Contact and Continuity

by

Nikola Nikolic

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

Waterloo, Ontario, Canada, 2014
© Nikola Nikolic 2014
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


That material can harbour life inspires careful consideration of the craft of building.

Building is the agency of architecture; material—its medium.

The act of building engages the whole body: touch, brings together mind, and material.

Guided by traditions of craft, I learn to work with wood, in order to explore the synergy between thinking and making, body and material, through the act of building a table, with my partner, and a tree-house, for a family in Waterloo, Ontario.
Acknowledgements

I am grateful to the Belland and Carson family for opening their homes and hearts. You made it possible for me to learn, and grow, in ways I could not have anticipated. I will cherish your friendship always. Gregore, thank you for believing in me from the very start, and for your help and advice.

To my advisor, and to my committee, I am indebted. Andrew, Robert, and John, you have paved the way for me. Your patience, and guidance, has been a gift.

To students and staff at the School of Architecture, I am grateful for your help; for your camaraderie. I could not ask for a friendlier or more inspired community to have worked alongside with.

Melissa, because of you, everything is possible. The greatest treasure has been to share, and learn, and grow, together.
To my mother and father, and to my brother Dean, and sister-in-law Candace, without whose love and support this work would not have been possible.

Thank you.
# Table of Contents

List of Figures

Introduction

- standing on the shoulders of giants 3
- contact and continuity 5

Building a Harvest Table

- August 2011: beginnings 11
- eastern white pine 15
- hand-tools in woodworking 17
- hand-planes 19
- wood grain 23
- steel in woodworking tools 27
- handsaws 33
- practice 45
- the primacy of touch 57
the body, and full-scale prototypes

some mistakes are easier to make on paper

the iterative process is a natural, skill-developing mechanism

a most profound lesson

in time and effort, the finishing process is often underestimated

Learning from the Past

experiencing the work of masters

Building a Tree-House

a new project

scots pine

white oak

timber frame construction

September 2012: fabrication commences

innovation

drawing by hand helps develop spatial awareness

time management is predicated on adaptability

a sense of scale

working across a range of tools

sharpening

August 2013: a change of site

when hand is mightier than machine

checks, shakes, and wood deformation

the anatomy of a well designed detail

the plasticity of wood

pine tar

January 2014: installation commences

tapping off

shortcuts are rarely so

a detail is simple only when it is simple to make

a poorly conceived detail

made to be touched...

Reflection

looking, listening, asking, touching

Appendix A - Critique

Appendix B - The Tools Most Used

Appendix C - Drawings

Appendix D - WBS - Tree-House Build

Bibliography
List of Figures

Building a Harvest Table

figure 1: Melissa, next to a stack of floor joists, salvaged from a century-old stone building. 13
figure 2: Our boards, riddled with iron nails. 14
figure 3: Using a magnet to find the location of embedded iron spikes. 15
figure 4: Preparing our first hand plane for use. 16
figure 5: Sharpening a plane blade. 16
figure 6: ‘Scrubbing’ with a modified jack-plane. 18
figure 7: A not-so-efficient attempt at thicknessing. 18
figure 8: Thicknessing with a scrub-plane. 21
figure 9: Deep cuts left by the convex blade of a scrub-plane. 23
figure 10: Melissa, sighting crests and valleys, along the length of a board. 24
figure 11: Using a jack-plane to flatten a scrub-planed surface. 25
figure 12: A spirit level eases the task of assessing how true a board is. 25
figure 13: Using a water-stone to sharpen a plane blade. 26
figure 14: Melissa, sharpening. 26
figure 15: A variety of plane blades, each suited for a particular task. 29
figure 16: Scrub, jack, and jointer-planes are used in combination to effectively thickness, true, and square a board. 30
figure 17: The long, flat sole of a jointer-plane. 30
figure 18: Because of its length, the jointer-plane is indispensable when truing long boards. 31
figure 19: Cutting our boards to size with a ryoba saw. 33
figure 20: A ryoba saw. 35
figure 21: Our boards, cut to length and planed flat on one side. 36
figure 22: Using a jointer-plane to square the edge of a board. 37
figure 23: Scribing with a marking gauge. 38
figure 24: Marking over a scribe line for better visibility. 39
figure 25: Cutting a groove along the edge of a board with a plough-plane. 40
figure 26: Using a rabbet-plane to cut a tongue. 40
figure 27: A nine-foot long groove. 41
figure 28: Fitting our first tongue-and-groove joint. 42
figure 29: Tongue-and-groove, detail. 42
figure 30: Tabletop, beginning to take shape. 42
figure 31: Sharpening. 44
figure 32: Relocating. 46
figure 33: Setting up shop at home. 46
figure 34: A mitred lap-joint. 48
figure 35: Using a dozuki saw to cut a mitre. 48
figure 36: Our tabletop, serving as a temporary work surface. 51
figure 37: Using a mallet and chisel. 52
figure 38: Finding creative ways to restrain our workpieces. 53
figure 39: Paring down a housed, half-lap joint. 53
figure 40: Attaching the mitred broadboard. 54
figure 41: A housed, half-lap mitre at the broadboard. 55
figure 42: Table-panel and frame, fully assembled. 56
figure 43: Testing the strength of the tabletop. 56
figure 44: Table-leg and concept sketch. 58
figure 45: Slowly feeling through a cut: a dovetail takes shape. 58
figure 46: Butt-chisels are easy to manipulate, and are well suited for precise work. 60
figure 47: One of several practice dovetail joints. 60
figure 48: Full-scale mock-up of the leg assembly: in search of a comfortable proportion. 62
figure 49: ibid. 62
figure 50: “K” marks the waste to be removed with a chisel. 64
figure 51: Laying out the final dovetail joint. 64
figure 52: Almost ready to assemble. 66
figure 53: A poorly designed connection: a tongue and groove with a modified bridle joint. 66
figure 54: A poor joint made better... 68
figure 55: A tongue and groove secured with a b-line pin. 68
figure 56: A glue-less assembly. 71
figure 57: Planing a bevelled edge. 72
figure 58: A tapered spacer attached to the fence of a rabbet-plane produces angled cuts. 73
figure 59: Flat head screws with countersunk washers secure a triangular support structure... 75
figure 60: ...designed to attach the trestle legs to the underside of the tabletop. 75
figure 61: An improved trestle leg-to-table top connection provides support across the entire width of the table. 77
figure 62: The support plank adds rigidity to the legs and is a means of attaching the legs to the tabletop. 77
figure 63: Dovetail, tongue and groove with b-line pin. 78
figure 64: Trestle leg, isometric. 79
figure 65: Trenches on the underside of the tabletop receive the trestle leg support. 80
figure 66: Assessing the fit of the leg support to table joint. 81
figure 67: ibid. 81
figure 68: Our table, assembled for the first time. 82
figure 69: Trestle leg-to-table top connection. 83
figure 70: The iterative process at work: a tapered trench holds an additional rail support, without fasteners. 84
figure 71: Preparing the table top for oiling. 87
figure 72: Taking very fine shavings with a jointer-plane. 87
figure 73: Melissa and me: smoothing with a Japanese block plane. 88
figure 74: In time and effort, the finishing process is often underestimated. 90
figure 75: A plastic drop cloth is used to create a dust-free environment for oiling. 91
figure 76: The harvest table, after finishing. 93
figure 77: The harvest table in use. 95
Learning from the Past

figure 78: George Nakashima Woodworker. The Office Showroom. 102
figure 79: Office Showroom: south elevation. 103
figure 80: Furniture made to be touched. 104
figure 81: Inside the Conoid Studio. 105
figure 82: Conoid Studio, office. 107
figure 83: Main Workshop. 109
figure 84: An organized workspace. 109
figure 85: A record of use. 109
figure 86: Blanks and spindles, stacked for future use. 110
figure 87: An old cherry tree features prominently on the grounds. 112
figure 88: A cedar gate with buried wood posts. 115
figure 89: The Wharton Esherick Museum. The building at rear was designed in collaboration with Louis Kahn. 117
figure 90: Formerly a log cabin garage, the visitor’s center features a hyperbolic roof. 118
figure 91: Wharton Esherick’s studio. 121
figure 92: A grand view overlooking the valley. 123

Building a Tree-House

figure 94: Gregoire’s yard, which backs onto Breithaupt Park, in Waterloo, Ontario. 128
figure 95: An old maple, at the rear of the yard: the initial site. 129
figure 97: Local sources of inspiration: the Historic City Hall... 130
figure 96: ...the Fire Hall... 130
figure 98: ...and the old Galt Post Office, in Galt, Ontario. 131
figure 99: An early concept model. 132
figure 100: A tall pyramidal gable harbours a lofty canopy. 132

figure 101: A covered platform on stilts gives the impression of being suspended. 133
figure 102: These timbers were once used to house tractor equipment shipped from Germany. 134
figure 103: This is Bill. He runs an independent mill in Granton, Ontario. 136
figure 104: Bill sold me choice pieces of air-dried, quarter sawn white oak for two dollars a board foot. 137
figure 105: Bill’s Barn is more than a century old, and still bears all the original members, including the pine cladding. 139
figure 106: The resiliency of timber frame construction keeps this barn standing, despite its dilapidated state. 140
figure 107: Several layers of timber frame ‘beams’. 142
figure 108: Planing bench and covered outdoor workspace. 144
figure 109: Cutting an angled mortise that will receive the hind trestle leg. 147
figure 110: A trestle with an angled leg helps stabilize the bench. 147
figure 111: A shouldered, half lap dovetail... 148
figure 112: ...joins the front leg to the bench top. 148
figure 113: A shallow ledge keeps tools close at hand. 149
figure 114: ...and the old Galt Post Office, in Galt, Ontario. 151
figure 115: Trued and squared footings are set into excavated post holes... 153
figure 116: ...made plumb with a spirit level, and braced into position. 153
figure 117: A laser pointer helps establish the elevations of the footings relative to one another. 153
figure 118: Structural Floor Plan. 154
figure 119: A straight edge is a visual aid used to assess the degree of flatness of a board. 156
figure 120: Winding sticks—used to gauge the degree of twist in a board—help with truing even the longest boards. 157
figure 121: I made this ink line, which is similar to a chalk line, but more accurate. 159
figure 122: An ink line is pulled taught and snapped to mark a center line on a major beam. 160
figure 123: Joints are laid out relative to center lines to ensure accuracy across all members. 161
figure 124: Rip cutting a tenon. 163
figure 125: Wedging open deep rip cuts prevents the wood from clamping down on the saw blade. 163
figure 126: A dado and tenon take shape. 165
figure 127: ibid. 165
figure 128: ibid. 165
figure 129: A snug fit for a through tenon: the underside of a dado with cross-tenon lap joint. 167
figure 185: 716 components make up the tree-house. Oiling 268 of them efficiently requires some organization.

figure 186: The site, cleared of ice and snow.

figure 187: Footings and platform beams are installed first.

figure 188: Perfectly level.

figure 189: The platform structure is pulled together tightly with cable clamps...

figure 190: ...and checked for squareness.

figure 191: A white oak dowel is used to secure the corner assembly.

figure 192: An auger is used to drill a hole through the sills and beam.

figure 193: A-gravel, sourced from a local gravel pit.

figure 194: The post are holes filled a few inches at a time...

figure 195: ...and tamped to minimize settling.

figure 196: Covering up after a day's work.

figure 197: Fitting a post, to a roof beam.

figure 198: An entire elevation—a "bent"—must be assembled before it can be fitted to the platform.

figure 199: Finessing the fit of a joint...

figure 200: ...because of expansion caused by oiling.

figure 201: Mortises with bevelled shoulders match the profiles of the railings.

figure 202: Modifying a tenon with a ryoba saw.

figure 203: Tamping a post and railing assembly into place.

figure 204: Because of concealed joinery, the remaining two bents are pre-assembled...

figure 205: ...and bolted to a road beam.

figure 206: An entire elevation—a "bent"—must be assembled before it can be fitted to the platform.

figure 207: Finessing the fit of a joint...

figure 208: Tamping a post and railing assembly into place.

figure 209: Because of concealed joinery, the remaining two bents are pre-assembled...

figure 210: ...and bolted to a road beam.

figure 211: A polished joint joins the tops of two principal rafters.

figure 212: A tapered cross-dado with a half lap key joint on the king post.

