and spatially “accurate” (Whitridge 224). Thus, through a kind of selective filtering, these Inuit maps could communicate essential information that would have been lost had a more conventional technique been employed.

These notions of the “trace” of Muybridge or the selective filtering of the Inuit maps imply that there is a level of information or experience that lies just outside of our daily life, yet remains perceptible to us. With their notion of “concept, percept, and affect”, Gilles Deleuze and Felix Guattari describe the way that artists are able to communicate with us on the level of sensation rather than intellect. Quoting D.H. Laurence, Deleuze and Guattari note that “artists struggle less against chaos... than against the ‘cliches’ of opinion” (Deleuze 203). The artist must move beyond a recounting of his lived experiences, just as he must avoid the safety of convention and opinion, as Deleuze and Guattari state: “art does not have opinions” (176).

Rather than speak of opinions, art must speak through sensations. The sensation exists outside of the work of art, outside of the life of the artist, it is almost as if the artist is tapping into an infinite realm, calling forth powerful forces that flow through the work and into our lives. Even though the work of art is created by the artist, the “percept” sensed by the viewer and the “affect” felt by the viewer exist with the work of art and take on a life outside of it: “Sensations, percepts, and affects are *beings* whose validity lies in themselves and exceeds any lived” (164). Describing these forces as “beings” further emphasizes the role of the artist as someone who both creates and uncovers.

Among other topics, of particular interest to me is Deleuze and Guattari’s description of materials – material is the means by which the artist is able “wrest the percept from the perceptions of objects... to extract a bloc of sensations” (167). And yet, “sensation is not the same thing as the material”. Materials are expressive and necessary, but ultimately it is the sensation of the work that speaks to us, rather than the material itself as Deleuze and Guattari put it: “All the material becomes expressive. It is the affect that is metallic, crystalline, stony” (167). This idea that materials are both a means to an expression, and an expression in themselves is one that I grow to understand further the more my skills at shaping material expands.

Admittedly, I came upon the writings of Deleuze and Guattari quite late in the development of this thesis work, and their theories have not fully permeated my work. And yet, as I have developed this series of



projects I have sought to align myself more with a form of expression that speaks through sensation. Whereas the connection between the form of the *Turbulence* piece and surface of the river from which it was derived is so direct that it seems almost mimetic or imitative, the same could not be said of the two later pieces. I have sought a means of expressing an inherent characteristic of the movement of water, rather than merely representing its outward appearance. When a viewer sees and touches the *Wind and Water* piece, I don't want them to see waves on the surface of a lake (even though the form was derived from this very thing.) I want them to feel the deep turmoil of the interplay of the wind and water – the wind pushing with unstoppable force and the water sloshing and resisting with massive weight and fluidic slipperiness, and I hope to give an impression of these two bodies pushing, leaning, and bulging into each other over time.

The first project, *Turbulence*, looks closely at the relationship between flow and stasis, and the forms of turbulence that result from the meeting of flowing water and a stationary object. The second project, *Vaporization*, seeks to give material form to the movement of steam, water in its most ephemeral state. The third project, *Wind and Water*, examines the interaction of water and wind by charting the development of waves as they are buffeted by a growing storm. Taken together, the three projects give a glimpse into the world of the flowing forms of water and mark the beginning of an inventory of such forms.

Underlying this work is a paradoxical notion of time – because water is always changing, one must look at it over a period of time in order to understand its forms. A snapshot will never do. Yet this is exactly what these projects seek to do, to create a static artifact from a moving stream of data. The strategy employed is to overlay many, many snapshots in the hope that the briefest of instants will join together to form comprehensible moments, and that these moments will linger, increase in duration, and finally coalesce into a fluid continuum.

What follows, then, are the results of a brief study, one whose principle goal was to look closely, with a sense of wonder, and an eye for beauty.



*Fig. 9.8 - Speed River*

## Turbulence

Pulled by the inexorable force of gravity, water flows downstream. The meeting of this flow with a fixed object results in two actions, that of erosion of the stationary object, and the introduction of turbulence into the flow. It is this meeting of two states of motion, stasis and flow, that gives life to rivers and streams. As water swirls behind a rock, an eddy is formed, giving fish a place to rest, feed, and lay eggs. As it meets an outcropping of firmer ground, the flow is forced to bend, and this bend introduces destabilizing forces into the flow – now the water flows faster near the outside of the bend and slower near the inside, rubbing away at the outer bank and depositing material on the inner in a complex spiralling motion that will ultimately change the course of the river (Schwenk 16-17).

It is this phenomenon, turbulence, that this project seeks to examine and give material expression to. In some ways this is paradoxical suggestion, for there is little chance that any static form could come close to capturing the essence of something that is by its very nature constantly flowing and changing. But as Theodor Schwenk (and many others) have pointed out, the form of the surface of a river is in fact, relatively stable, that is, as they flow downstream, individual water molecules may be in constant motion, moving in three dimensions through peaks, troughs and valleys, but the peaks, troughs and valleys themselves stay in much the same position. As Schwenk describes it:

*a form is all the time being created simply out of movement, with new substance constantly flowing through it. This is an archetypal principle of all living creation – an organic form, in spite of continuous chemical change, remains intact.*

(Schwenk 33)

This is, of course, due to the fact that the form of the river is a result of the meeting of moving water with static objects, and typically this relationship change only seasonally, or dues to weather extremes.

The site chosen for the investigation is a section of the Speed River, beginning approximately half way between Hespler and Preston. Following the Speed River either on foot or by canoe, one can clearly see the impacts of human settlement on the course of the river, as the river approaches built-up communities, it's course straightens and the river narrows. As one follows the river away from towns and villages, it becomes wider, and its course meanders. The chosen site begins in an



Fig. 9.9  
The slow evolution of a river towards meandering form.  
(from Schwenk)

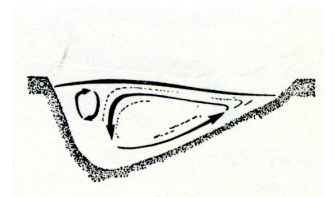


Fig. 9.10  
Cross section of a river showing spiraling flow resulting from resistance from the river bed and shore (from Schwenk)

