

Prototyping for Extimacy: Emerging Design Methods

By Philip Beesley

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PROTOTYPING ARCHITECTURE

The Conference Papers



Michael Stacey

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Prototyping Architecture: The Conference Papers

Michael Stacey: Editor

The Architecture & Tectonics Research Group at the University of Nottingham with The Building Centre Trust, London, is pleased to present this book, which records the Prototyping Architecture International Conference at the Building Centre, London, held on 21 – 23 March 2013, to coincide with Prototyping Architecture Exhibition. The second edition has been published by Riverside Architectural Press to co-inside with the ACADIA 2013 Adaptive Architecture Conference.

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Content

1 INTRODUCTION

2 RESOURCEFUL AND INVENTIVE

- 2.1 Fabric Formwork - Prototyping Concrete as Material, Process and Context
- 2.2 Clay, Craft, Culture: Material Explorations at Grymsdyke Farm
- 2.3 Prototyping Sentinel: Studies towards an Interface Architecture
- 2.4 The Deceptive Ease of Folding: The Industrialisation of a Prototypical Product
- 2.5 Prototyping and Prototypical: Two models for Architecture Practice
- 2.6 Kinetic Facade, Theme Pavilion Expo 2012 Yeosu, South Korea
- 2.7 Adaptive Prototyping Process as Mechanism towards Holistic Architectural Design
- 2.8 Keynote: Architecture in the Prototyping Age: Thinking Ahead

3 MATTER AND TECTONICS

- 3.1 Compagnon 1:1
- 3.2 Open Matter(s)
- 3.3 Robot Manufactured Formwork for Doubly Curved Concrete Surfaces with Precisely Embedded Optical Fibres Displaying Live Images
- 3.4 Learning by Doing: an Immersive Manufacturing Experience with Undergraduate Architecture Students
- 3.5 Knitectonics
- 3.6 Exploring Material Reciprocities for Textile-Hybrid Systems as Spatial Structures
- 3.7 Proto-materials: Material Practices in Architecture at Molecular and Cellular Scales
- 3.8 Prototyping Biomimetic Structure for Architecture
- 3.9 Autarki: Coupling a 1:1 Cross Laminated Timber Building Prototype with Parametric Energy Simulation to Investigate Scenarios for Energy Self-Sufficiency

4 TECTONICS AND TECHNOLOGY TRANSFER

- 4.1 Building with Beesley
- 4.2 TRADA Pavilion - Searching for Innovation and Elegance in Complex Forms Supported by Physical and Software Prototyping
- 4.3 The Evolution of Shell Lace
- 4.4 Low-Cost Prototyping of Comfortable and Healthy Homes in Tanzania
- 4.5 A Short History of Building Fabric and Architecture
- 4.6 Prototyping Architecture - Hurlingham Club Evolutionary Prototypes, Survival of the Fittest Ideas
- 4.7 Digital Design and Fabrication of Carbon Fibre Beam Prototypes with Stress/Deflection Analysis Driven Envelope Morphology
- 4.8 Keynote: Third Generation Light Weight Vehicle Architecture

5 PERFORMATIVE

- 5.1 Keynote: Bricolage / Bricoleur
- 5.2 De-Fabricating Protoarchitecture
- 5.3 FabPod: A Prototypical Design System for Acoustically Diffused Enclosures
- 5.4 Soundforms
- 5.5 Soft Kinetic Prototypes for Adaptive Architecture
- 5.6 Keynote: Prototyping for Extimacy: Emerging Design Methods

6 INTERNATIONAL PEER REVIEW COMMITTEE

7 CONTRIBUTORS

1

Introduction

Michael Stacey

Prototyping Architecture: The Conference Papers records the Prototyping Architecture International Conference at the Building Centre, London, held on 21 – 23 March 2013, to coincide with Prototyping Architecture Exhibition. All papers have been peer-reviewed by an International Peer Review Committee. This conference was staged to coincide with the to coincide with Prototyping Architecture Exhibition. This exhibition explores the importance of prototypes in the delivery of high quality contemporary architecture - performative architecture that is inventive, purposeful and beautiful. Maximising the effective use of materials and resources whilst delivering environments that facilitate human well-being.

The conference and this book presents to opportunities, for exhibitors including James Timberlake, Philip Beesley, Mark White, Frank Barkow and Anne-Mette Manelius to set out their approach to architecture, research and the importance of prototypes in their practice. Thus deepening the understanding of their architecture and the prototypes within the exhibition. The conference is a platform for a wider range of voices within this material culture field, from experimental practice within architecture to the first use of carbon fibre in new build architecture. Widening the scope of this vital topic in contemporary architecture and practice by facilitating discourse between world leading participants in their fields.

The speakers range from architects, researchers, theoreticians, material scientists, industrial designers, engineers and students of these disciplines. Many of the papers are presented by multi or intra disciplinary teams, which are characteristic of contemporary scientific research teams and the design teams producing contemporary architecture, alike. However there is still space and respect for the individual scholarly research or practitioner and the contribution he or she can make to contemporary discourse about architecture. Potentially deepening our collective understanding of this topic, which retains its importance to humankind as it shapes and houses our lives.