figure 213: A mortise in the main collar beam receives a tenon on the king post...

figure 214: ...which securing the shouldered, lapped dowestock joints on the secondary collar beams.

figure 215: A mortise with shouldered half-lap dovetails, in the center of the main collar beam.

figure 216: The Kongming Lock.

figure 217: Assembly of the tapered cross-dados, with half lap key joint.

figure 218: Securing the valley rafter to king post assembly with oak dowels.

figure 219: A feeling of satisfaction.

figure 220: A bridle joint joins the tops of two principal rafters.

figure 221: A view looking down through the roof structure.

figure 222: A bridle joint joins the tops of two principal rafters.

figure 223: A view looking down through the roof structure.

figure 224: A bridle joint joins the tops of two principal rafters.

figure 225: A view looking down through the roof structure.

figure 226: A view looking down through the roof structure.

figure 227: A view looking down through the roof structure.

figure 228: A view looking down through the roof structure.

figure 229: A view looking down through the roof structure.

figure 230: A view looking down through the roof structure.

figure 231: A view looking down through the roof structure.

figure 232: A view looking down through the roof structure.

figure 233: A view looking down through the roof structure.

figure 234: A view looking down through the roof structure.

figure 235: A view looking down through the roof structure.

figure 236: A view looking down through the roof structure.

figure 237: A view looking down through the roof structure.

figure 238: A view looking down through the roof structure.

figure 239: A view looking down through the roof structure.

figure 240: A view looking down through the roof structure.

figure 241: A view looking down through the roof structure.

figure 242: A view looking down through the roof structure.
figure 243: ...securing them in place. 290
figure 244: A view of the platform structure, from above. 293
figure 245: Hidden deck fasteners secure the decking to the platform, and act as spacers to accommodate expansion in the wood. 294
figure 246: The fasteners are inserted into a precut groove on the sides of the deck planks. 294
figure 247: ...and zinc-coated screws are screwed diagonally through the fasteners, and decking into the structure below. 294
figure 248: Grace and Nolan, helping me install the decking. 296
figure 249: ibid. 296
figure 250: ibid. 296
figure 251: Soft to the touch. 298
figure 252: Grace, trying to stay out of the mud. 298
figure 253: The completed deck. Three, four, five, and six inch widths make up the herringbone pattern. 300
figure 254: With the arrival of spring, the edges of the mud-sills at the entrances were beginning to chip. 302
figure 255: With a round spokeshave, I carved a deeper chamfer... 302
figure 256: ...which will be less susceptible to wear. 302
figure 257: The completed deck. Three, four, five, and six inch widths make up the herringbone pattern. 307
figure 258: East elevation. 309
figure 259: Footing, mud-sill, and post connection, detail. 310
figure 260: Mud-sill at entrance, detail. 311
figure 261: Oak decking at mud-sill, detail. 312
figure 262: Decking, herringbone pattern, detail. 313
figure 263: Railing and side-wall, detail. 315
figure 264: Deck, post, railing, and side-wall interior, detail. 317
figure 265: Railing-to-post connection, shouldered interior detail. 318
figure 266: Railing-to-post connection. 319
figure 267: Railing-to-post connection, detail. 319
figure 268: Nolan, swinging. 320
figure 269: ibid. 321
figure 270: Post, railing, and side wall exterior, detail. 323
figure 271: Grace and Nolan, lounging. 324
figure 272: Valley rafter at corner brace, detail. 326
figure 273: ibid. 327
figure 274: Collar beam and purlin connection at valley rafter, detail. 329
figure 275: Collar beam connection, underside. 331
figure 276: Principal rafter, roof beam, post, and cedar plank, detail. 332
figure 277: Cedar plank and collar beam, detail. 333
figure 278: Early morning light. 335
figure 279: Late afternoon light. 336
figure 280: Jac, Jana, Grace, and Nolan. 339
figure 281: Story time in the tree-house. 340
figure 282: ibid. 341
figure 283: The completed tree-house. 343
figure 284: Grace and Nolan. 345

Appendix A - Critique

figure 285: Working 358
figure 286: Lounging 362
figure 287: Playing 363

All photos taken by Nikola Nikolic and Melissa Ng, unless otherwise noted:
Figures 204, 205, 206 by Rachel Novak
Figures 238, 248 by Jeremy Carson
Figures 261, 262 by Jana Carson
Introduction
India. Second millennia BCE: Jain, and Buddhist stonemasons carve religious sanctuaries into the sides of mountains. Although plenty of natural caves exist, the sacred act of carving into living stone mirrors a spiritual awakening; “opening the mind to cosmic enlightenment” (Crouch and Johnson 9).

Japan. Sixth-century: Cutting down a tree is an act of moral significance. A carpenter will repay their debt to nature, by way of exacting and beautiful workmanship; honouring the life of the tree and assuring its continued existence “as a thing of beauty to be treasured for centuries” (Brown 21).

Mali. Sixteenth-century: The Bambara craftsman’s knowledge is tied to “the mystery of the primal cosmic unity…” and their work is “considered to be the embodiment of a particular aspect of the cosmic forces…” (Hampâté Bâ 14).

standing on the shoulders of giants
This document represents a personal exploration of the culture of craft and embodied learning. What follows is a record of a sustained attempt to think about architecture with my entire body, in an act of building. As a guide, I have looked to technical, historical, and philosophical texts, and to the works of those who came before me. I owe a great deal to the masters of a bygone era, for they have shown me a way. Although we may never repeat their customs, we would do well to take their values to heart, because they are human.

During the course of this work, I was driven to make beautiful constructions ‘to be treasured for centuries’. However, the reader should consider them neither coherent architectural statements, nor strictly formal objects, in and of themselves, but as open ended experiments. Much attention was given to their fit and feel in relation to the body. First and foremost, the reader should consider the works to be an embodiment of a slow, repetitive, and often messy process, which I have attempted to portray here in the form of a photo essay.
Building a Harvest Table
Anyone who has only been shown how to force a piece of wood against a mechanized saw will have learnt very little, but if [they] have had to saw that piece of wood by hand [they] will be more likely to know that much more about it, [they] will have greater respect for it and will understand in greater depth the problems that will have to be faced in its manipulation.

Ernest Joyce,
The Encyclopedia of Furniture Making
Having acquired a few dozen reclaimed timbers in the summer of our first year of graduate studies, my partner Melissa and I endeavoured to make a harvest table. With what little construction experience and woodworking ability there was between us, we could not have known what an act of building would do to challenge our assumptions, and shape our values.

We were taken by the age of our timber, more than a century old, covered with dust, and plaster. Because the boards were pierced with nails, we could not rely on power tools to dress them. Using reclaimed wood required working by hand, with hand-tools. We sought guidance from craft traditions and found inspiration in the work of the late masters George Nakashima and Wharton Esherick, among others. The ancient art of wood joinery provided us a template for almost every possible type of wood construction, and building traditions offered a return to the fundamentals of architecture: to material, to the body, to the earth.
To accommodate dimensional changes in our tabletop, we looked to the eighteenth-century American door, which employed a rigid perimeter frame, grooved on the inside face, to carry a floating panel—often divided in two with a rail—made up of smaller tongue-and-groove boards that would expand, and contract, freely. In the construction of our table, a rigid frame would also allow us to maintain an undressed edge along the perimeter of the tabletop: a design detail we had decided upon after our first encounter with the reclaimed timbers.

Work commenced with a general cleaning. We removed metal fasteners and other debris embedded in the boards, before planing them flat, to the correct thickness and width. Each face was made true (to meet the edge of an adjacent face at a ninety-degree angle). During the course of this process Melissa and I became familiar with basic tool use and wood properties.

As a compliment to working by hand, Melissa and I decided to avoid, wherever possible, the use of adhesives and mechanical fasteners. More an opportunity to learn about wood than a matter of principle, relying on wood joinery as a means of assembly, we hoped to broaden our understanding of how things were built, and exercise our capacity to visualize complex details.

In any wood construction, one must consider the movement of wood with changes in humidity. In glued-up assemblies, components generally expand and contract as one unit, and quality glues will expand and contract in joints that change shape over time. Depending on the species of wood used and the type of construction, wood movement in glue-less assemblies is often more difficult to manage.

As a compliment to working by hand, Melissa and I decided to avoid, wherever possible, the use of adhesives and mechanical fasteners. More an opportunity to learn about wood than a matter of principle, relying on wood joinery as a means of assembly, we hoped to broaden our understanding of how things were built, and exercise our capacity to visualize complex details.

In any wood construction, one must consider the movement of wood with changes in humidity. In glued-up assemblies, components generally expand and contract as one unit, and quality glues will expand and contract in joints that change shape over time. Depending on the species of wood used and the type of construction, wood movement in glue-less assemblies is often more difficult to manage.

To accommodate dimensional changes in our tabletop, we looked to the eighteenth-century American door, which employed a rigid perimeter frame, grooved on the inside face, to carry a floating panel—often divided in two with a rail—made up of smaller tongue-and-groove boards that would expand, and contract, freely. In the construction of our table, a rigid frame would also allow us to maintain an undressed edge along the perimeter of the tabletop: a design detail we had decided upon after our first encounter with the reclaimed timbers.

Work commenced with a general cleaning. We removed metal fasteners and other debris embedded in the boards, before planing them flat, to the correct thickness and width. Each face was made true (to meet the edge of an adjacent face at a ninety-degree angle). During the course of this process Melissa and I became familiar with basic tool use and wood properties.
Halfway through the process of thicknessing, truing, and jointing our boards, Brad, a friend and colleague (and professional woodworker) visited us in the workshop. He lifted a handful of shavings cut from the boards we were planing up to his nose, and with a breath identified the genus and species to be eastern white pine. “The species of wood can even be identified by its flavour”, he said. In the weeks up to this meeting, Melissa and I had been comparing pictures of wood grain, attempting, unsuccessfully, to identify what we were working with. Brad’s display was an inspiring reminder of the power of the human body; of the role the craftsman’s senses play in embodying and reading the material environment.

*Pinus strobus*, or eastern white pine, the provincial tree of Ontario, is a moderately hard conifer native to eastern North America. White pine wood is lightweight and straight of grain, and exhibits a creamy white to yellowish-brown colour that darkens considerably when exposed to light. Fresh white pine has a pleasant, bitter-sweet scent, not quite lemony-mint. White pine constitutes a major portion of the lumber produced in its native area. Because it was straight grained, free of knots, and easy to work, old growth white pine was traditionally used in colonial homes for floor boards, panel siding, and furniture; the tallest specimens, which often had no extending branches under a hundred feet, were used as ship masts. First nations peoples of eastern North America, ingested parts of the white pine for nourishment.
Hand tools must be wielded with care, and understanding for work to progress efficiently. With patience, and practice, the craftsman learns to think and feel through their tools, which become extensions of their body. In ancient Japan, a carpenter did not work with mere tools, but with *dōgu*, "instruments of the way." The intense personal relationship between a craftsman and their tools is compounded when the tools a craftsman uses are of their own making.

Although woodworking tools number in the hundreds, only a few are needed to perform a wide variety of tasks. Nonetheless, the learning curve is high. Close to half of the time Melissa and I spent building was dedicated to calibrating, maintaining, and learning to use our tools properly.

*Left:*
Preparing our first hand-plane for use.
Using a hand-plane to dress wood can yield a surface of unparalled quality. There is no other tool that can come close, except perhaps the Japanese ยารี บอน�, ‘spear plane’, which has fallen out of regular use for at least a thousand years.

Hand-planes work by cleanly shearing a layer of wood fibres with a steel blade held at a consistent angle and depth. A properly calibrated plane will leave behind a smooth surface characterized by its clarity and depth, especially when compared to a sanded surface. Sandpaper abrades the surface of wood, tearing at, then filling in the opened pores with dust produced by every pass. The damaged cell structure of a sanded surface appears muddled, and is more susceptible to water damage than a properly planed surface.
While the plane blade is the heart of a hand-plane, the body, in addition to providing a comfortable hand-grip, and holding the blade in place, performs several important functions. The area of the sole pressing down on the wood in front of the cutting edge prevents fibres from shearing out ahead of the cut. The long sole of a jointer plane helps flatten a board as it rides across crests until they are planed down to a uniform level. The short sole of a smooth plane allows for easy manipulation, while the narrow blade and sole of a scrub plane minimizes friction.