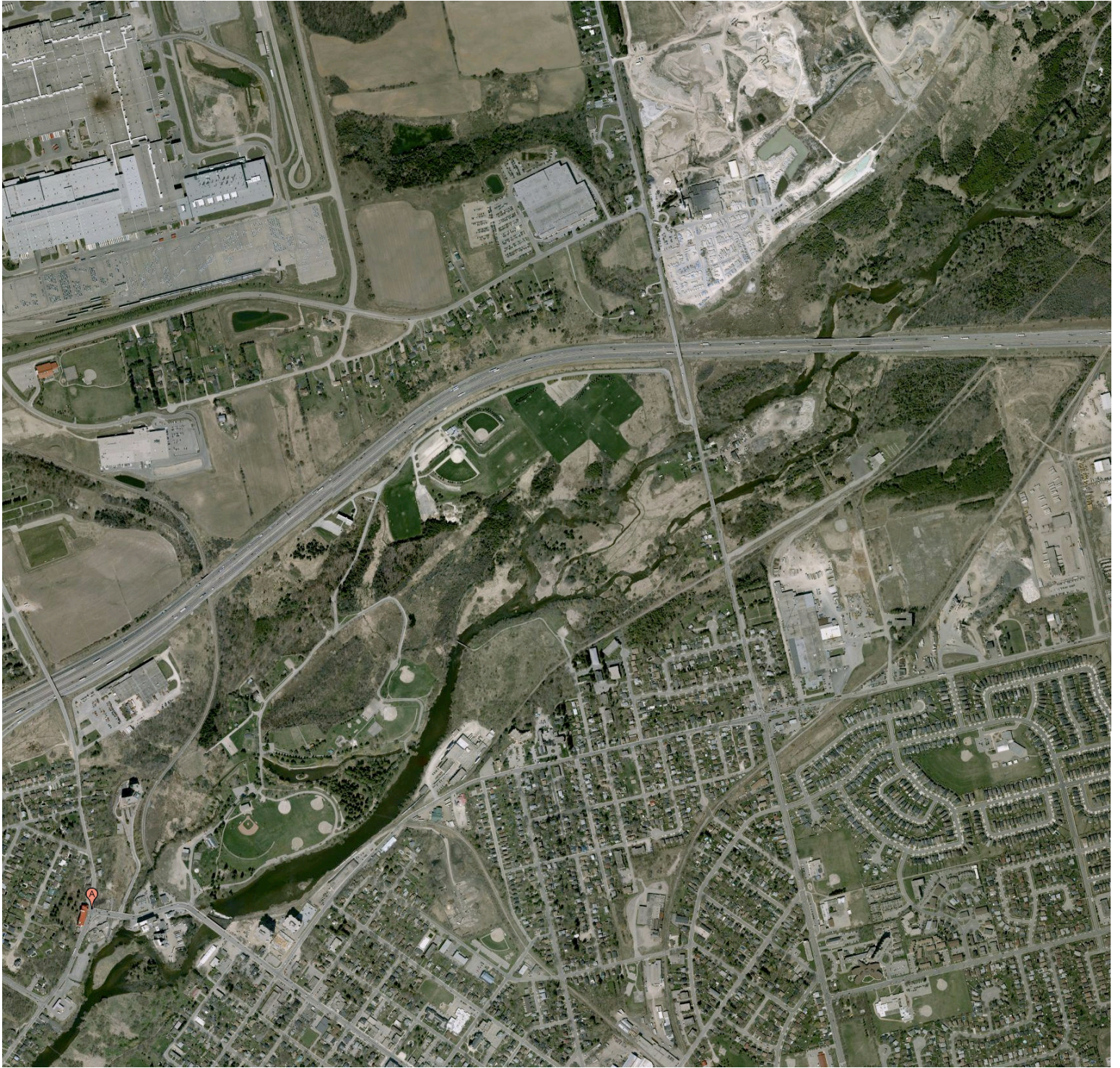
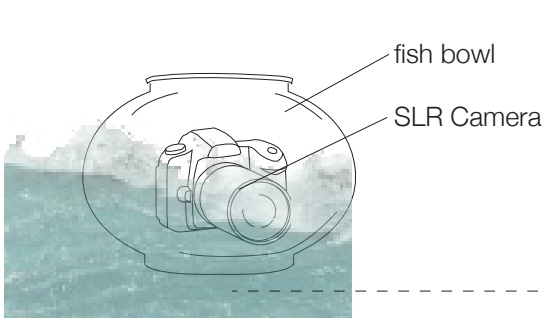


Fig 9.11 - Speed River  
Aerial View

area where the river's course is relatively natural in its irregularity, and ends near Preston, where the river is much more regular.

The technique chosen for the observation is rather prosaic, a digital camera was placed within a fish bowl, and positioned in the water so as to capture the pattern of the surface of the river in various locations. As the water flowed around the fishbowl, it would create different contours on the side of the glass. These contours would vary according to the speed of the water, the depth of the river, and the turbulence in any given area. In still or slow moving water, the contour would be almost flat, in smooth yet quick-flowing water the contour would be deeper, but usually with a single curvature, and in turbulent water the contour was much more unpredictable and varied in shape. The contour could then be easily traced, and a composite surface created using Rhino3d, a digital modelling program. The final surface was milled from baltic birch, a material chosen partly for its lack of knots and imperfections, but primarily because of the striations created by the alternating layers of veneer. These striations help greatly to read the three dimensionality of the piece, an effect inspired by the use of plywood in the work of Tapio Wirkkala (see Chapter 3, Transcending).

The final result then, is an indexical representation of the turbulence in the river's surface. It would be impossible to take the finished piece to the river and seek to find the precise locations where the data was taken from. However, if one was familiar with the river and the patterns of its flow, it is conceivable that features of the river could be recognized in the form of the wood. Smooth areas could be contrasted with turbulent ones, and the pattern of the finished piece could be correlated with the pattern of the river. In this way, even though several transformational operations have taken place, the form of the flow has survived.



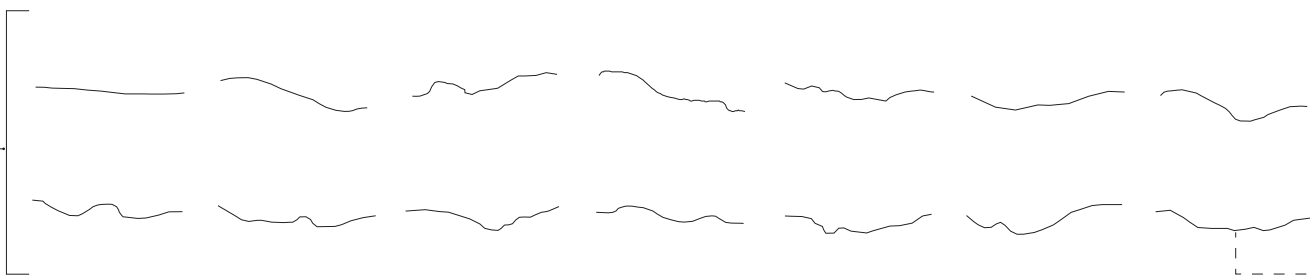
1) photograph turbulence of river surface