Prototyping Architecture: The Conference Papers has been set out with the same running order as the conference. The conference has been structured in four themes: Resourceful and Inventive, Matter and Tectonics, Tectonics and Technology Transfer and Performative. In this book these become chapters. However these themes overlap, with prototyping in all chapters, the themes intertwine, for example biomimetic or bio-inspired design appearing in all four strands.

5.6 KEYNOTE

Prototyping for Extimacy: Emerging Design Methods

Philip Beesley



Fig. 5.6.1 Protocell Mesh at the Prototyping Architecture Exhibition, Nottingham

Philip Beesley is a professor in the School of Architecture at the University of Waterloo. A practitioner of architecture and digital media art, he was educated in visual art at Queen's University, in technology at Humber College, and in architecture at the University of Toronto. At Waterloo, he serves as Director for the Integrated Group for Visualization, Design and Manufacturing, and as Director for Riverside Architectural Press. Beesley's Toronto-based practice, PBAI, is an interdisciplinary design firm that incorporates industrial design, digital prototyping, and mechatronics engineering. His work is widely cited in the rapidly expanding technology of responsive architecture.

Ode by Arthur O'Shaughnessy¹

We are the music-makers,
 And we are the dreamers of dreams,
 Wandering by lone sea-breakers,
 And sitting by desolate streams;
 World-losers and world-forsakers,
 On whom the pale moon gleams:
 Yet we are the movers and shakers
 Of the world forever, it seems.

With wonderful deathless ditties
 We build up the world's great cities,
 And out of a fabulous story
 We fashion an empire's glory:
 One man with a dream, at pleasure,
 Shall go forth and conquer a crown;
 And three with a new song's measure
 Can trample an empire down.

We, in the ages lying
 In the buried past of the earth,
 Built Nineveh with our sighing,
 And Babel itself with our mirth;
 And o'erthrew them with prophesying
 To the old of the new world's worth;
 For each age is a dream that is dying,
 Or one that is coming to birth.

Read by Michael Stacey as an introduction to Philip Beesley's Keynote at *Prototyping Architecture Conference*.

(Endnotes)

1 Arthur O'Shaughnessy 1844–1881, sourced from Louis Untermeyer, 1885–1975 ed., *Modern British Poetry*, Library of Congress 1920

Read by Michael Stacey as an introduction to Philip Beesley's Keynote at Prototyping Architecture Conference

Diffusive Prototyping: a manifesto

Looking at the bundled vesicles at the amygdala and limbic core, and my bicameral brain, and the distributed neural matter and ranging islands of ganglia close to my elbows and knees and chest and sinuses, it is tempting to characterize my body as a kind of archipelago, a ragged bundle bound together by tribal agreement. Such an image, in its diffusion and its multiple forms, might offer a model for contemporary prototyping.

The work that I am pursuing with my collaborators is founded in intimacy and touch. This work tends to be invested in layers that use digital fabrication to make quite delicate and resonant responses. They tend to be controlled by actuators and sensors, producing turbulent responses that ripple out into expanded physiologies, sharing space with the viewers. The work starts in rather quiet ways, setting out ghost-like crystalline forms following diagrids and textile forms in order to make very lightweight, resonant scaffolds. Networks of simple computational devices and sensors allow viewers to be tracked, offering small increments of gentle muscular movements that register our own presence, rippling back to us, starting to offer a sense of breathing, ambient architecture. The structures of this space are saturated with turbulence that offers clutching, and pulling, imparting a fertile churn.



Fig. 5.6.2 Philip Beeley, Detail of Viewer with Breathing frond, Hylozoic Ground, Venice Biennale for Architecture, 2010

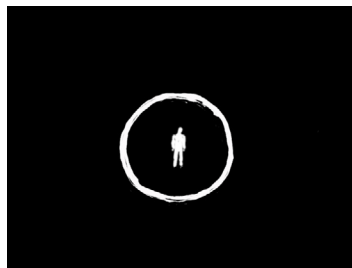


Fig. 5.6.3 Reductive form-languages follow a logic where a minimum exposing envelope contains a large proportion of enclosed territory

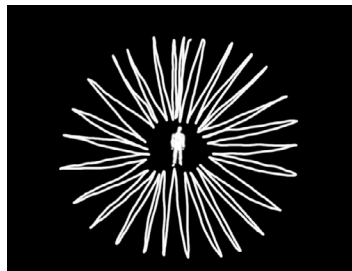


Fig. 5.6.4 In contrast to reductive forms, this image of a diffusive form follows a logic where an exposing presents the maximum possible exposing face in proportion to the territory it encloses

If my clothing floats and ripples outward, and if fluxing heat and cold cloaks me, is it accurate to say that the boundaries of my body lie at my skin? I try to think of what 'I' am, when I say that word. One voice speaks as the writer of this text, but what kind of creature is operating within that voice? Of course I want to make elegant things. As I draw the profiles of a skeleton frame building structure, I am guiding my hand in an attempt to follow an optimum of purity. In the back of my mind is the example of elder Michelangelo poised before his own drawing sheet, etching a perfect circle. Standing beside him is his muse Plato, speaking of the beginning of the world rooted in the balanced sphere of a single One, and then a double, and triad and harmonies efflorescing: that vision of origins moves

through crystalline pure multiples outward into sacred forms before falling away into the decaying soil of a circumstantial world. It returns always into the resting silent surface of the single sphere.