Whether the body is made of metal, or wood, is also a consideration: many carpenters claim that wood planes produce a nicer finish as a result of the burnishing action of wood on wood, while others prefer the durability and weight of a metal plane, especially when working hard woods. The design of a hand-plane reflects its intended use more than a carpenter’s preferences however, and planes are made for a variety of very specific tasks, including: scrubbing, jointing, truing, smoothing, and routing.
Wood grain is directional. Except when removing large amounts of wood with a scrub plane, truing end grain with block plane, or rabbeting end grain with a rabbet plane, one should always move in the direction of overlapping grain. Planing in the wrong direction will result in broken or torn fibres. There are several visual cues that can be used to determine the directionality of wood grain. Except in burls and around knots, grain on the outside face (bark-side) of a board overlaps in the direction of growth, from bottom to top, and top to bottom on the inside face (pith-side). Growth rings can be used to distinguishing the inside face from the outside face of a board. Growth rings near the crown of a tree are less dense than at the base of the trunk, which must be strong to support massive loads. The orientation of grain around knots signal the direction of tree growth, as do ray and vessel cells, which are easier to spot in hardwoods like oak, walnut, and butternut. Only the most experienced woodworkers can read wood grain with confidence.

**right:**
Deep cuts left by the convex blade of a scrub plane.

**figure 9**
above:
Melissa, sighting crests and valleys, along the length of a board.

above, left:
Using a jack-plane to flatten a scrub-planed surface.

above, right:
A spirit-level eases the task of assessing how true a board is.
Steel technology makes woodworking as we know it, possible: it is the interface between maker and material. Steel is an alloy that contains iron, carbon, and other elements. The alloy ingredients of a particular steel, and the methods employed in the fabrication of that steel might make it suitable for one task, but not another. A basic understanding of the properties, and characteristics of common tool steels is vital, if the woodworker wishes to use them properly.
Sharpness is of great concern to the woodworker. How sharp a blade can be made, how long a blade stays sharp, and how easily a blade re-sharpens is determined by the grain, structure, and hardness of a particular variety of steel. When steel exhibits a small and uniform crystalline structure, it is considered to have a fine, even grain, and—depending on its composition—will sharpen very well. Properly formed carbon steel can be made very sharp, but it is often too brittle on its own to be of any use. Elements like chromium, which are used to harden steel, make very strong bonds with the carbon atoms present in the alloy, resulting in a larger, durable, but often less uniform, crystalline structure.

The structure of steel is also a result of the forging process. It is claimed that hand-forged steel is superior to drop-forged or hot rolled steel produced in a factory. A reason why this may be true, is that the process of hammering red hot steel into its rough shape causes the crystalline structure to break apart, and realign more tightly, in the direction of the steel flow. Provided this is done properly, an experienced blacksmith can often produce a finer grained steel by hand-forging than through other processes.

In practice, a high concentration of chromium in A2 steel, improves the durability of a plane blade, but also compromises its ability to take on a very sharp edge. This may be fine for working hard woods but is less than desirable for softer woods. O1 steel is less durable, but easier to sharpen because it contains far less chromium. The addition of tungsten imparts a tighter grain to O1 steel, that can be made sharp enough for general use with softer woods, but not quite as sharp as a fine grained, hand-forged, carbon steel blade: the ideal candidate for smoothing soft woods. Hand-forged carbon steels made by early American, and traditional Japanese master smiths, were often laminated with a ductile backing steel to produce a durable blade, capable of taking on a very keen edge.

Above: A variety of plane blades, each suited for a particular task.
above, left: Scrub, jack, and jointer-planes are used in combination to effectively thickness, true, and square a board.

bottom, left: The long, flat, sole of a jointer-plane.

above: Because of its length, the jointer-plane is indispensable when truing long boards.
Handsaws are usually designed to cut parallel to wood grain (rip cut), or across wood grain (cross cut). The teeth on a rip cut saw are sharpened to a square or chisel-like profile and are deeper and fewer in number than the teeth on a crosscut saw, which are shallower, more numerous, and sharpened to a knife-like profile to prevent tearing out end grain. The set describes the width of the blade at the cutting edge, or kerf. The set is made wider than the rest of the blade by bending every other tooth outward, away from the centre of the blade. The set relieves friction caused by wood bearing against the sides of the saw blade, that would otherwise lead to binding. The profile, set, number of teeth per inch (TPI), and thickness of the blade are a few of the considerations that go into the design of a saw, and will vary depending on the nature of the material and cut.
In The Book of Five Rings, Miyamoto Musashi describes the proper technique for holding a sword, a technique that applies equally well to holding a Japanese pull saw: “…hold it rather tightly with the thumb and the index finger, neither firmly not tightly with the middle finger, and firmly with the ring and little fingers” (Musashi 38).

Most Japanese handsaws, the ryoba saw included, cut on the pull stroke. This distinction carries several advantages over handsaws that cut on the push stroke. Because a pull saw acts in tension, its blade can be made thinner, and can therefore accommodate finer cuts. Pulling down through a cut, one expends less energy by relying on gravity, and pulling toward the body while cutting allows for a greater degree of control than pushing away from the body: this is why Japanese hand-planes are also designed to be pulled toward the body.

The traditional Japanese ryoba saw is an fine example of these design considerations in a simple form, that, to the layman, belies its sophistication. A ryoba saw can accommodate rip cuts and cross cuts because of its double edged blade, which is hand forged from the highest quality alloys. Good quality blades have minimally set teeth, taper from haft to tip and from the edges to the centre, to further reduce binding. Even higher quality blades are thinner at the tip than at the haft (where the teeth are finer to facilitate starting a cut) and thickest at the shaft, where the blade meets the handle.

The unassuming handle of a ryoba deserves special attention. Because of its length and elliptical cross section, it can accommodate hands of all shapes and sizes. In ancient Japan, the tools of war and trade were often made by the same master smiths and woodworkers, and the shape of sword and saw handles developed in parallel.

above: A ryoba saw.
above: Using a jointer-plane to square the edge of a board.

Our boards, cut to length and planed flat on one side.
above:
Scribing with a marking gauge.

above:
Marking over a scribe line for better visibility.
Above, left: Cutting a groove along the edge of a board with a plough plane.

Above, right: Using a rabbet plane to cut a tongue.

Above: A nine-foot long groove.
top, left:
Fitting our first tongue-and-groove joint.

middle, left:
Tongue-and-groove, detail.

bottom, left:
Tabletop, beginning to take shape.
The one who practices consciously, listens and adapts: sensitivity is increased through careful repetition; improved technique and intuition follow. The one who relies on force, practices aimlessly. In woodworking, the practice of sharpening a tool blade is paramount: it is a foil for every other task, and a measure of care. There is no short-cut, no formula for mastery. I am only beginning to understand this. The majority of my sharpening attempts have been characterized by overexertion: too much pressure, too quickly. Gradually, I have learned to slow down, to practice sharpening softly, to listen. A slow, careful approach has always resulted in a sharper blade.
top, left:
Relocating.

bottom, left:
Setting up shop at home.
figure 34

figure 35

top, left:
A mitred lap-joint.

bottom, left:
Using a dozuki saw to cut a mitre.

overleaf:
Our tabletop, serving as a temporary work surface.
above, left:
Finding creative ways to restrain our workpieces.

above, right:
Paring down a housed, half-lap joint.

above:
Using a mallet and chisel.
above:
Attaching the mitred breadboard.

above:
A housed, half-lap mitre at the breadboard.
The immediacy and intimacy of touch are among the more rewarding aspects of furniture making. The sensory feedback a craftsman receives from prolonged contact with tools and materials in an act of making, alters their physiology, and psychology. For the designer, the effects, and affects of touch can positively aid the development of problem solving skills, especially those relating to the many issues surrounding material constructions. It is for this reason that architects in some traditional craft societies were, as a rule, master craftsmen; masters of touch.

above, left:
Table panel and frame, fully assembled

above, right:
Testing the strength of the tabletop.
The role touch plays in the evolution of intelligence is not fully understood. Many neurologists believe that early hominids, using their hands to make and use simple tools for the first time, affected the growth of more complex neural passageways in their brains, allowing them to think through more complex problems, and in turn, to develop even more complex tools. It is thought that, over a period of several millennia, this process led to the development of language, and later, civilization. In ‘The Hand’, neurologist Frank R. Wilson posits that even during the span of a single human life, the use of our hands and whole body in highly skilled applications, can positively affect our overall psychology.

In ‘The Senses of Touch: Haptics, Affects, and Technologies’, Dr. Mark Paterson, studies the affective nature of touch, and maintains that touch can communicate an array of emotions, including aggression, and love. Craftsmen have long depended on the emotive capacity of touch to convey meaning in their work. When a person responds to the feel of something that is handmade, or finely crafted, they are responding to the touch of the maker. A designer or craftsman, touching and working closely with materials, may even begin to care for those materials as if they were a loved one, and their sense of care—or lack thereof—is invariably embedded in the things they design and make.
above, right: Butt-chisels are easy to manipulate, and are well suited for precise work.

bottom, right: One of several practice dovetail joints.
In addition to aiding a performative analysis of a construction detail, full scale prototypes allow a designer to use their entire body as a measure of form, and function—both of which contribute toward an overall aesthetic. Although aesthetic concerns in design are usually associated only with a subjective appreciation of beauty, or appearance, it is important to remember that aesthetic derives from the Greek word aisthētikos, which refers to perception by the senses. In design, notions of beauty can be informed by more than sight, and reason alone.

Working with full scale mock-ups, Melissa and I tested a number of proportions for the assembly of the trestle leg, and ultimately rested with one that would support our feet most comfortably while sitting in a reclined position.
above, left:
"X" marks the waste to be removed with a chisel.

bottom, left:
Laying out the final dovetail joint.

overleaf, top:
Almost ready to assemble.

overleaf, bottom:
A poorly designed connection: a tongue and groove with a modified bridle joint.
Full scale prototypes can reveal errors made during the conceptual stages of design. Designing on paper, or on the computer, in a material-less, scale-less, virtual environment, it can be difficult to account for the physical properties of materials, and the myriad forces acting upon them.

In the design of a modified bridle joint (figure 53), Melissa and I neglected to accommodate the direction of wood grain. As a result, a joint that appeared fine on paper, was, in reality, susceptible to shear failure due to short grain, near base of the bridle connection.
top, left:
A poor joint made better...

bottom, left:
A tongue-and-groove secured with a bow-tie pin.
right:
A glue-less assembly.
above:
Planing a bevelled edge.

above:
A tapered spacer attached to the fence of a rabbet plane produces angled cuts.
above, right:
Flat head screws with
countersunk washers
secure a triangular support
structure...

bottom, right:
...designed to attach the
trestle legs to the underside
of the tabletop.
above, right:
An improved trestle leg-to-table top connection provides support across the entire width of the table.

bottom, right:
The support plank adds rigidity to the legs and is a means of attaching the legs to the tabletop.
above:
Trestle leg. Isometric.

figure 62, left:
Dovetail, and tongue and groove with bow-tie pin.
above: Trenches on the underside of the tabletop receive the trestle leg support.

above, left: Assessing the fit of the leg support-to-table joint.

above, right: Ibid.
above:
Our table, assembled for the first time.

above:
Trestle leg to table top connection.
Referring to the contemporary disconnect between head and hand in ‘The Craftsman’, Richard Sennett reminds the reader that ‘Going over an action again and again . . . enables self-criticism’, and that ‘Afraid of boring children . . . the enlightened teacher may avoid routine—but thus deprives [them] of the experience of studying their own ingrained practice and modulating it from within’. ‘As a person develops skill, the contents of what he or she repeats, change’ (Sennett, 21).

The results of this practice are unsurprising: after making the leg-to-table rail supports, which are mechanically fastened to the underside of the table, Melissa and I developed a tapered, trench detail to receive a third, central rail, held in place with no fasteners at all (figure 70).
Less obvious are the obstacles inhibiting the iterative process in contemporary education. Architectural pedagogy is encountering an unprecedented wave of automation and digitization that promises precision, and efficiency by reducing the time spent on manual labour.