Speed River

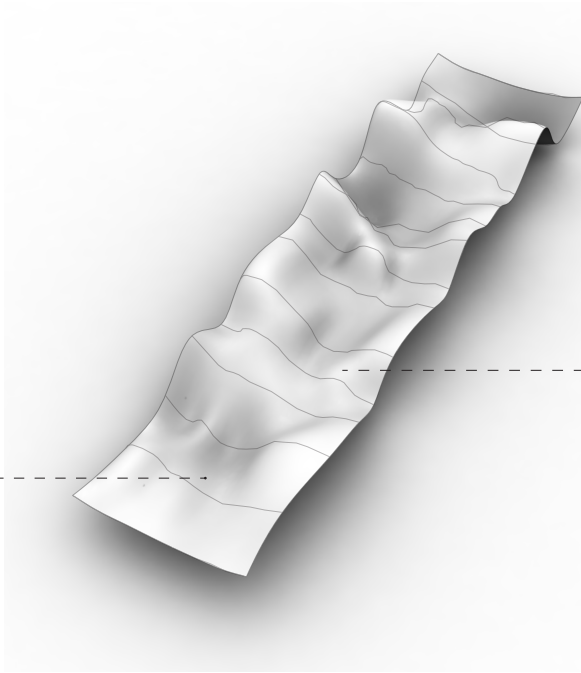
2) repeat at various locations



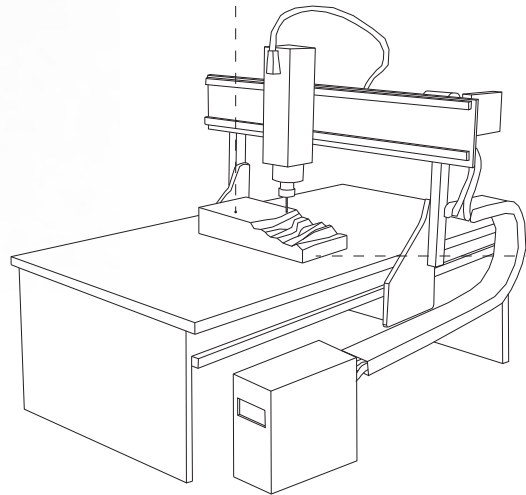
3) collate images



4) extract vector of surface contours



5) loft contours into surface



6) carve surface using CNC milling machine



6) final piece

Fig 9.12 - *Turbulence* - Procedure Diagram

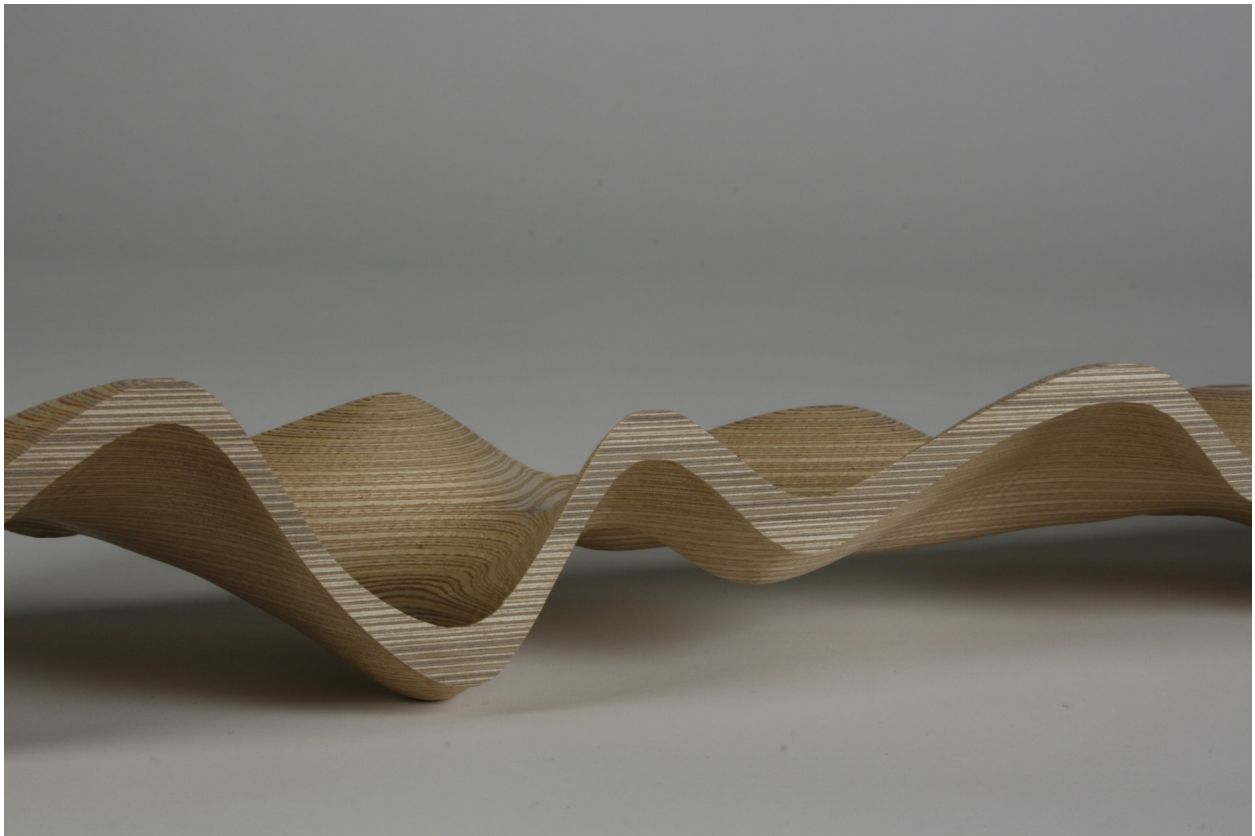


*Fig. 9.13 - The Surface View*





*Fig. 9.14 - 9.16 - finished piece*







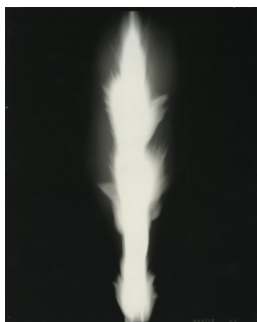
## Vaporization

As mentioned in the introduction to this chapter, water is an ever-changing element, this is particularly true of liquid and gaseous water. Indeed, under most environmental conditions, water is continuously moving from a liquid to a gaseous state through evaporation and condensation that is invisible to the human eye. If a water molecule near to the surface accumulates sufficient kinetic energy (typically by being subject to an increase in heat, as temperature and kinetic energy are proportional) it will actually leap out of the water, changing phase from liquid to a gas. In the case of water that is heated to its boiling point, this process is accelerated greatly, with a large number of molecules rapidly escaping into the atmosphere, only to shortly thereafter cool, and condense into water vapour. It is these tiny droplets of water that are commonly referred to as steam. By a strictly scientific definition, steam is the invisible, gaseous state of water, which usually only occurs right at the mouth of a kettle, just above the surface of the boiling water. However, what most people call steam is actually water in its liquid state, in the form of droplets so small that they are suspended in air. Hovering as they do, droplets of water vapour are subject to and provide a visible record of the atmosphere's flowing movements. Clouds, fog, smoke, and in some cases dust are analogous in that they similarly make visible what is invisible.

While exploring some of the techniques discussed in Chapter 4, I set out to try to give material expression to this most ephemeral state of water, as a test case of the sensitivity of my working methods. While undertaking a number of experiments, I discovered that when a column of steam passes through the beam of a laser, its form is brought into sharp contrast. By using a standard laser level, a kettle, and a digital camera, I was able to record this phenomenon. A short video of the steam moving through the laser could be exported as a stream of still images. Using Adobe Photoshop and Illustrator, I was able to automate the process of selecting the steam against the dark background, creating a series of vector outlines that could then be used to direct a CNC machine, in this case a laser-cutter. Of the three projects in this chapter, it is likely that this one represents the most direct translation from natural phenomenon to digital data to physical material.

It is important to note that this is not a record of the shape of the entire column at any one point in time, for the method I employed focuses only on the steam in that brief instant when it passes through

*facing page: fig. 9.17  
"Steam" - digital photograph*



the field of the laser level. Rather it is a series of snapshots which when stacked together, form a three-dimensional record of the way the steam moved. In this way the finished piece is somewhat similar to Hiroshi Sugimoto's project *In Praise of Shadows* (see figure 9.18). *In Praise of Shadows* is a series of time lapse photos taken of a candle as it burns and flickers in the breeze, but much better to hear Sugimoto describe it:

*Late one midsummer night, I threw open the windows, and invited in the night breeze. Lighting a candle, I also stopped open my camera lens. After several hours of wavering in the breeze, the candle burned out. Savoring the dark, I slowly closed the shutter. The candle's life varied on any given night—short intensely burning nights, long constantly glowing nights—each different, yet equally lovely in its afterglow.*

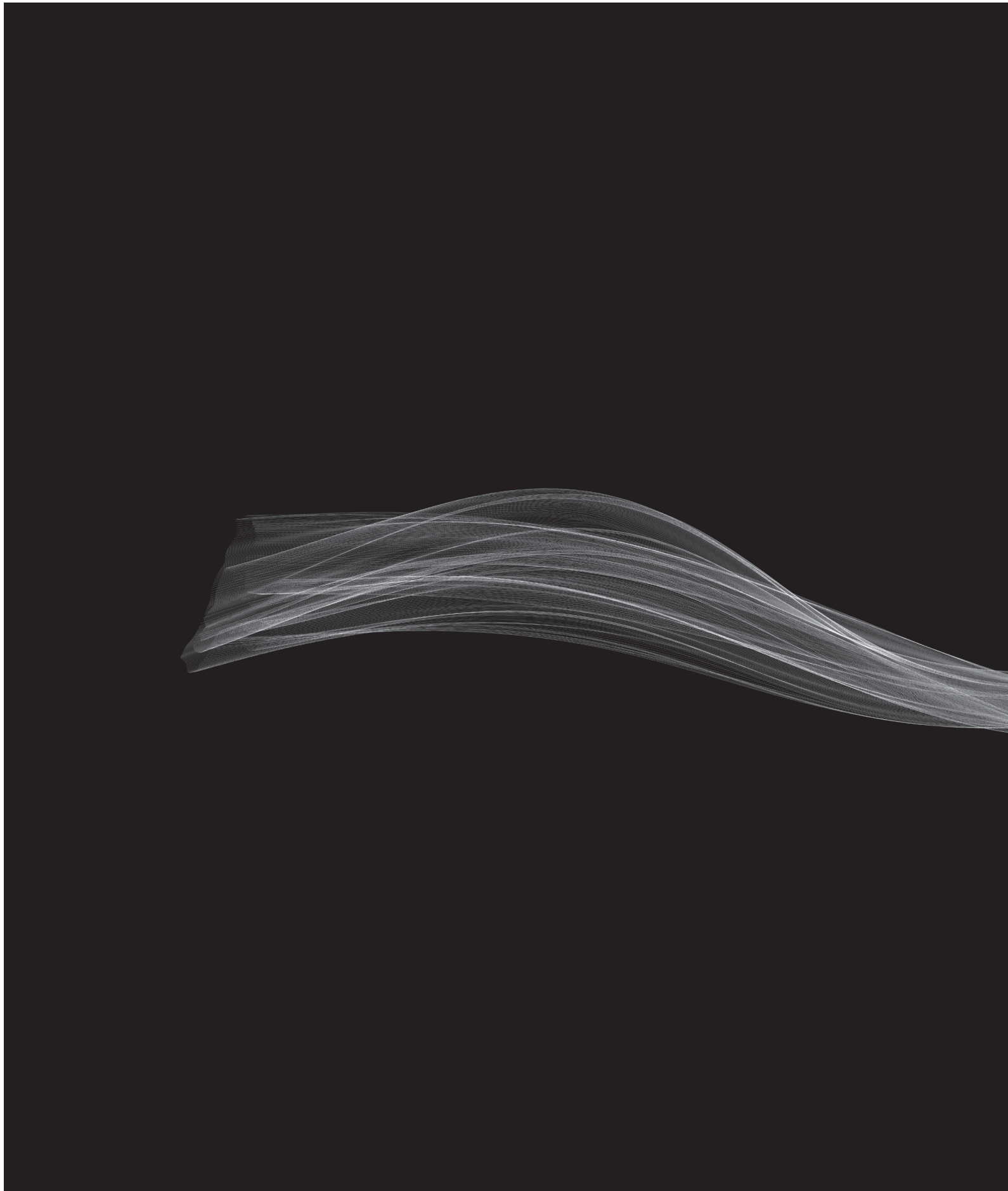
Sugimoto's photos then, are a very sensitive record of the meeting of the flame, the candle, and the breeze of a midsummer night. Sugimoto seemingly achieves the impossible, he is able to compress time, to show hours in an instant. Never for one second did the candle ever take on an appearance similar to what we see in the photos, and yet they are able to tell the life of the flame and the shadow.