“Yet machinery is mis-used when it deprives people themselves from learning through repetition”. “The smart machine can separate human mental understanding from repetitive, instructive, hands-on learning” warns Sennett. “When this occurs, conceptual human powers suffer” (Sennett, 22).

above, left:
Preparing the table top for oiling.

above, right:
Taking very fine shavings with a jointer-plane.
Early on during the table build, I was quick to impose upon Melissa, my opinion. I would attempt to correct her technique, offering advice on how to best grip and use a particular tool—not appreciating the fact that what felt comfortable and right to me, may not have been to her. The physicality of building together reminded us both that our bodies move and grow differently. Physiology plays a large role in the development of personal preference; comfort is not simply a matter of opinion. This is very easy to take for granted, and it has profound implications in the field of design.

I return to this experience often, and am reminded to listen; to listen with every sense; to sense empathetically.
The treatment, or finish, can preserve and elevate the appearance of wood—or ruin it. Although there is a tremendous variety of wood finishes to choose from, most will fall under oil, water, wax, or resin based finishes that are naturally derived, synthesized, or a combination of the two. Each will offer unique advantages; each is suited to a particular context.

In the context of finishing our pine table, Melissa and I desired an all natural, oil based finish, that would provide a beautiful yet durable, food-safe, waterproof surface. To this end, pure tung oil is without parallel. Tung oil is derived from the nut of the tung tree, native to southeast Asia. Tung oil hardens to a transparent film when exposed to air, creating a protective layer in and around the wood being treated. Depending on relative humidity, pure tung oil can take two or more weeks to harden between coats, which is why it needs to be applied thinly. For heavy use surfaces, such as a table, up to ten coats are needed. After two months of oiling, Melissa and I settled with six: enough to cause water to bead.
right:
The harvest table after finishing.

overleaf:
The harvest table in use.
Learning from the Past
In order to know what should be built . . . it was first necessary to observe what already existed. What was worth preserving? What sense, what atmosphere, should be duplicated in a new construction? It is possible for a code or formula to be followed to the letter and yet result in a work devoid of life, inert. This is the meaning of tradition: not formulae, but innate sense; not “design,” but patterns of action and use. Only this can result in the preservation of those fragile constructs we call “culture.”

Azby Brown, paraphrasing Tsunekazu Nishikawa
The Genius of Japanese Carpentry
As our table neared completion, our reverence for wood grew. Thriving on the spirit of craftsmanship, Melissa began to experiment with other materials, including paper and clay, and continued working with wood, building furniture and other craft, centered around the space of the table. I began designing and fabricating a timber frame tree-house; experimenting with wood joinery, and furniture, at a larger scale. We wanted to inform our work, by experiencing the work of a master. Having read about George Nakashima and Wharton Esherick, and having studied photos of their craft, Melissa and I were inspired to drive to Philadelphia, to visit their studios outside the city.
above:
George Nakashima
Woodworker. The Office
Showroom.

above:
Office Showroom south
elevation.
above: Inside the Conoid Studio.

above: Furniture made to be touched.
right:
Conoid Studio, office.
above, right:  
Main Workshop.

middle, right:  
An organized workspace.

bottom, right:  
A record of use.
Blanks and spindles, stacked for future use.
An old cherry tree features prominently on the grounds.
right:
A cedar gate with burned wood posts.
above, right:
The Wharton Esherick Museum. The building at rear was designed in collaboration with Louis Kahn.

bottom, right:
Formerly a log cabin garage, the visitor's center features a hyperbolic roof.
left:
Wharton Esherick's studio.
right: A grand view overlooking the valley.
right:
Seasoning lumber.
Building a Tree-House
I became acquainted with Gregoire shortly after work on the harvest table had commenced. Greg asked me to design a tree-house, that would be located in a maple tree on his property, in Waterloo, Ontario. Greg wanted a tree-house for his grandchildren, Grace, and Nolan, who were six, and four years of age respectively.

Nearly a year passed before any serious work on the tree-house began. After having completed the table, awakened to the potential of wood as a building material, I considered the tree-house an opportunity to apply what I had learned investigating the relationship between furniture and the body, material and craft—at a larger scale. With the harvest table as a precedent, I made arrangements with Greg so that I could design, and then build the tree-house. In the time leading up to this arrangement, Greg had decided to move the build site from within the maple tree, to a place beside it, on the sloped part of his yard, at the rear of his property.
Gregoire’s yard, which backs onto Breithaupt Park, in Waterloo, Ontario.

In the interest of preventing unnecessary damage to the maple, and to ensure some longevity to the build, Greg wanted the tree-house to be a freestanding pavilion, capable of accommodating his grandchildren through childhood, into young adulthood. We agreed that the pavilion should be intimate and playful enough for a child, spacious enough for an adult, and comfortable to both.

An old maple, at the rear of the yard: the initial site.
Experientially, we wanted the pavilion to retain the feel of a proper tree-house. I felt the design should inspire wonder in a manner suited to the larger scale and longer lifespan of the build, and to the sensibility of the owners, and neighbourhood. It seemed appropriate to adopt a gazebo typology, and to reference to the rich local vernacular; I was inspired by the towers and roof-scapes characteristic of the 19th century Waterloo, Cambridge, and Galt landscape.

Local sources of inspiration:
the Historic City Hall...

...and the old Galt Post Office, in Galt, Ontario.
After a number of exchanges, Gregoire and family, and I agreed upon a concept design (figure 101) in which the floor, supported above the ground and inside of the footings, lends a feeling of suspension. A tall, pyramidal gable roof harbours one of the boughs of the maple, a leafy canopy furthers the sensation of being in the tree, and vertical elements that are accentuated to imply an upward rise take a cue from the Gothic revival common in the Tri City area.

Because the tree-house would be inhabited by children, it had to be designed to work. A square form showing symmetry would make the structure easier to resolve, easier to construct, and would allow some freedom in the expression of individual members and joints. The chosen design would make an excellent testing ground for sustainable building practices in the form of pre-fabrication, timber-frame construction, and natural materials and finishes.

above: A covered platform on stilts gives the impression of being suspended.
Pinus sylvestris, or Scots pine, is a lightweight, moderately hard conifer native to Europe and Asia. Scots pine was introduced to North America in the 16th century, but does not grow very well there, due in part to adverse soil conditions and poor diversity in the initial seed stock—making it susceptible to damage by pests. Scots pine wood is similar in appearance and smell to other pine woods. It is a major source of lumber in its native area because it grows straight and tall, and is used in all manner of constructions, most notably in the stave churches of Norway, where the tree was once an important resource in the pine tar industry.

above: These timbers were once used to house tractor equipment shipped from Germany.
Bill’s Barn is more than a century old, and still bears all the original members, including the pine cladding.

**Quercus alba**, or white oak, is a dense hardwood native to eastern North America, where it is one of the most prevalent hardwoods. White oak heartwood is brown to light-brown in colour, with sapwood that is noticeably lighter. White oak is prized for its durability and rot resistance: a result of its closed cell structure, making it ideal for use in applications susceptible to damage by water. The **USS Constitution**, a frigate of the United States Navy, was famously nick-named “Old Ironsides” after the war of 1812, because her white oak hull and masts proved exceptionally durable.

*above:* This is Bill. He runs an independent mill in Granton, Ontario.

*right:* Bill sold me choice pieces of air-dried, quarter-sawn white oak for two dollars a board foot.
It was not until the widespread use of iron tools that more complex forms of wood joinery would have developed, around 200 BCE. By the middle of the 1st century, Buddhist carpenters spread out from India and into China via central Asia, disseminating their knowledge of wood construction, which, by the time it had reached Japan in the 6th century would already have been highly developed. Because of environmental and cultural factors, timber frame construction and wood joinery flourished in Japan, resulting in what many consider to be the epitome of wood architecture. At the height of their craft, Japanese carpenters, driven by intense rivalry among guilds, produced in the order of seven hundred unique joints of varying complexity, four hundred of which are still in use today.

above: The resiliency of timber-frame construction keeps this barn standing, despite its dilapidated state.
Timber frame construction began to fall out of favour when it could not keep up with the pace of industrialization. By the 20th century, stud frame construction had largely replaced the slower, but otherwise superior, timber frame tradition. More recently, people are returning to timber framing for its structural efficiency, beauty, and comparatively low embodied energy. With the adoption of engineered lumber, and advances in manufacturing, we can expect to see timber-frame technology re-entering the construction industry in a big way.

In Europe, then Scandinavia, timber frame construction developed somewhat later, maturing into a sophisticated and refined craft responsible for the ornate roof trusses that we still admire, in the many churches, cathedrals and palaces throughout those regions.

Early European colonists, setting foot in North America for the first time, pressured by harsh weather and a need for shelter, adapted their ornate woodworking traditions toward the utilitarian, and developed an efficient structural system, comprised of a series of cross-sectional frames, or ‘bents’— joined together with beams to form an enclosure. This stripped back, functional vernacular, characterized much of the wood construction that followed. We can still witness the remnants of this craft in the many barns that proliferated across the continent.
I constructed a temporary work shelter out of doors so that I would have enough space to joint, thickness, and true the lumber that would become the structure of the tree-house. Given that several of the structural members would end up six to thirteen feet in length, I also made a work bench, loosely influenced by traditional Japanese planing benches, and the Ruobo bench: a European design dating back to the 18th century. While I was open to utilizing both hand and power tools, the limitations of the machine tools available to me meant that I would have to dress the largest members by hand.

Building my own bench allowed me to experiment with, and monitor the performance of, common timber-frame joints, in the months leading up to the installation of the tree-house.

September 2012: fabrication commences
above, right: Cutting an angled mortise that will receive the hind trestle leg.

bottom, right: A trestle with an angled leg helps stabilize the bench.
above: A shallow ledge keeps tools close at hand.

top: A shouldered, half-lap dovetail...

below: ...joins the front leg to the bench top.
right:
Truing and squaring a cedar post: one of four cedar wood footings.
A laser pointer helps establish the elevations of the footings relative to one another.

above, right:
Trued and squared footings are set into excavated post holes...

middle, right:
...made plumb with a spirit level, and braced into position.

bottom, right
A laser pointer helps establish the elevations of the footings relative to one another.
After the post-holes had been excavated and the footings marked, I began work on the floor assembly. With total span of 12 feet and an effective depth of 5 ¾ inches, the primary floor beam, (figure 118, a) exhibited a substantial amount of deflection under load. In traditional Japanese timber construction, the span of a floor beam is often broken up by a post, with a dado with cross-tenon lap joint, (figure 132) I adopted the dado with cross tenon lap joint in the connection of the primary and secondary floor beams (figure 118, a,b,c). The absence of a central post, however, necessitated the development of a unique structural system to diffuse the deflection of the primary floor beam (a), to the footings (g), I modified the dado with cross-tenon lap joint at center, adding stub-mortises at the junctions of the primary and secondary floor beams (a,b,c), that receive a lever arm (d). The primary floor beam, deflecting under load, thus rotates the lever arm about a fulcrum (e), which diffuses the load away from the center of the platform toward the mud-sill (f), and out to the primary and secondary floor beams, where they connect to the footings.
Above:
A straight edge is a visual aid used to assess the degree of flatness of a board.

Above:
Winding sticks—used to gauge the degree of twist in a board—help with truing even the longest boards.
I made this ink-line, which is similar to a chalk-line, but more accurate.
above: Joists are laid out relative to center lines to ensure accuracy across all members.

above: An ink line is pulled taught and snapped to mark a center line on a major beam.
right: Rip cutting a tenon.

far right: Wedging-open deep rip cuts prevents the wood from clamping down on the saw blade.
right:
A dado and tenon take shape.
A snug fit for a through tenon: the underside of a dado with cross-tenon lap joint.
Figure 131

above:
A dado with cross-tenon lap joint, assembled.

Figure 132

above:
The underside of a dado with cross-tenon lap joint.
above, right:
These mud-sills, roughly two meters long, frame the playhouse floor.

middle, right:
Angled stub-tenon lap joints at the corners...

bottom, right:
...intersect the main cross beam, at the location of the corner posts.
Fixing one of many mistakes: a scarf joint is used to lengthen a mud-sill.
A modified dado with cross-tenon lap joint connects the main floor beam to six supporting beams... so that bending can be deflected to the mud-sills and footings.
During the fabrication of the platform, I had been working from rough sketches of joints, and an accurate and complete computer model. Nonetheless, I found it difficult to visualize all of the joints in relation to one another. My ‘spatial blurriness’ was the cause of many errors in measuring, and cutting. I needed to internalize the project in order to reduce human error. I took the time to draft all key details by hand, and produced a component schedule inspired by Japanese layout drawings. The physical act of tracing every contour of every joint by hand, familiarized my body to the landscape of the project. Drawing in two dimensions forced me to visualize the construction in three dimensions. During this exercise, I redesigned several joints after realizing they would be impossible to assemble.