Watching the steam flow through the plane of the laser, it appears to dance, jumping and pulsing with life and energy – it is never still for an instant. One interesting aspect of this project is the consistency between the original phenomenon and the various forms that the data took through its execution. Viewing the outlines of the steam on my computer monitor, particularly when stacked vertically in the 3d modelling program (see facing page), I was struck by how light and diaphanous they seemed, as if the slightest breeze could blow them away.

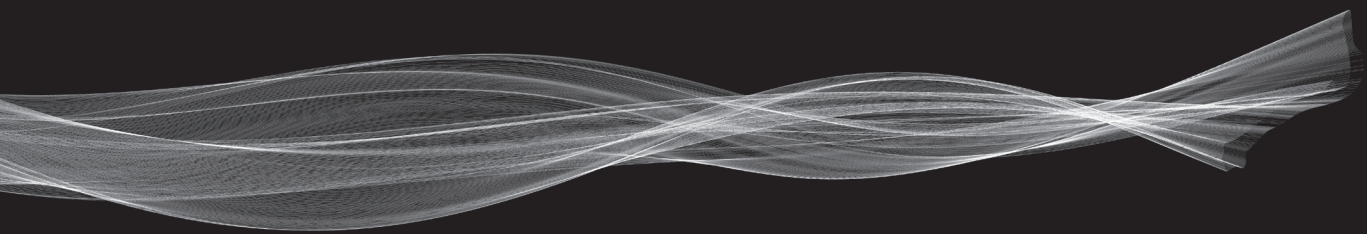
Fig 9.18  
*"In Praise of Shadows"*  
Hiroshi Sugimoto

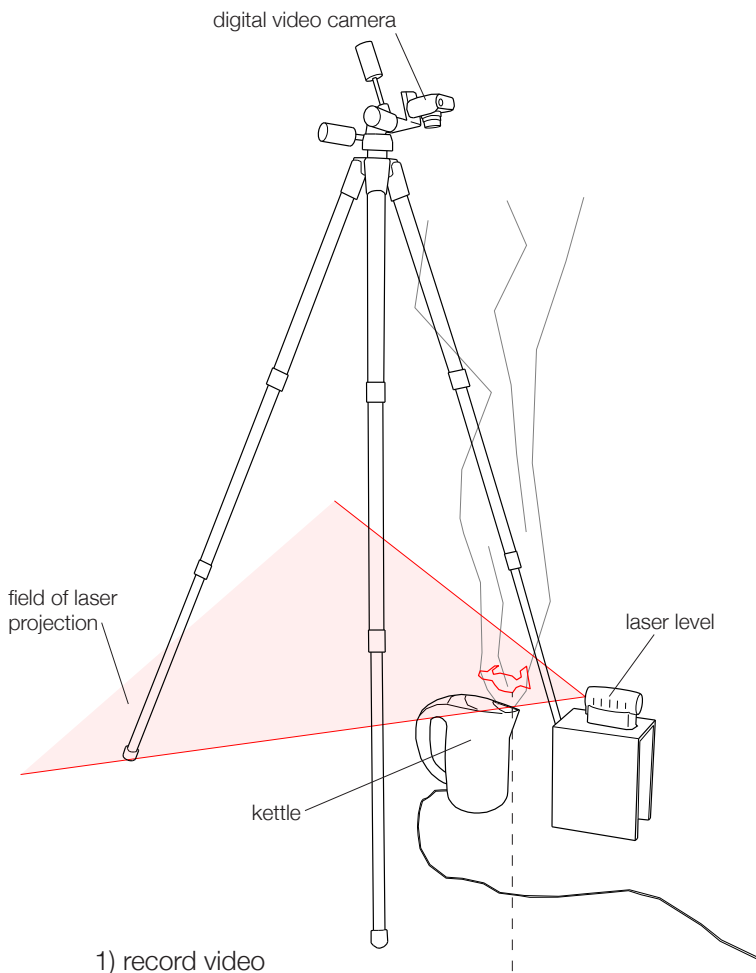
Fig 9.19 - 9.20 (following pages):  
views of digital model







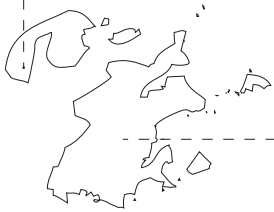




1) record video



2) export still images



3) select steam and export as vector lines



4) vectors lines lofted into a volume, sectioned, and numbered for fabrication

full 10 seconds recorded

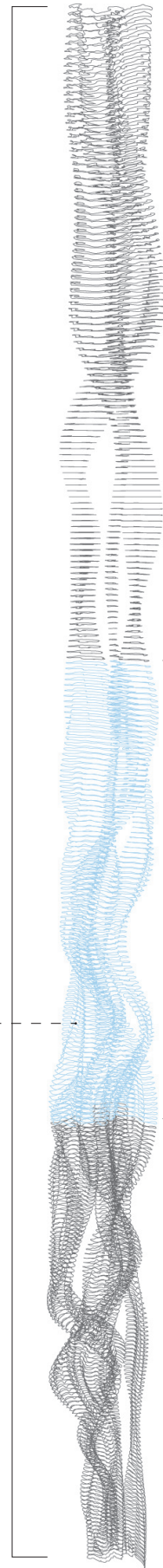




Fig. 9.21 - Vaporization - Procedure Diagram

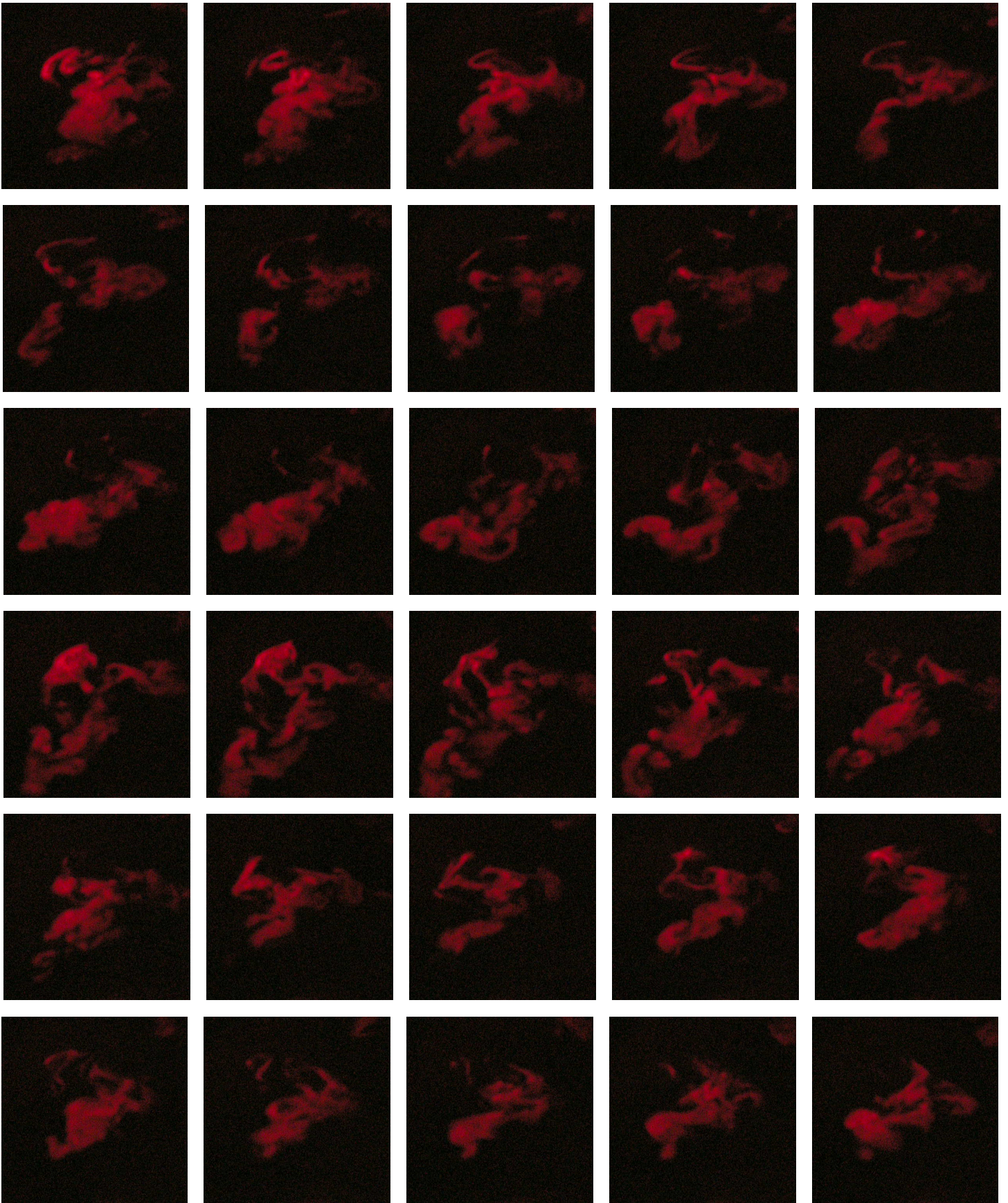


Fig. 9.22  
stills from video

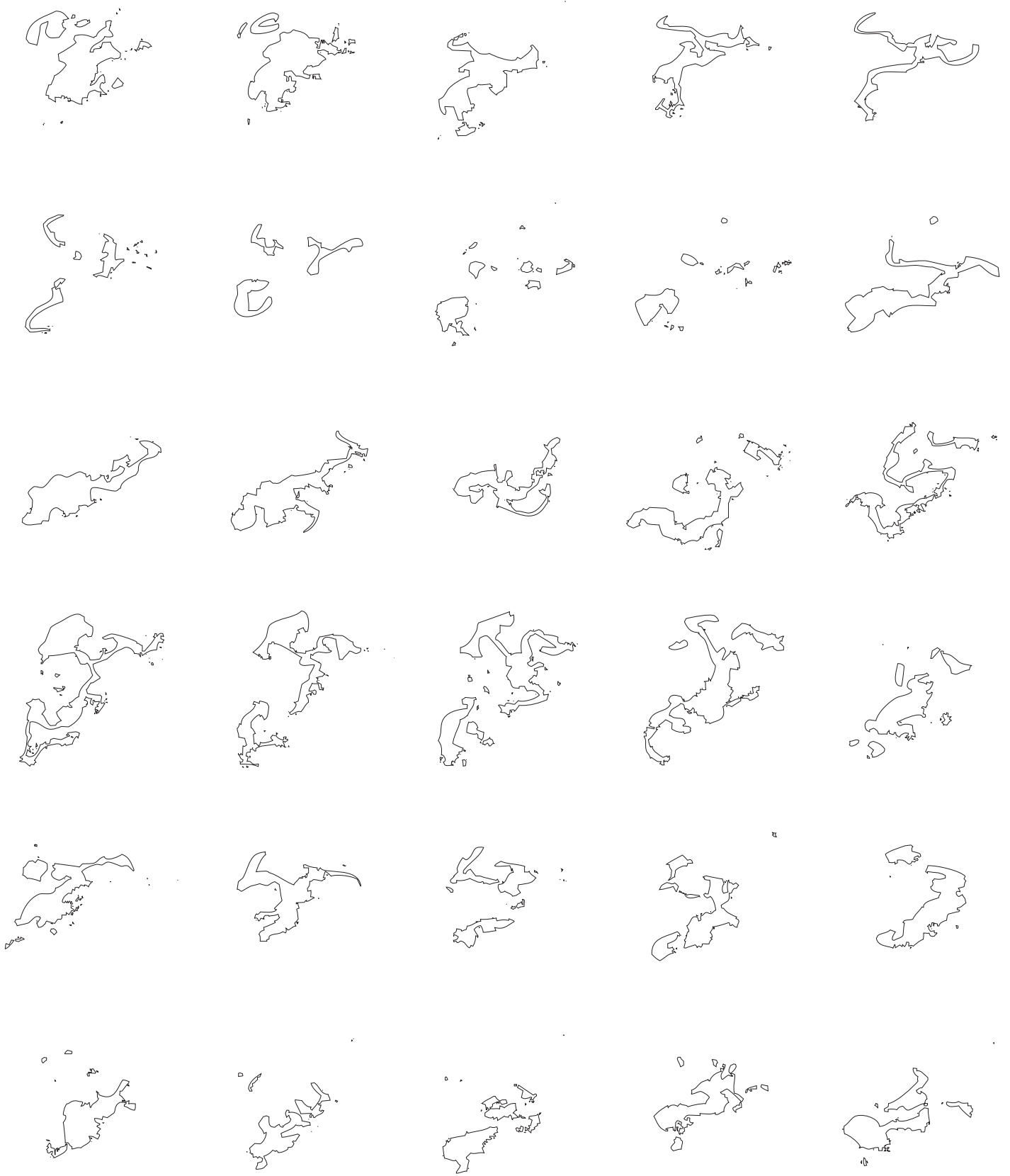


Fig. 9.23  
video stills translated to vector selections



*Fig. 9.24*  
*finished piece*



*Fig. 9.25*  
*finished piece*





## Wind and Water

It is difficult to say what exactly a wave is – intuitively we know what waves look and sound like, and we may know that waves are caused by wind blowing air over water. But a wave is not water, and a wave is not wind, rather a wave is a form in motion that is caused by the meeting of wind and water (waves can of course, be formed in many other ways, for example when a stone is dropped in a pond, but for the purposes of this project, I have chosen to focus on the meeting of wind and water). Seen in this light then, waves can be seen as the byproduct of an engagement of forces, as Schwenk describes it:

*The actual form of the wave is the result of the interaction of opposing forces, in interplay with one another. The wave is the newly formed third element, arising between the polarities – for instance of water and wind – and appears at their surface of contact.* (Schwenk 28).

With this piece I intend to create a form that is somewhat more removed from the original than I have done with the others – for example, the river surface piece *looks* something like the surface of water and the steam piece looks something like a column of steam. With this final project I am seeking to find a way to move a little bit further away from the literal form of the water phenomenon, in the hopes that I might instead discover another form, one that is more evocative of the relationship between wind and water.

Like the other projects, my observation of the waves required the development of a specific recording process as well as specialized equipment. I needed to find a way to observe the form of the waves over time, and to translate that physical form into digital data, hence the creation of the wave machine. The wave machine itself required a surprising amount of development and iteration before arriving at a working solution. An early version consisting of a perforated tube with a Styrofoam ball was discarded as it was difficult to digitally isolate the location of the ball within the tube (that is, to ascertain the height of the wave at any given point in time). As well, it was difficult to secure this prototype to the slimy, uneven rocks of the lake floor.

A second version was created that overcame these early flaws. This version of the wave machine works like a sensing finger, on one end is a paddle that floats on the water's surface, on the other is a brightly

facing page: fig. 9.26  
Lake Ontario



Fig. 9.27  
Rock Formation in Bolivian desert.

coloured disc that can easily be “seen” against the blue-grey lake by the Photoshop selection tool that I would later utilize. Tripod legs provide some stability on the lake floor, but still needed to be weighted down so that the whole machine would not get washed away by large waves. Further adjustments were need to the pivot connection, both for durability and to minimize friction. In the end it worked something like a finger trailing lightly behind a canoe, only instead of being connected to the hand of a lazy paddler, this finger was connected to my laptop computer and ultimately to a CNC milling machine.