Drawing by hand helps develop spatial awareness.
right: Structural axonometric of the playhouse. Refer to Appendix C.
Right:

Railing layout diagram. Every component is drawn unfolded to facilitate locating joints relative to each face.
<table>
<thead>
<tr>
<th>Task</th>
<th>Start</th>
<th>End</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0 - TREEHOUSE BUILD</strong></td>
<td>13/08/03 9:00 AM</td>
<td>14/03/30 5:00 PM</td>
<td>8mo 3w 2d 6h</td>
</tr>
<tr>
<td>1.1 - Phase 1: Prefabrication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MILESTONE - 1.1.1 - Dimensioning Begin</strong></td>
<td>13/08/03 9:00 AM</td>
<td>13/08/03 9:00 AM</td>
<td>1mo 2w 1d</td>
</tr>
<tr>
<td>1.1.2 - Dimensioning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1.1.2.1 - Dimensioning Principal Rafters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.1.1 - Planing Principal Rafter, block 1</td>
<td>13/08/05 9:00 AM</td>
<td>13/08/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.1.2 - Planing Principal Rafter, block 2</td>
<td>13/08/06 9:00 AM</td>
<td>13/08/06 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.1.3 - Planing Principal Rafter, block 3</td>
<td>13/08/07 9:00 AM</td>
<td>13/08/07 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.1.4 - Planing Principal Rafter, block 4</td>
<td>13/08/08 9:00 AM</td>
<td>13/08/08 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.1.5 - Thicknessing Principal Rafters, blocks 1-4</td>
<td>13/08/09 9:00 AM</td>
<td>13/08/09 12:00 PM</td>
<td>3h</td>
</tr>
<tr>
<td>Only on one side.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.1.6 - Ripping Principal Rafter, blocks 1-4</td>
<td>13/08/09 1:00 PM</td>
<td>13/08/09 3:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>- 1.1.2.1.7 - Thicknessing Principal Rafters, ripped faces, 1-8</td>
<td>13/08/09 3:00 PM</td>
<td>13/08/09 5:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>1.1.2.2 - Dimensioning Tertiary Posts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.2.1 - Planing Tertiary Post, block 1</td>
<td>13/08/12 9:00 AM</td>
<td>13/08/12 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.2.2 - Thicknessing Tertiary Post, block 1</td>
<td>13/08/13 9:00 AM</td>
<td>13/08/13 12:00 PM</td>
<td>3h</td>
</tr>
<tr>
<td>Only on one side.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.2.3 - Ripping Tertiary Post, block 1</td>
<td>13/08/13 1:00 PM</td>
<td>13/08/13 3:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>- 1.1.2.2.4 - Planing Tertiary Posts, ripped faces, 1-2</td>
<td>13/08/13 3:00 PM</td>
<td>13/08/13 5:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>1.1.2.3 - Dimensioning Railings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.3.1 - Planing Railing, block 1</td>
<td>13/08/14 9:00 AM</td>
<td>13/08/14 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.3.2 - Planing Railing, block 2</td>
<td>13/08/15 9:00 AM</td>
<td>13/08/15 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.3.3 - Planing Railing, block 3</td>
<td>13/08/16 9:00 AM</td>
<td>13/08/16 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.3.4 - Planing Railing, block 4</td>
<td>13/08/19 9:00 AM</td>
<td>13/08/19 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.3.5 - Thicknessing Railings, blocks 1-4</td>
<td>13/08/20 9:00 AM</td>
<td>13/08/20 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.4 - Dimensioning Roof Beams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.4.1 - Planing Roof Beam, block 1</td>
<td>13/08/21 9:00 AM</td>
<td>13/08/21 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>- 1.1.2.4.2 - Planing Roof Beam, block 2</td>
<td>13/08/22 9:00 AM</td>
<td>13/08/22 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>- 1.1.2.4.3 - Planing Roof Beam, block 3</td>
<td>13/08/22 1:30 PM</td>
<td>13/08/22 5:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>- 1.1.2.4.4 - Planing Roof Beam, block 4</td>
<td>13/08/22 5:00 PM</td>
<td>13/08/22 9:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>1.1.2.5 - Dimensioning Tie Beams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 1.1.2.5.1 - Planing Tie Beam, block 1</td>
<td>13/08/23 9:00 AM</td>
<td>13/08/23 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.5.2 - Planing Tie Beam, block 2</td>
<td>13/08/27 9:00 AM</td>
<td>13/08/27 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>- 1.1.2.5.3 - Planing Tie Beam, blocks 1-2</td>
<td>13/08/28 9:00 AM</td>
<td>13/08/28 5:00 PM</td>
<td>1d</td>
</tr>
</tbody>
</table>

There is a reason why a traditional woodworking apprenticeship lasted upwards of seven years—fifteen in ancient Japan: developing skill requires prolonged effort. Lacking a high degree of skill, and an innate sense of discipline, my efforts were slow, and wrought with failure—essential ingredients in any learning process. However, aiming to finish in a reasonable amount of time, in the interest of completing a master’s degree in architecture, I created a work breakdown structure, outlining the remainder of the build. A **WBS** was instrumental in expediting my work-flow. Being able to keep track of a task in relation to all others allowed me to allocate my time and effort more efficiently. Rarely did I meet my projected deadlines. My sense of time adapted whenever I revised my schedule. The final revision of the tree-house **WBS** revealed eight months of seven-hour work days, five days a week, spent on building alone; this metric does not represent any work done up to the production of the drawing set, or any research and practice carried out in parallel to the build.

Left:
**WBS**, excerpt. Refer to Appendix D

**time management is predicated on adaptability**
A six foot square marked on the ground feels too small. A thirteen foot rise feels too tall. While fabricating the many components that make up the tree-house, I found that an acute sense of scale, like an acute sense of time, remains the most elusive.

Above: Melissa, posing next to a height of four meters: the height of the tree-house.

Above: Assessing the platform width, and floor to ceiling height.
above:
After the footing joints are located, a power drill with an auger bit helps waste out deep sections of wood.

above:
A hole in this mirror allows the auger bit to pass through; its reflection helps keep the drill plumb.
In "The Genius of Japanese Carpentry", author Azby Brown points out that modern Japanese temple carpenters, having access to power tools, must still learn to use traditional hand tools. Being able to work across a range of tools affords the modern carpenter tremendous flexibility. Nonetheless, the modern temple carpenter chooses, whenever possible, to use hand tools for the subtle tactile feedback they provide over power tools.

above:
A paring chisel is used to clean up the inside faces of a mortise.

above:
After an initial drilling with an auger bit, a mortise is given shape with a mortise chisel.

working across a range of tools
The ability to sharpen well hinges on the development of other skills, including concentration, patience, and listening. At its most basic, sharpening by hand involves lightly stroking the bevelled edge of a blade across a water-stone—so called because it is lubricated with water—or similar, flat, abrasive surface. Lapping a blade across a series of water stones, each with a finer grain than the last, produces a sharp edge. In practice, one must consider the composition of the blade and what kind of abrasive it is best suited for; one must determine how much sharpening is necessary and be weary of over-sharpening; one must develop good posture and technique for smooth, steady, efficient strokes. With good technique, every blade will produce a unique vibration—a signature tone—and it takes a practiced concentration to grow sensitive to the sound and feel of a steel blade, floating on its bevel across a water stone.
above, and right: Custom wood cradles are used to clamp a post at an angle, to facilitate the cutting of a tenon.
Priority is given to instilling in the young apprentice a sense of respect and humility, not merely toward his superiors, but more importantly toward the wood and the work. The first tasks are deceptively simple: sweeping the shop floor, fetching tea, helping lift heavy members. Yet even these seemingly mindless tasks have the potential to teach concentration, exactitude, and teamwork, all of which are absolutely essential for the more complicated work ahead.

Azby Brown,
The Genius of Japanese Carpentry

above:
Cleaning up after a day’s work.
In the summer of 2013 Gregoire and Pat decided they would be selling their house the following year. It made sense to move the installation of the tree-house to their daughter and son-in-law’s property nearby. Fortunately, this news came before any building on site had commenced. Because I was nearly a year into the construction of all the components, with only a few pieces that make up the roof structure left to fabricate, there was little room for modifications to the overall design.

A few minor changes included lowering the height of the platform to accommodate a flatter site, and lowering the height of the roof, to comply with zoning by-laws. I also removed a railing side-wall, in order to open up the tree-house to a part of the yard the children frequently play in: a space inhabited by a burning bush that Grace and Nolan affectionately refer to as “The Enchanted Forest”.

*August 2013: a change of site*

In the summer of 2013 Gregoire and Pat decided they would be selling their house the following year. It made sense to move the installation of the tree-house to their daughter and son-in-law’s property nearby. Fortunately, this news came before any building on site had commenced. Because I was nearly a year into the construction of all the components, with only a few pieces that make up the roof structure left to fabricate, there was little room for modifications to the overall design.

A few minor changes included lowering the height of the platform to accommodate a flatter site, and lowering the height of the roof, to comply with zoning by-laws. I also removed a railing side-wall, in order to open up the tree-house to a part of the yard the children frequently play in: a space inhabited by a burning bush that Grace and Nolan affectionately refer to as “The Enchanted Forest”.

*August 2013: a change of site*

In the summer of 2013 Gregoire and Pat decided they would be selling their house the following year. It made sense to move the installation of the tree-house to their daughter and son-in-law’s property nearby. Fortunately, this news came before any building on site had commenced. Because I was nearly a year into the construction of all the components, with only a few pieces that make up the roof structure left to fabricate, there was little room for modifications to the overall design.

A few minor changes included lowering the height of the platform to accommodate a flatter site, and lowering the height of the roof, to comply with zoning by-laws. I also removed a railing side-wall, in order to open up the tree-house to a part of the yard the children frequently play in: a space inhabited by a burning bush that Grace and Nolan affectionately refer to as “The Enchanted Forest”.

*August 2013: a change of site*
figure 156

above:
Triangulating the locations of the post holes at the new site.

figure 157

above:
A gas powered auger has difficulty dislodging large stones.
A foot below grade under a layer of sod and clayish topsoil Gregoire and I encountered a very cobbly but well graded, gravelly-sand. The soil promised very good load-bearing characteristics, and excellent drainage, but the amount of cobble (stones ranging in size from a few inches to a foot in diameter) made digging very difficult. After a few rotations, the auger—lodged or floating on stones too large to remove—had to be lifted out so that the offending obstacle(s) could be dislodged, with a shovel, or a crow-bar, or some similar tool. When these tools proved ineffective, I resorted to clawing around the half buried stones, and prying them out by hand.
Due to substantial warping, this board will be cut into smaller components.