The day that I finally succeeded in collecting the data was slightly breezy, the waves were between 15 and 30cm peak to trough and picked up noticeably within the hour or so that I spent – a summer thunderstorm was blowing in. As the wind picked up, the form of the waves changed, they became deeper and further apart, the wind was blowing a larger volume of water with each wave. This introduced an element of change that is not present in the other two pieces. The water level in the river is constantly changing, however it was taking place at a pace that was much slower than I could discern. The steam column was changing much faster, yet its overall shape remained much the same over time. Here, each wave was different, and they were also changing in a trending pattern that was visible over the short amount of time that I was present.

As with the other two projects in this series, there is the difficulty of representing a phenomenon that changes over time by using a static medium. With this project I wanted to highlight the effect of the incoming storm as well as the form of the thrusting of the wind and the lurching of the water. As can be seen in the following diagram, the data of the waves was collected and collated to take the form of a long line, similar to the readout of an EKG machine. Four 15-second long slices of time were isolated, one from the beginning and end, and from the 10 minute and 20 minute mark of the data. These slices were then lofted into a continuous form using Rhino 4.0, a three-dimensional modelling program.

The result of this operation is that the a new form has been created, one that is a merging of the different slices of time, and yet within this new form, the original slices remain visible. When viewed directly in profile, it is possible to trace the exact pattern of the form of the waves, and when one moves around the piece, the form is animated as it flows and merges into another slice of time. In this way, the viewer’s relationship to the piece reintroduces an aspect of movement that may have gotten lost in the translation form flowing water to static data.

*Fig 9.29 (following pages):  
overlay of cumulative wave data lines*

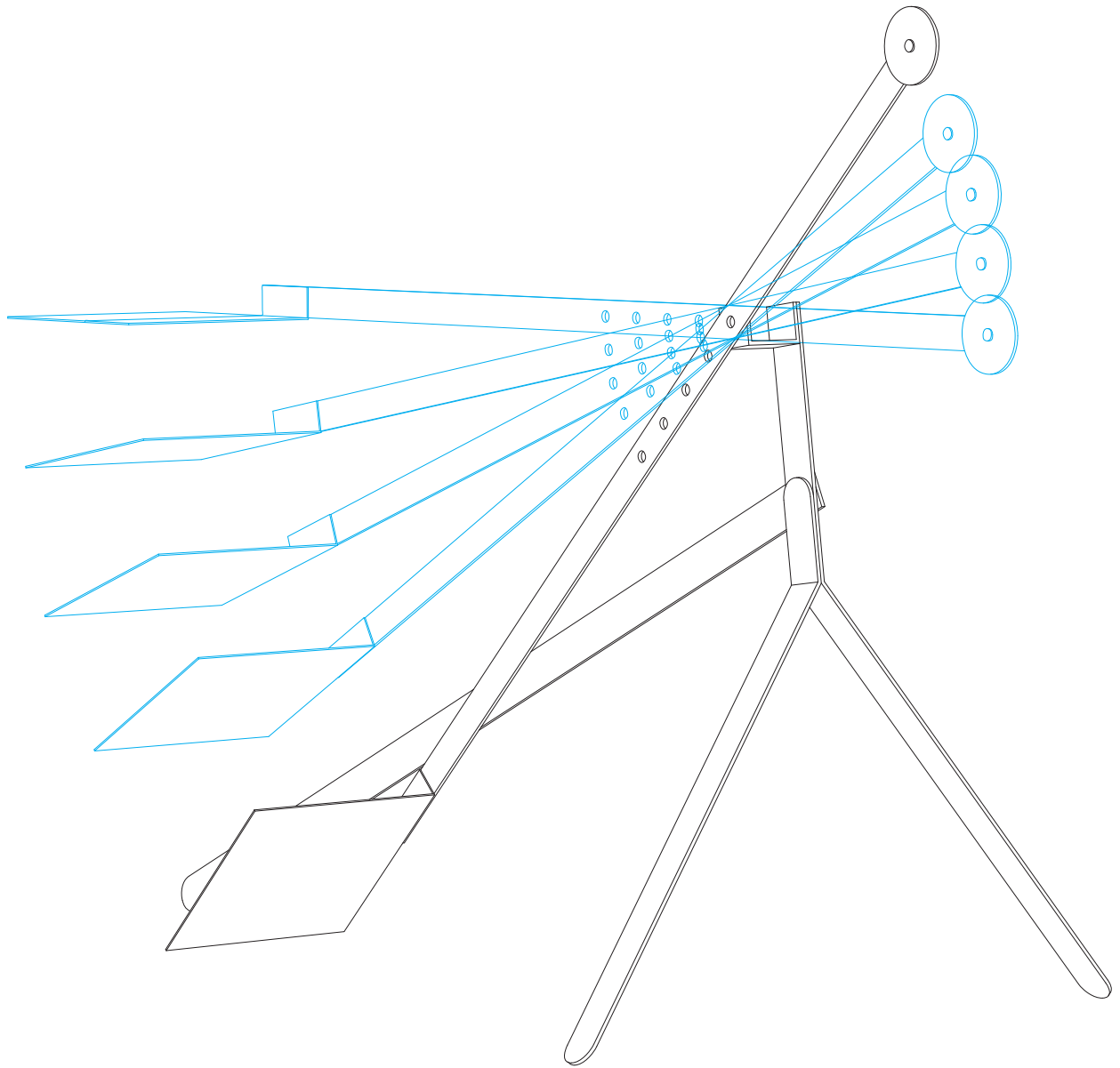
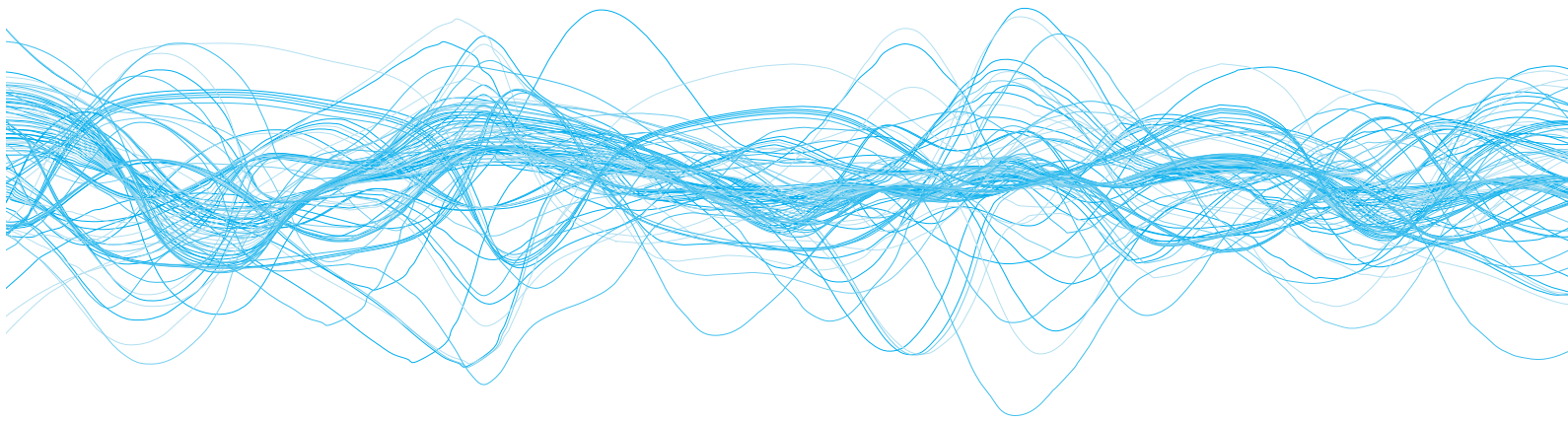
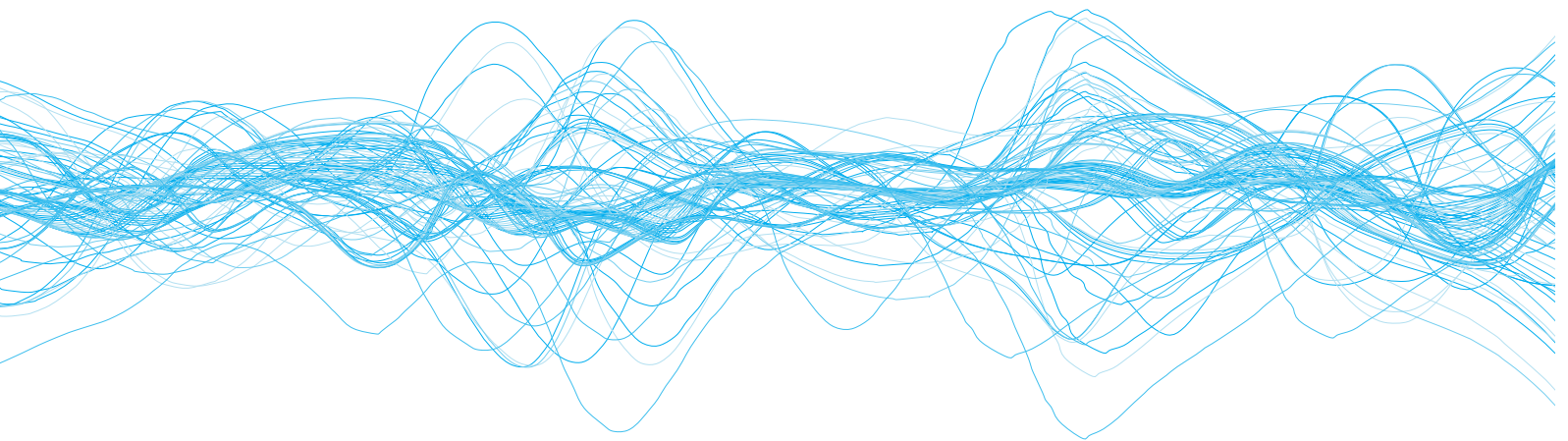
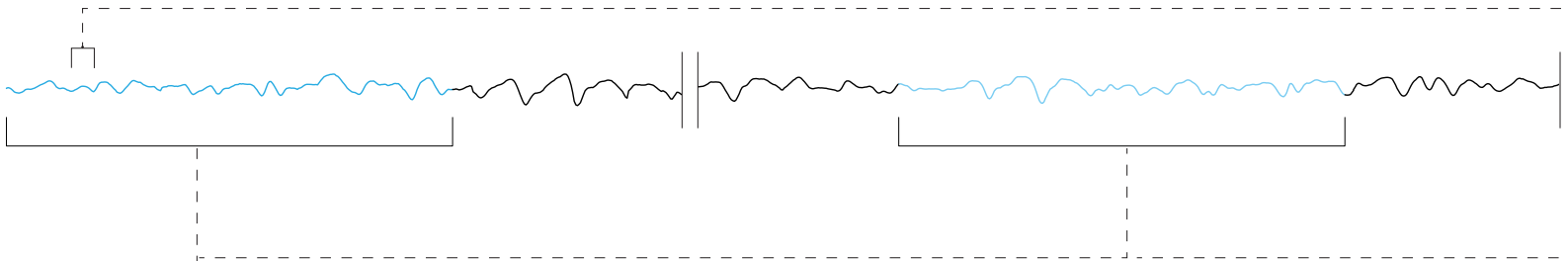


Fig. 9.28  
Wave Machine







00:00 - 00:15



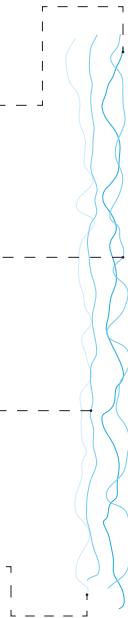
10:00 - 10:15



20:00 - 20:15



29:15 - 29:30



4) extract representative slices of time

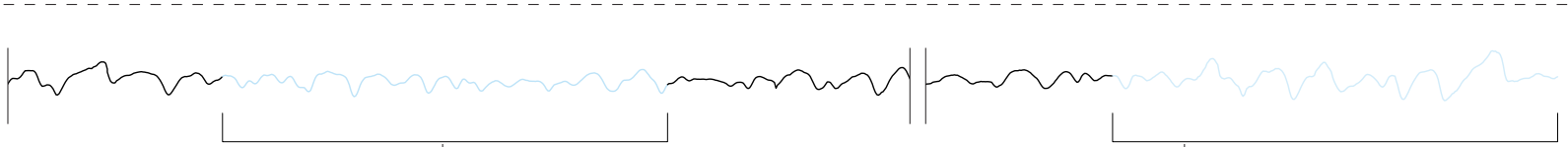
5) loft slices into continuous form



1) stills from video



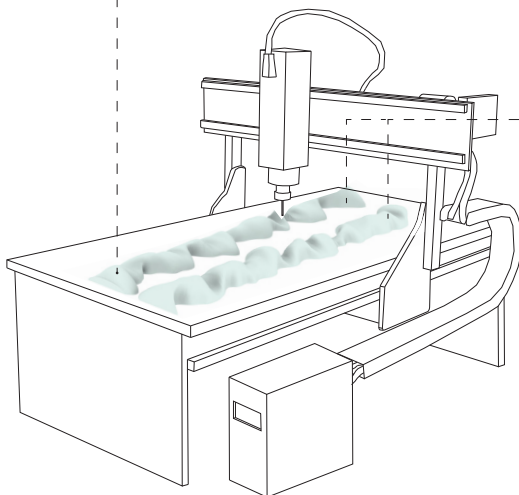
2) auto-select centre of circle



3) connect points to form line



6) make 1:5 scale prototype



7) carve form using CNC milling machine



8) final piece

Fig. 9.30 *Wind and Water* - Procedure Diagram



*Fig. 9.31*  
*Wave Machine in Motion*





*Fig. 9.32*  
*finished piece*



*Fig. 9-33*  
*finished piece*



*Fig. 9.34*  
*finished piece*



*Fig. 9-35*  
*finished piece*



*Fig. 9.36*  
*finished piece*



## Conclusion

When reflecting back upon the work of this thesis, it is crucial for me to keep in mind that this work is by its very nature an ongoing project. Through a series of cumulative and incremental actions, my work has slowly and gently changed the world that I live in while also immediately and powerfully impacting on the way that I think and act. When considered individually, each project offers a number of small lessons, and when taken together, they begin to paint a portrait of a way of working that shows great promise. I have set out to explore different ways of combining technology, technique, and material in the hope of some day producing powerful, moving pieces of art and architecture myself one day. While it is true that I have difficulty declaring a definitive process or procedure that can lead to such an end, this is because I can definitively say that such process does not exist. One must always be stepping out into the unknown, leaping from a stable platform of experience with a strong determination of where to go, but no clear idea of exactly how to get there. With the work of this thesis, I have been able to greatly strengthen and enlarge my platform, while also steeling my courage and desire to jump from it.

Perhaps it should come as no surprise that the *Hydrophilia* projects feel somewhat unresolved. From the outset, the project was designed to be near to impossible – to give physical form to the flowing movement of water. And yet, small successes have been made. Although the choice of material has remained constant throughout the project, the technology and techniques I have employed have evolved. From sticking a camera in a fishbowl and then into the river, to using a laser level to highlight the outline of a column of steam, to constructing a simple machine that gently touches the surface of a lake, my methods have increased in sensitivity, without resorting to complicated digital motion capture equipment.

Just as the methods I have employed have grown more sensitive, so too has my knowledge of water itself. Part of this is due to ongoing research into the way water behaves; as I understand more about the science of water, my lived experience of water changes. But any improvements in my ability to record and transform data from the movement of water likely come largely from the experience of attempting to do so – that is from repeated iterations, careful reflection, happy accidents, and from just rolling up my sleeves and getting my hands dirty. It is thought that Constantin Brancusi



Fig 10.1  
"Bird in Space"  
Constantin Brancusi, 1928.

spent over 20 years working on his series of sculptures entitled *Bird in Space*, so perhaps I can find solace in the fact that after a year and half this project remains a work in progress<sup>1</sup>.

Perhaps of all the projects, the North House Ceiling reached the greatest stage of completion, but that does not mean that it does not leave unanswered questions. Faced with the difficulty of understanding delicate and crucial issues such as scale, materiality, and texture, we found that the computer can be a rather inarticulate tool, and that full-scale prototypes can speak volumes.