The cellular structure of wood absorbs and releases water with changes in humidity. Living wood has a high moisture content that evaporates after a tree is felled, which causes shrinkage, and, depending on internal stresses, deformation. As green lumber seasons, its internal moisture content will come into equilibrium with the moisture content of the air around it. A rapid loss of moisture while seasoning causes differential shrinkage, resulting in checks, shakes, and warping, along the length of a piece of wood. Checks fan out radially from the pith and usually are of no concern. Shakes follow the contours of growth rings, and may signal compromised structural integrity. Wood must be seasoned properly, in a kiln, or covered out of doors, to limit checking, and warping. Warped lumber can be corrected with the correct application of heat and pressure. Steam bending is one way to correct—or cause—permanent deformations in wood, however, lacking the proper equipment, this can be difficult to do with thicker sections of wood.
above, left:
A radially cut board will be less susceptible to deformation.

bottom, left:
Using a band-saw to cut a new principal rafter.
Laying out a joint in timber frame construction, one must consider the steps required in its fabrication. There are several ways to cut an angled tenon; the main difference between them is usually the number of cuts made. The order of operations in fabrication and assembly is one of several factors influencing the design of a particular detail. A joint that is made up of standard angles (30°, 60°, 45°, 90°, etc.), will be easier to lay out, and thus fabricate, because of commonly known ratios and standard tool markings. With any given construction detail, the designer needs to consider performance and appearance in concert with the time needed, and level of difficulty inherent in its fabrication, and assembly, all of which are related to cost.

left: Laying out and then cutting a tenon, at the base of a principal rafter.
above: “Splitting the line” on the waste side to ensure an accurate fit. Here, a bridle joint is being cut at the top of a principal rafter.

above: A bird’s-mouth mortise in this roof beam will receive the tenon at the bottom of a principal rafter.
above: A gable assembly takes shape.

above: Fitting a bird’s-mouth mortise and tenon joint at the roof beam-to-principal rafter.
above: The valley rafters were among the more complicated pieces to make.

above: Valley rafters, top and bottom. A table saw, power drill, ryoba saw, mallet, and chisels were used in their making.
right: Leftover framing lumber, donated from another student build.

far right: Salvaging pieces with suitable grain.
above:
These tongue and groove pieces are glued together to make a solid panel that...

above:
...is notched into a frame to allow expansion. The white oak rail protects the panel end-grain from moisture and offers increased support.
right: Once fully assembled, the panel will act as a diaphragm, and should mitigate the need for knee braces at the post and roof beam above.
Articulation of the structure is carefully considered. Chamfers contoured to the human hand create shadows and communicate depth, a slight camber is carved into the bottom edge of the mud-sills, lightening their appearance. Eastern white pine can very easily be shaped to convey hospitality.

*above:*

This four-foot railing is held sturdy by a mortise and tenon joint.

Mud-sill, wall-panel, and railing assembly.

*the plasticity of wood.*
above: Eminently handleable, a draw-knife offers a remarkable degree of freedom in form-finding.

above: Judging the proportion of a gently cambered chamfer.
After a component is dimensioned and the joints are cut, it is smoothed to the touch.
above:
One part pine tar to one part linseed oil.

On heavily trafficked areas, and for exterior applications, a good finish can drastically improve the durability and lifespan of wood. The heartwood of certain species, including local varieties of white oak, black locust, eastern white cedar, and old-growth douglas fir can be used unfinished, to great effect, in certain applications out of doors. In the right conditions, unfinished black locust fence posts have been known to survive upwards of sixty years. Scots pine (which constitutes the majority of the tree-house structure) is not very resistant to damage from water or insects, once it is felled. Yet scots pine was used extensively throughout Scandinavia, in the construction of stave churches and similar buildings, some of them still intact since the 12th century. The durability of old-growth heartwood, a sophisticated building science, and periodical maintenance have all contributed to the longevity of these buildings. We know that Viking, and later, medieval builders used pine tar as an effective vapour barrier in the preservation of several scots pine constructions.
Pine tar, a resinous material, is the product of the stump and roots of the pine tree burned at high temperatures, under high pressure, traditionally extracted in built-up mounds. Pine tar was used as a water-proof barrier on wooden buildings, and ships, on steel to prevent the onset of rust, and in pharmaceuticals, as a mild antiseptic.

An ancient recipe of equal parts pine tar and linseed oil should protect the tree-house for three to five years before needing a fresh coat. Linseed oil acts as a thinner and is mixed with pine tar to facilitate absorption. Pine tar has a rich, sweet smell. Applied when warm, it hardens via oxidative polymerization, resulting in an odourless elastic film, that can accommodate movement in wood. Certain grades, and mixtures of pine tar can withstand harsh conditions, without maintenance, for up to 15 years. A high quality pine tar finish is not toxic. Because children will be in contact with the tree-house, health and safety are a primary concern.

I prepared a heavier grade of pine tar for the roofing, decking, and footings of the tree-house, and a lighter grade for the rest of the structure. The undersides of the cedar roof planks are left unfinished, in the hope that the cedar scent might permeate the structure during humid weather.
Winter had set in when I was ready to begin installing, a year later than I had originally anticipated. The post-holes excavated in the months previous had been covered to prevent settling due to water infiltration. Thankfully, Reuben—a friend and colleague, with construction experience and good sense—had advised me to insulate the post-holes, to prevent the soil exposed to cold air from freezing.

Outside of a few minor alterations completed on-site, the pre-fabricated components came together easily: the installation took little over a month to complete.
above, left:
Footings and platform beams are installed first.

bottom, left:
Perfectly level.
above, left: The platform structure is pulled together tightly with cable clamps...

bottom, left: ...and checked for squareness.
top, right:
An auger is used to drill a hole through the sills and beam.

bottom, right:
A white oak dowel is used to secure the corner assembly.
top, right:
A gravel, sourced from a
local gravel pit.

middle, right:
The post are holes filled a
few inches at a time...

bottom, right:
...and tamped to minimize
settling.
above:
Covering up after a day’s work.
above: An entire elevation—a “bent”—must be assembled before it can be fitted to the platform.

above: Fitting a post to a roof beam.
above:...because of expansion caused by oiling.

above: Finessing the fit of a joint.
Mortises with bevelled shoulders match the profiles of the railings.
above: Modifying a tenon with a ryoba saw.

above: Tamping a post and railing assembly into place.
above: Because of concealed joinery, the remaining two bents are pre-assembled...

above: ...and installed simultaneously. Tall mortises in the first bent accommodate this procedure.
above: Installing the horizontal braces at the post and beam connections, after the frame is fully assembled.

above: Using a mortise and chisel to adjust the fit of a tenon at the wall panel.
above:
Shouldered, half-lap dovetail joints receive the horizontal braces...

above:
...which carry the valley rafters, and secure the post and beam assembly.
Above, and left:
Installing the valley rafters
and collar beams.
Self-supporting joinery makes the installation process relatively easy.
above:
The structure provides a sturdy scaffold.

above:
A bridle joint joins the tops of two principal rafters.
above: A mortise with shouldered half-lap dovetails, in the center of the main collar beam.

bottom, left: ...which secures the shouldered, lapped dovetail joints on the secondary collar beams.

middle, left: A mortise in the main collar beam receives a tenon on the king post.

top, left: A tapered cross-dado with a half-lap key joint on the king post secures the tops of the valley rafters.
The tapered cross-dado with a half-lap key joint at the head of the king post was inspired by the Kongming Lock: a wooden puzzle that Melissa gave me several years ago. The design of this puzzle is attributed to Zhuge Liang, a brilliant strategist who lived during the three kingdoms period of Chinese history, between 181 and 234 AD. An analysis of the puzzle reveals six wooden keys, that, when correctly assembled in two groups of three keys each, will interlock along one axis only.

At the location of the king post and valley rafter connection, I use two interlocking keys, seated in a tapered cross-dado: once installed there is no way for this joint to come apart.
right:
Securing the valley rafter-to-
king post assembly with oak
dowels.

Figure 222
left:
A feeling of satisfaction.
above:
These dovetail notches receive the roof purlins.

above:
A view looking down through the roof structure.
above: A pinned, half-lap joint at the top of the bridging.

above: King-post, valley-rafter, and purlin assembly.
Traditionally, an evergreen sapling is fixed to the peak of a newly completed structure; today, timber framers will “top off” to celebrate a culture of hard work, and to offer thanks to the trees used in the process.
Rather than spend the time needed to fabricate 448 wooden spacers—needed to achieve a desired roof plank spacing—I considered fixing metal braces to the underside of the roof planks instead. In actuality, screwing 448 fasteners to 176 planks proved tedious. In the absence of a wood spacer, the gap left between plank and rafter exposed the brads used to fasten them. Realizing my mistake, I opted to make the requisite number of wooden spacers.
Cedar lumber is jointed, thicknessed, and halved diagonally to create triangular sections...

...that will be cut into 448 triangular spacers.
It is important to consider the very small, and the very large, simultaneously. A single angled cut—
when it is not calibrated to the tools used to make it—necessitates the fabrication of a complex jig,
adding time and cost to a project.

Above, left:
A handmade jig couples with
a table saw.

Bottom, left:
...to make an angled cut on a
valley rafter spacer.
Roof planks are installed from the top-down.

Spacers are attached to the bridges and rafters with a brad nailer.
above:
Roof detail. Early afternoon.

above:
Installing the ridge-caps.
above:
View of the completed roof from below.

above:
Looking southwest, from the street.
top, left:  
Oak dowels, sized with a dowel former...

middle, left:  
...are used to pin the major structural joints...

bottom, left:  
...securing them in place.
right:
A view of the platform structure, from above.
top, left:
Hidden deck fasteners secure the decking to the platform, and act as spacers to accommodate expansion in the wood.

middle, left:
The fasteners are inserted into a precut groove on the sides of the deck planks...

bottom, left:
...and zinc-coated screws are screwed diagonally through the fasteners, and decking, into the structure below.
The continuous groove cut along the edges of the decking made for a quicker installation process, because the hidden fasteners could be placed anywhere along their length. However, when water collects in the groove, the edges of the boards swell. The top surface contracts faster than the still moist underside, causing a visible deformation of the edges. The resultant ‘cupping’ inhibits good drainage and may eventually cause the top edges of the boards to split off or splinter—shortening the lifespan of the deck considerably. It would have been smarter to locate the deck fasteners first, and to cut small grooves at those locations with a biscuit jointer.

Left:
Grace and Nolan, helping me install the decking.
top, left:
Soft to the touch.

bottom, left:
Grace, trying to stay out of the mud.
right:
The completed deck.
Three, four, five, and six-inch widths make up the herringbone pattern.
top, left:
With the arrival of spring, the edges of the mud-sills at the entrances were beginning to chip.

middle, left:
With a round spokeshave, I carved a deeper chamfer...

bottom, left:
...which will be less susceptible to wear.
The design and fabrication of the tree-house was largely guided by my sense of touch; it was made to be touched. Although photographs cannot substitute the physical immediacy of actual experience, I hope that the following selection might intimate qualities of light, proportion, and patterns of use.
There is no secret, no key piece of information which if revealed would instantly confer enlightenment and expertise. If you do not make progress, you cannot blame your teacher. If you have no teacher, do not place your highest priority on finding the "right" one ... you must develop on your own. [The] key is not an academic or intellectual comprehension. The only way to understand it is to do it.

Jou, Tsung Hwa, on the way, in taijichuan
In Traditional Chinese Medicine (TCM), Looking, Listening, Asking, and Touching make up the “Four Examinations” that together help the physician reveal a pattern diagnosis for a given patient. Of the four examinations, Touching is normally considered the most important. Pulse taking constitutes a major part of the Touching Examination, because, according to TCM, the pulse reveals a great deal about a patient’s condition. The master physician, placing their index, middle, and ring finger along the radial artery below the wrist, palpates the pulse with each finger, at three different pressures: superficial, middle, and deep; this allows for a remarkably nuanced reading of the pulse, which is taken on both wrists. Over a period of centuries, master physicians have identified in the order of twenty-eight pulse types, each associated with a specific set of symptoms. Given that most patients exhibit a combination of several pulse types, producing an accurate diagnosis from the pulse alone requires great skill and experience. In many cases, a physician will supplement their reading of the pulse with information gathered during the other three examinations: Looking, Listening, and Asking.
The Four Examinations in TCM underscore a dynamic common in many if not all, traditional craft cultures: the pivotal role of the body in reading, learning from, and interacting with, the surrounding environment. Whether we consider Chinese Medicine, or Woodworking, Taichi, or Pottery; the process of learning to think with the whole body is imbedded into the practice of these crafts. In a material craft like woodworking, the act of building is a mechanism through which learning and thinking with the body is cultivated in the apprentice, or student. In the context of an architectural education, the value of a craft guided approach to learning and thinking is two-fold: the student, working closely with materials over an extended period of time, in an act of building, embodies the qualities of the materials they work, within the context of construction, and, as a result of the affective nature of touch, develops a care for those materials and the process of building. For the craftsman, care often manifests itself as a sense of empathy: the craftsman architect is humble, and respectful of the value of material resources, and the value of labour and teamwork.