As can be seen in the project timeline, the development of the ceiling began with a series of digital renderings that provided an idea of what the ceiling might look like – renderings that were created over the course of a few days. The next 11 months were spent actually trying to build the thing and are a testament to the difficulty that contemporary architects face of having to measure up to a computer rendering. I also received a first hand lesson in the time-consuming assembly that seems inherently built into many projects employing digital fabrication techniques. Lurking in the shadows of many of these projects are countless student volunteers, and their collective efforts make a mockery of the term “rapid prototyping.”

The ceiling project (and even more so, the North House itself) speaks volumes about the importance of interdisciplinary collaboration. A brief meeting with an adhesive specialist from 3M led to our experiments with a special adhesive transfer tape, one that allowed us to construct the entire textile ceiling without sewing a single stitch. The tape had never been used before for such an application, just as the laser cutter we contracted had never cut fabric before, but such is the value of experimentation and collaboration. A truly rich source of unexpected innovation lies in the interaction of people with different expertise.

My involvement with the North House gave me invaluable experience in designing and managing a full-scale project, as well as a fluency with digital design tools that has impacted greatly on my subsequent work. But just like the many other gratuitous displays of technology found in the annals of contemporary architecture, this one begs the question: just because you can build a ceiling out of over 4000 individual pieces of translucent fabric, each one varying in shape and size according to set parameters of transparency and light dispersion, does that necessarily mean that you should?

The *Bosphorus* remains like a fleeting memory of a dream. It represents a way of working that is much less self-conscious, one that I would like to return to after my thesis is completed. The piece was intended to embody both a reading of a landscape (a desert) and a text (*The English Patient*), and throughout the course of its development both of these sources provided a base of inspiration upon which I could build. When I made the piece I did not explicitly intend to explore the use of one technique or another, I merely sought ways to give material expression to a

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<sup>1</sup> From the Guggenheim Museum Online Collection Catalogue: <http://www.guggenheim.org/new-york/collections/collection-online/show-full/piece/?search=Constantin%20Brancusi&page=1&f=People&cr=5>



complex feeling. Now that I have more carefully explored the means with which I could have done this, and given the accumulation of experience this thesis has afforded me, it would be interesting to see how I would approach the project now. The goal of expressing complex thoughts and feelings using physical materials has to be one of the strongest motivators for all artists and designers, whether that be the feeling of floating on a thin carpet of stone, high above a raging river, or huddling in a dark cave, seeking an escape from an earthly body and a closer bond with God.

The territory explored in *Material Transformations* is again one that I would like to return to in future projects. There is something incredibly compelling in the process of alchemy that takes places when a project shifts materiality. Despite my many misgivings towards computers, I remain an admitted technophile. I like to explore new computer applications and the varied and fluent use of digital fabrication tools presents itself as an antidote to the unstimulating flatness of my computer monitor. An example of how this could impact my future work lies in the *Hydrophilia* projects. From the outset I wanted the three pieces to appear as a suite, as a body of connected work. One way that I sought to achieve this was through the use of shared materiality, they are all made out of layered plywood. However as I began work on the third piece *Wind + Water*, I began to feel somewhat trapped by this strategy. While a common materiality serves to highlight the difference in the forms of each piece, and hence in that of the captured motion, laminated plywood is not the absolute best material for expressing any one of these three movements. One can only imagine the column of steam fashioned out of polished chrome, or the surface of the waves out of blown glass to see the possibility inherent in this exploration. Materials and material processes are rich and active, alive in a way that a digital representation could never be, and the possibility of exploiting this is tantalizing.

This thesis began with the carving of spoons, so perhaps it is fitting that it should end with them. When I started to carve the spoons, I thought of them as a way to explore pure technique, using just my hands, a few simple tools, and the wood. I thought that by removing any sophisticated technology, and limiting myself to a single material, I could examine the development of technique as a sort of test case under controlled conditions. I also thought that perhaps I could do a similar operation with the other elements (materials and technology). Not too long after I began, I realized that this is impossible, you cannot extricate one variable from the matrix. I soon learned that there was a wealth of complexity in wood, and that the fact that my spoons were carved by hand did not entirely explain their appeal. Spoons (like just about everything we make) are cultural artifacts, and due to the intimate way that we interact with them, it is no surprise that we often develop a very special relationship with them.

I have since developed a much greater sensitivity to the characteristics of different species of wood, and how to transform them through different ways of working and finishing them (of course, seeing as how there are an estimated 100 000 different species of trees on the planet, and countless ways to cut, carve, smooth, lacquer, oil, and stain them, in this area there remains much for me to learn.)



Fig 10.2  
Studies in alternative materiality.

The spoons have become for me a sort of metaphor- in-practice, almost a form of meditation. There is a ritual strangeness to this practice. Every time I carve a spoon I follow the same process. Yet every time, the experience provides new challenges, and the final results are always very different. The spoon that I set out to carve and the one I end up with are very different, a result of the opportunities provided by the wood and the obstacles put in place by my lack of skill. It is a ritual that rewards patience, and one that constantly presents me with the material fact of my actions in the world, it is both humbling and empowering.

Comparing the possibilities presented by these projects, it is clear that they occupy different places within the development of my working process. An open-ended and somewhat unfinished project such as the *Hydrohilia* pieces or *Material Transformations* present a series of questions and opportunities, whereas a project such as the North House Ceiling has led somewhat more towards the development of tools and techniques, ones that will most likely be used on a different project in the future. From the outset, the North House Ceiling was much more focussed on a specific end, and this may be why its lessons are somewhat more specific in focus. These can both be contrasted with the spoons, which can be seen as a metaphor-in-practice, one that I can return to again and again, both as a stable ground and as a source of new learning. All of these projects have impacted on me in different ways, and it is through their variety that they present value to me.

The terms that I have used to attempt to describe the process of making (technique, technology, materials, intent) have proven inadequate to fully account for the myriad forces that coalesce in a successful object, work of art, or piece of architecture. Yet the notion of elements mixing together, rubbing up against one another under the guidance of intent, remains a powerful one for me. Deleuze and Guattari may have developed a more elaborate framework with their notion of “percept, affect, and concept,” yet at the end of the day, they are able to identify and dissect works of art, but not provide a guide for how to successfully create them (although, admittedly, this is not necessarily their stated intent.) By carefully studying the the different ways that works of art speak to us, they can give a better understanding of the direct, visceral path that these works take into our consciousness. Ultimately, however, reading Deleuze does not necessarily bring one any closer to actually communicating through pure sensations, just as a painter who has seen one of Lucio Fontana’s *Concept Spaziale* paintings is not necessarily any closer to escaping the cliches of the stretched canvas that face all painters. When all is said and done, the artist must act, and the work must “stand up on its own” (Deleuze 164).

Similarly, Richard Sennett, in his description of the motivating force that drives a craftsman and guides his decision making, defines craftsmanship as “an enduring, basic human impulse, the desire to do a job well for its own sake” (9). Often, for Sennett, this is something that cannot be expressed, even by those craftsmen he cites as examples. Again, there is no clear path. In setting out to create a project, one with the power to move people, one that will stand up on its own, no one can

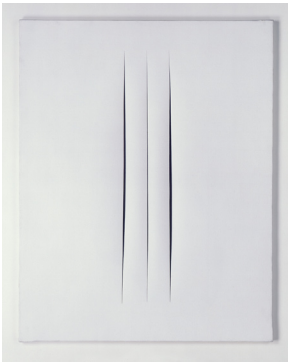


Fig 10.3  
Lucio Fontana,  
*Concetto spaziale*, 1965

exactly instruct you how to go about it. From the outset, you yourself may not know the way, but you will know it when you have done it.

While it is true that absolutely clear conclusions may be difficult to reach, I have nonetheless reached a few. Foremost among them is that a work of art or a powerful building cannot be created solely within the mind of the artist or the architect. To create a physical artifact is to delineate a fact in this world, a piece of wood cut to exactly 12 inches long is just that. While it is true that the mind is capable of incredible imaginings, from time to time these ideas need a confrontation with fact, not only to ground them in reality, but to propel them even further into the unexpected. Within every idea there are a host of assumptions that must be tested and proven. More importantly though, by operating solely within the realm of the cerebral, you are missing out on a world of feedback and inspiration – and computers are no answer either. The realm of the digital is still dull and flat and remains a pale substitute for our lived experience. If anything, this thesis has been a demonstration of the value of physically doing things – engaging with the material world – a world of chance, complexity, friction, and opportunity.

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