The complexity of the pulse taking examination in TCM reveals another dimension inherent in craft traditions: the continuum in which these traditions operate and evolve. Ideas, techniques, and technologies are the cumulative effort of generations past, present, and future, recycled, reinterpreted, reimagined. Understood in this context, tradition is a kind of technology, shaped by many hands over many generations to preserve “those fragile constructs we call culture” (Brown, 18). Craft cultures are an embodiment of a particular tradition: they offer a way of perceiving and operating in the world in a given context. TCM teaches us how we might better understand and respond to, the myriad factors contributing to overall health; the craft of woodworking aligns us to the myriad properties and qualities of wood, and suggests how we might harness them in a new construction.
A student, learning a traditional craft, may supplement their own experience and that of their colleagues with the continuum of experience embedded in that craft: allowing a student to test and refine their own understanding; to contribute to that continuum, and to apply their understanding to an even broader continuum, which, in the context of this author’s exploration is architecture.

The act of building, guided by the craft continuum, has revealed to me that thought and action inform one another, and that both are in constant flux. In woodworking, as in architecture, every idea owes allegiance to material processes, to environmental processes, and to the lives affecting and affected by these processes. Craft traditions offer students a way of familiarizing themselves with these processes in a specific context. I must stress the “care” in careful, for craft traditions, like woodworking, do not provide answers—but examples: it is up to the student to interpret these examples carefully, and critically, with their whole self, by looking, listening, asking, and touching.
A ten-foot long table to spread out on, to work, and to dine on, is a very accommodating piece of furniture. Being a harvest table, the overall build should be more robust. The top flexes under normal use, and I would not risk sitting on an edge on a regular basis, and not at all on a corner, for fear of collapse. Though pine is soft to the touch, edges and corners could have been made round for greater comfort. I was concerned the rough-sawn edges of the table top would be uncomfortable: where it has worn, it is very soft and pleasant to touch. The finish should have been applied more carefully. Although tung oil has a natural resistance to mildew, there appear to be small patches developing in areas where water has been spilled frequently. Judging by an unpleasant odour, more pronounced in humid weather, the undercoats have not fully cured.
A designation more suitable than tree-house, or playhouse, is gazebo. I worry that, attempting to satisfy designer, adult, and child, the gazebo falls short of providing the ideal space for all. As a place of shelter, the roof does not offer shade enough in the morning and late afternoon, although the surrounding foliage helps in this respect. A light rain may have been less of an issue under the leafy-canopy, inside and around the ornamental roof, inside and around the maple tree on the original site. Because the roof does not provide overhang, nor does it drain water away from the exposed wood joinery, I have no prediction as to the longevity of the structure. I do look forward to monitoring how it weathers.
As a place of rest and contemplation, the gazebo performs reasonably well. While the floor is not quite large enough to accommodate lounge furniture, railings at seating height allow one to inhabit the frame comfortably, making a small space feel considerably larger. The integrity of the structure is reassuring, although knee braces, or a more rigid diaphragm under the railings would stiffen the posts more. Several if not all of the connection details could be made more efficient. Wood joinery is nice to behold: it does not reveal all of its secrets at once. The softness of cedar, and pine, and the gentle shape of hand-carved members make the gazebo, for the most part, comfortable and safe to touch and inhabit. Ornament is restrained and integrated with other functions wherever possible: this is a benefit, given that the overall form may draw too much attention to itself—though part of the function of a gazebo is to provide ornament.

Where formal restraint is questionable, is in a child’s space of play. I do believe that the gazebo in its original incarnation—on a slope under a maple tree, with a raised floor providing a crawl-space below—would have accommodated a greater dimension of play, in concert with the surrounding landscape. As it is, the gazebo is somewhat less integrated with its new site.

It would be unfair not to acknowledge the wonder that the overall structure, and individual details, inspire, in children and adults alike. The play of light, the natural beauty of cedar, pine, and oak, and the attention to detail are qualities that the family, and neighbours, have responded well to. The gazebo is an expression of a process of learning and experimentation. It is play.
The following diagram is a display of the tools that I used most frequently during the building of the harvest table, and tree-house.
1. 30cm Ryoba saw
2. 24cm Ryoba saw
3. 25cm Kataba saw
4. 23cm Dozuki saw
5. Flush-cut Saw
6. Adjustable protractor
7. Suminagashi (ink line)
8. Carpenter's square
9. Combination square
10. Two dovetail chisels, 1/2" & 3/4"
11. Set of six butt chisels, 1/8" — 1"
12. Marking gauge
13. Small brass mallet
14. Lead holder
15. 240-grit water-stone
16. 1000-grit water-stone
17. 2400-grit water-stone
18. 4000/8000-grit water-stone
19. 3-1/4" slick
20. Large rubber mallet
21. 1/4" mortise chisel
22. 2" mortise chisel
23. 2" bevel edge chisel
24. Sliding Bevel
25. Tape Measure
26. Draw-knife
27. Plane mallet
28. Rubber-plane
29. Winding sticks
30. Round Spokeshave
31. Smooth plane
32. Scrub-plane
33. Jack-plane
34. Jointer-plane
35. Plough-plane
36. Skew rubber-plane
above:
East Elevation.

above:
Structural Floor Plan.
right.
Structural axonometric.
above:
Post at bracing. detail.

right:
Entrance assembly.
above:
Railing-to-post joint. Inside.

above:
Railing-to-post joint. Outside.
above: Mud-sill schedule.

above: Railing schedule.
above:
Roof plank schedule.

above:
Post schedule.
above:
Purlin, bridging, collar beam, king-post, and ridge-cap schedule.

above:
Roof beam, and bracing schedule.
The version included here is the last of several revisions, each more detailed than the last. Rarely do things go according to plan. Being able to adapt to setbacks is as important as trying to predict tasks with accuracy.
<table>
<thead>
<tr>
<th>Task</th>
<th>Start</th>
<th>End</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 - TREEHOUSE BUILD</td>
<td>13/08/03 9:00 AM</td>
<td>14/03/30 5:00 PM</td>
<td>8mo 3w 2d 6h</td>
</tr>
<tr>
<td>1.1 - Phase 1: Prefabrication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MILESTONES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1 - Dimensioning Begins</td>
<td>13/08/03 9:00 AM</td>
<td>13/08/03 9:00 AM</td>
<td></td>
</tr>
<tr>
<td>1.1.2 - Dimensioning</td>
<td>13/08/05 9:00 AM</td>
<td>13/08/09 5:00 PM</td>
<td>4w</td>
</tr>
<tr>
<td><strong>1.1.2.1 - Dimensioning Principal Rafters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.1.1 - Planing Principal Rafter, block 1</td>
<td>13/08/05 9:00 AM</td>
<td>13/08/09 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.1.2 - Planing Principal Rafter, block 2</td>
<td>13/08/06 9:00 AM</td>
<td>13/08/06 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.1.3 - Planing Principal Rafter, block 3</td>
<td>13/08/07 9:00 AM</td>
<td>13/08/07 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.1.4 - Planing Principal Rafter, block 4</td>
<td>13/08/08 9:00 AM</td>
<td>13/08/08 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.1.5 - Thicknessing Principal Rafters, blocks 1-4</td>
<td>13/08/09 9:00 AM</td>
<td>13/08/09 12:00 PM</td>
<td>3h</td>
</tr>
<tr>
<td>Only on one side.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.1.6 - Ripping Principal Rafter blocks 1-4</td>
<td>13/08/09 1:00 PM</td>
<td>13/08/09 3:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>1.1.2.1.7 - Thicknessing Principal Rafters, ripped faces, 1-4</td>
<td>13/08/09 3:00 PM</td>
<td>13/08/09 5:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td><strong>1.1.2.2 - Dimensioning Tertiary Posts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.2.1 - Planing Tertiary Post, block 1</td>
<td>13/08/12 9:00 AM</td>
<td>13/08/12 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.2.2 - Thicknessing Tertiary Post, block 1</td>
<td>13/08/13 9:00 AM</td>
<td>13/08/13 12:00 PM</td>
<td>3h</td>
</tr>
<tr>
<td>Only on one side.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.2.3 - Ripping Tertiary Post, block 1</td>
<td>13/08/13 1:00 PM</td>
<td>13/08/13 3:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td>1.1.2.2.4 - Planing Tertiary Posts, ripped faces, 1-2</td>
<td>13/08/13 3:00 PM</td>
<td>13/08/13 5:00 PM</td>
<td>2h</td>
</tr>
<tr>
<td><strong>1.1.2.3 - Dimensioning Railings</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.3.1 - Planing Railing, block 1</td>
<td>13/08/14 9:00 AM</td>
<td>13/08/15 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.3.2 - Planing Railing, block 2</td>
<td>13/08/15 9:00 AM</td>
<td>13/08/15 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.3.3 - Planing Railing, block 3</td>
<td>13/08/16 9:00 AM</td>
<td>13/08/16 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.3.4 - Planing Railing, block 4</td>
<td>13/08/19 9:00 AM</td>
<td>13/08/19 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>1.1.2.3.5 - Thicknessing Railings, blocks 1-4</td>
<td>13/08/20 9:00 AM</td>
<td>13/08/20 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td><strong>1.1.2.4 - Dimensioning Roof Beams</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.2.4.1 - Planing Roof Beam, block 1</td>
<td>13/08/21 9:00 AM</td>
<td>13/08/21 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>1.1.2.4.2 - Planing Roof Beam, block 2</td>
<td>13/08/21 1:30 PM</td>
<td>13/08/21 5:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>1.1.2.4.3 - Planing Roof Beam, block 3</td>
<td>13/08/22 9:00 AM</td>
<td>13/08/22 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>1.1.2.4.4 - Planing Roof Beam, block 4</td>
<td>13/08/22 1:30 PM</td>
<td>13/08/22 5:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>1.1.2.4.5 - Thicknessing Roof Beams, blocks 1-4</td>
<td>13/08/23 9:00 AM</td>
<td>13/08/23 5:00 PM</td>
<td>1d</td>
</tr>
</tbody>
</table>
1.1.2.5 - Dimensioning Tie Beams
   - 1.1.2.5.1 - Planing Tie Beam, Block 1
   - 1.1.2.5.2 - Planing Tie Beam, Block 2
   - 1.1.2.5.3 - Thinning Tie Beams, Blocks 1-2

1.1.2.6 - Dimensioning Purlins
   - 1.1.2.6.1 - Planing Purlin, Block 1
   - 1.1.2.6.2 - Planing Purlin, Block 2
   - 1.1.2.6.3 - Planing Purlin, Block 3
   - 1.1.2.6.4 - Planing Purlin, Block 4
   - 1.1.2.6.5 - Thinning Purlins, Blocks 1-4
   - 1.1.2.6.6 - Ripping Purlins, Blocks 1-4
   - 1.1.2.6.7 - Thinning Purlins, Blocks 1-8

1.1.2.7 - Dimensioning Bridges
   - 1.1.2.7.1 - Planing Bridge, Block 1
   - 1.1.2.7.2 - Planing Bridge, Block 2
   - 1.1.2.7.3 - Thinning Bridges, Blocks 1-2
   - 1.1.2.7.4 - Ripping Bridges, Blocks 1-2
   - 1.1.2.7.5 - Thinning Bridges, Blocks 1-4

Only on one side.

- 1.1.2.8 - Cutting Purlins Blocks In Half

1.1.4 - Jointing:
   - 1.1.4.1 - Jointing Posts
      - 1.1.4.1.1 - Jointing Secondary Post, Block 1
      - 1.1.4.1.2 - Jointing Secondary Post, Block 2
      - 1.1.4.1.3 - Jointing Secondary Post, Block 3
      - 1.1.4.1.4 - Jointing Secondary Post, Block 4
      - 1.1.4.1.5 - Jointing Tertiary Posts, Blocks 1-2
      - 1.1.4.1.6 - Jointing Primary Posts, Blocks 1-2
      - 1.1.4.1.7 - Jointing Primary Posts, Blocks 1-4

- 1.1.4.2 - Jointing Roof Beams
      - 1.1.4.2.1 - Scribing Joists, Blocks 1-4
      - 1.1.4.2.2 - Jointing Roof Beam, Block 1
      - 1.1.4.2.3 - Jointing Roof Beam, Block 2
      - 1.1.4.2.4 - Jointing Roof Beam, Block 3
      - 1.1.4.2.5 - Jointing Roof Beam, Block 4

- 1.1.4.3 - Jointing Braces, Purlins, & Bridges
      - 1.1.4.3.1 - Jointing Braces, Blocks 1-4
      - 1.1.4.3.2 - Jointing Purlins, Blocks 1-4
      - 1.1.4.3.3 - Jointing Valley Rafter, Block 1
      - 1.1.4.3.4 - Jointing Valley Rafter, Block 2
      - 1.1.4.3.5 - Jointing Valley Rafter, Block 3
      - 1.1.4.3.6 - Jointing Valley Rafter, Block 4

- 1.1.4.4 - Jointing Mudsills, Blocks 1-2
      - 1.1.4.4.1 - Jointing Mudsill, Blocks 1-2

- 1.1.4.5 - Jointing Sills and Beams
      - 1.1.4.5.1 - Jointing Mudsills, Blocks 1-2
      - 1.1.4.5.2 - Jointing Mudsills, Blocks 3-4
      - 1.1.4.5.3 - Jointing Major Beams

- 1.1.4.6 - Jointing Railings and Sidelights
      - 1.1.4.6.1 - Jointing Railings, Blocks 1-4

- 1.1.4.7 - Jointing Sidelights

1.1.4.7.1 - Jointing Decking, Roofing
      - 1.1.4.7.1.1 - Jointing Decking
      - 1.1.4.7.1.2 - Joint & Thickness Beams
      - 1.1.4.7.1.3 - Joint & Thickness Beams (Contd)
      - 1.1.4.7.1.4 - Mark Beams for Ripping
      - 1.1.4.7.1.5 - Rip Beams to Rough Dimensions
      - 1.1.4.7.1.6 - Rip Beams to Exact Dimensions
      - 1.1.4.7.1.7 - Cut Beams to Exact Lengths
      - 1.1.4.7.1.8 - Rip Grooves on Board Edges
- 1.1.4.7.1.0 - Chamfer Board Edges 14/02/03 1:00 PM 14/02/03 5:00 PM 4h
- 1.1.4.7.1.10 - Thickness Planks for Biscuits 14/02/04 8:00 AM 14/02/04 10:00 AM 2h
- 1.1.4.7.1.11 - Cut Holes 14/02/04 10:00 AM 14/02/04 1:00 PM 2h
1.1.4.7.2 - Jointing Roofing
- 1.1.4.7.2.0 - Board Count & Dimensions 14/02/01 9:00 AM 14/02/01 1:10 PM 3h 30m
- 1.1.4.7.2.1 - Mark Planks for Cutting 14/02/02 9:00 AM 14/02/02 1:10 PM 3h 30m
- 1.1.4.7.2.2 - Cut Roof Planks 14/02/04 11:15 PM 14/02/05 1:30 PM 1h 15m
- 1.1.4.7.2.3 - Mark Planks for Chamfering 14/02/05 1:30 PM 14/02/05 5:30 PM 3h 30m
- 1.1.4.7.2.5 - Chamfer Planks 14/02/06 9:00 AM 14/02/06 5:00 PM 1d
1.1.4.7.3 - Jointing Ridge Caps
- 1.1.4.7.3.0 - Board Count & Dimensions 14/02/07 9:00 AM 14/02/07 1:10 PM 3h 30m
- 1.1.4.7.3.1 - Cut Boards to Size 14/02/07 1:30 PM 14/02/07 3:15 PM 1h 45m
- 1.1.4.7.3.3 - Joint & Thickness 14/02/07 3:15 PM 14/02/07 5:00 PM 1h 45m
- 1.1.4.7.3.4 - Cut Log Joints 14/02/08 9:00 AM 14/02/08 1:30 PM 3h 30m
- 1.1.4.7.3.5 - Cut Gable on Top Face 14/02/08 1:30 PM 14/02/08 5:00 PM 3h 30m
1.1.4.7.4 - Jointing Railing Post Assembly
- 1.1.4.7.4.0 - Board Count & Dimensions 14/02/09 9:00 AM 14/02/09 1:10 PM 3h 30m
- 1.1.4.7.4.1 - Joint & Thickness Collar Ties 14/02/09 1:30 PM 14/02/09 5:00 PM 3h 30m
- 1.1.4.7.4.3 - Collar Tie 14/02/10 9:00 AM 14/02/10 1:50 PM 1d
- 1.1.4.7.4.4 - Collar Tie 14/02/11 9:00 PM 14/02/11 1:00 PM 1d
- 1.1.4.7.4.5 - Modify Collar Tie Joint at Valley Rafter 14/02/12 9:00 AM 14/02/12 1:00 PM 1d
1.1.4.7.5 - Chamfer Roof Structures
- 1.1.4.7.5.0 - Chamfer Valley Rafter 14/02/13 9:00 AM 14/02/13 5:00 PM 1d
- 1.1.4.7.5.1 - Chamfer Principal Rafter 14/02/13 9:00 PM 14/02/13 1:10 PM 3h
- 1.1.4.7.5.2 - Chamfer Principal Rafter 14/02/13 1:10 PM 14/02/13 4:00 PM 3h
- 1.1.4.7.5.3 - Chamfer Edges on Parapet & Bridges 14/02/13 4:00 PM 14/02/13 5:00 PM 1h
MILESTONE 1.1.5 - Miscellaneous
1.1.5.1 - Sizing, Tool Fitting, Contingency Buffer & Miscellaneous 13/11/20 8:00 AM 13/11/20 8:00 AM 1h 2h 4d
1.2 - Phase 2: Installation
MILESTONE 1.2.1 - Footings, Platforms, & Walls 14/02/07 9:00 AM 14/02/23 5:00 PM 2h 2h 4d
1.2.1.1 - List & Diagram of Operations for Install 14/02/07 9:00 AM 14/02/07 1:00 PM 1d
1.2.1.2 - Tool & Material Checklist 14/02/08 9:00 AM 14/02/08 1:00 PM 3h 30m
1.2.1.3 - Cut Rails & Dowels 14/02/21 7:00 PM 14/02/21 10:00 PM 2h
1.2.1.4 - Gather Tools & Materials 14/02/23 8:00 AM 14/02/23 1:00 PM 3h
1.2.1.5 - Coordinate Resources 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
1.2.1.6 - Move Materials to Site 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
1.2.1.7 - Clear Site & Working Area 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
Source: dry backfill. Source: dry backfill.
1.2.1.8 - Miscellaneous Setup 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
Source: dry backfill. Source: dry backfill.
1.2.1.9 - Install Footings 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
Refer to list of operations.
1.2.1.10 - Install Railings and Supporting Platform Structures 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
Refer to list of operations.
1.2.1.11 - Fence Platform Corners with Dowels 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
Refer to list of operations.
1.2.1.12 - Pick-Up Gravel Backfill & Plywood 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
1.2.1.13 - Backfill Post Holes 14/02/23 1:30 PM 14/02/23 1:30 PM 3h
1.2.1.14 - Install Secondary Posts 14/02/23 8:00 AM 14/02/23 5:00 PM 1d
1.2.1.15 - Install Northern Railing 14/02/23 8:00 AM 14/02/23 10:30 AM 3h 30m
Refer to list of operations.
1.2.1.16 - Install Eastern Railing 14/02/23 10:30 AM 14/02/23 12:30 PM 1h 30m
Refer to list of operations.
1.2.1.17 - Install Southern Railing 14/02/23 12:30 PM 14/02/23 1:30 PM 3h 30m
Refer to list of operations.
1.2.1.18 - Install Braces and Keys, Source with Cable Clamps 14/02/23 1:30 PM 14/02/23 5:00 PM 3h 30m
1.2.1.19 - Install Dowel Pins 14/02/23 5:00 PM 14/02/23 1:30 PM 3h 30m
1.2.1.20 - Cover Joints at Tops of Posts 14/02/23 1:30 PM 14/02/23 5:00 PM 3h 30m
MILESTONE 1.2.2 - Roofing and Decking
1.2.2.1 - List & Diagram of Operations for Install 14/02/14 8:00 AM 14/02/14 10:00 AM 3h
1.2.2.2 - Tool & Material Checklist 14/02/14 10:00 AM 14/02/14 10:30 AM 30m
1.2.2.3 - Gather Tools & Materials 14/02/14 10:30 AM 14/02/14 11:30 AM 1h
<table>
<thead>
<tr>
<th>Operation Description</th>
<th>Start Date/Time</th>
<th>End Date/Time</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install Mudsills and Supporting Platform Structure</td>
<td>14/01/18 1:30 PM</td>
<td>14/01/19 1:30 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Fasten Platform Corners with Dowels</td>
<td>14/01/19 1:30 PM</td>
<td>14/01/20 1:30 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Pick Up Gravel Backfill &amp; Plywood</td>
<td>14/01/20 1:30 PM</td>
<td>14/01/20 4:30 PM</td>
<td>3h</td>
</tr>
<tr>
<td>Backfill Post Holes</td>
<td>14/01/20 4:30 PM</td>
<td>14/01/21 1:30 PM</td>
<td>4h</td>
</tr>
<tr>
<td>Test-Fit Secondary Posts</td>
<td>14/01/23 9:00 AM</td>
<td>14/01/23 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Northern Bent</td>
<td>14/01/26 9:00 AM</td>
<td>14/01/26 10:30 AM</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Install Eastern Bent</td>
<td>14/01/26 10:30 AM</td>
<td>14/01/26 12:00 PM</td>
<td>1h 30m</td>
</tr>
<tr>
<td>Install Southern Bent</td>
<td>14/02/22 9:00 AM</td>
<td>14/02/22 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>Install Braces and Keys, Secure with Cable Clamps</td>
<td>14/02/22 1:30 PM</td>
<td>14/02/22 5:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>Install Dowel Pins</td>
<td>14/02/23 9:00 AM</td>
<td>14/02/23 1:30 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>Cover Joints at Tops of Posts</td>
<td>14/02/23 1:30 PM</td>
<td>14/02/23 5:00 PM</td>
<td>3h 30m</td>
</tr>
<tr>
<td>MILESTONE - Roofing and Decking</td>
<td>14/02/14 9:00 AM</td>
<td>14/03/30 5:00 PM</td>
<td>1mo 3w 2d 6h</td>
</tr>
<tr>
<td>List &amp; Diagram of Operations for Install</td>
<td>14/02/14 9:00 AM</td>
<td>14/02/14 10:00 AM</td>
<td>1h</td>
</tr>
<tr>
<td>Tool &amp; Material Checklist</td>
<td>14/02/14 10:00 AM</td>
<td>14/02/14 10:30 AM</td>
<td>30m</td>
</tr>
<tr>
<td>Gather Tools &amp; Materials</td>
<td>14/02/14 10:30 AM</td>
<td>14/02/14 11:30 AM</td>
<td>1h</td>
</tr>
<tr>
<td>Coordinate Resources</td>
<td>14/02/14 11:30 AM</td>
<td>14/02/14 12:00 AM</td>
<td>30m</td>
</tr>
<tr>
<td>Reserve U-Haul</td>
<td>14/02/14 11:30 AM</td>
<td>14/02/14 12:00 AM</td>
<td>30m</td>
</tr>
<tr>
<td>Transport Roof Structure, Clear and Prepare Site.</td>
<td>14/02/21 9:00 AM</td>
<td>14/02/21 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Valley Rafters &amp; King Truss</td>
<td>14/02/24 9:00 AM</td>
<td>14/02/24 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Principal Rafters, Bridges, Purlins</td>
<td>14/02/24 9:00 AM</td>
<td>14/02/24 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Roof Planks</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Roof Planks</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Ridge Caps</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Ridge Caps</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Docking</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Install Dowel Pins</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Move Materials to Site</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Move Materials to Site</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Roof Structure</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Roof Structure</td>
<td>14/02/25 9:00 AM</td>
<td>14/02/25 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Roof Structure &amp; Consolidate Pieces</td>
<td>14/03/04 9:00 AM</td>
<td>14/03/04 5:00 PM</td>
<td>1w</td>
</tr>
<tr>
<td>Wipe Roof Structure &amp; Consolidate Pieces</td>
<td>14/03/04 9:00 AM</td>
<td>14/03/04 5:00 PM</td>
<td>1w</td>
</tr>
<tr>
<td>Oil Roof Planks</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Roof Planks</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Decking</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Decking &amp; Consolidate Pieces</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Decking</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Decking &amp; Consolidate Pieces</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Decking</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Decking &amp; Consolidate Pieces</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Decking</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Wipe Decking &amp; Consolidate Pieces</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
<tr>
<td>Oil Decking</td>
<td>14/03/05 9:00 AM</td>
<td>14/03/05 5:00 PM</td>
<td>1d</td>
</tr>
</tbody>
</table>