But perhaps those principles are not inevitable. Would a designer wedded to the rules of nature agree with the distilling rules that I imagine are binding me? Why, when I think of the myriad of forms that the natural world has offered, would I prefer closed, pure, gloss-faced cubes and spheres to tangled masses of dark and fertile soil? Why, when I think of rain and snow, would I assume that the perfectly balanced optimum of a spherical drop of rain is obviously better than the wasteful frills and ornament that radiate outward from the branching arms of a frozen snowflake? I do think that way. Perhaps I am guided by some kind of moral compass. A raindrop is better than a snowflake, I think. The surface tension of the meniscus encircling a drop of rain pulls inward; the hydrogen bonding of the water molecules draw together and pull, echoed by the inward pulling of the surface tension of the encircling meniscus. The result is an optimum where the least possible exposing surface encloses the greatest possible mass within. The result gives a kind of potency: the greatest retention of energy; the greatest amount of shelter, the least vulnerability to incursion and disruption from anything on the exterior.

If my home was located in Manitoulin, northward in Ontario, the origin of the world in some Canadian First People's visions and at the literal edge of a completely frozen north land while the great Wisconsin cap layer retreated twelve thousand years ago, I might have been wedded to the rule of that great rule of the conserving, distilling sphere. I would want the food I caught to be saved, and I would want my fire to last, and I would want my armour to close against the threats that came across the fields. The reductive form-language of Plato is like a machine for resisting interaction: its rules are ones of closure, and of saving against threat. When we think of using things well, and minimizing our footprint it is almost inevitable to think about a kind of reduction, and closure, that winds things up into the most perfect way of using things imaginable. Yet, along with a transcendent perfection in Platonic form language it would seem that we are also given a machine for resisting interaction with the world. There can be no less interaction than the form of a sphere.

If I think about perfect forms for a droplet of water, why I would not think of a snowflake along with a drop of rain? Why do I automatically think that a snowflake is a frilly, excessive, wasteful thing? Why would I not think that this kind of form is its own kind of optimum? If we think about a need for things to shed heat, to cool, and to seek interaction with the world, then the kind of diffusive form-language that snowflakes teach us about might offer their own kind of optimums. Rather than prioritising enclosing territory and maximum defensiveness, such a form seems instead to seek the most radical involvement with the perimeter- with the world- possible. Another kind of optimum, then. The maximum possible involvement. The minimum defence. A delicious efflorescence of involvement and exchange. Perhaps those form-languages of radical exfoliation that make batteries efficient, or perhaps the mitochondria in our own cells might inform involvement with the world. Replacing the sense of the stripped, certain horizon with something that might offer a soil-like generation of fertility, and involvement in material terms. A kind of expanded presence. Perhaps this implies a renewed kind of stewardship.

Some technical crafts present themselves in encouraging ways. Air, gas and fluid are in-

creasingly available as design spaces. The Yale mechanical engineer Michelle Addington suggests how energy exchanges around the body and around buildings can be addressed in thermodynamic exchanges exposing the dynamic of convective plumes around each of us. Rather than the air as a void, it implies air as an addressable medium for designers. Rather than space being neutral it can be seen as populated and structured. The aurora borealis has a direct anatomy, tracing out the fault lines in the earth's crust and offering energy exchanges that can be addressed. This sense also extends into the scale of the cell. Dr. Donald Ingber's contemporary cancer research gives us an anatomy that offers a kind of design space. Fluid anatomies are here seen in cytoplasm structured as two protein modes- myocin, organized in microtubules offering compression and actin, acting as tensile lines, working together in a tensegrity grid, structuring the viscous medium and therefore becoming addressable as a design space. Artificial life researchers Rachel Armstrong and Martin Hanczyc are part of a movement working with new protocells- prototype cells- exposing the ways designers can work with skin-making mechanisms and carbon-fixing mechanisms. This range of processes tends to be characterized by delicacy. They increasingly move from the Vitruvian idea of a static world into the dynamic form of a metabolism.

In the work of my own studio, we have moved through several phases. We have moved through geotextiles, scaffolds serving as a protection and growth layer that might impart a new fundament, an earth-surface machine, moving into a sense of working quite directly with fertility, working to make explicit soil-fields. Geometry has been quite important in the work, functioning not as stochastic and random systems, but rather intermediate states and quasiperiodic systems in which things start to stutter and convulse, moving into new possibilities while still drawing upon precise formations. Recently we have tried to work in intimate ways, rooting this in an expanded physiology working directly with the body.



Fig. 5.6.6 Erratics Net, Philip Beesley with Caroline Munk and Daltech students, Peggy's Cove, 1997

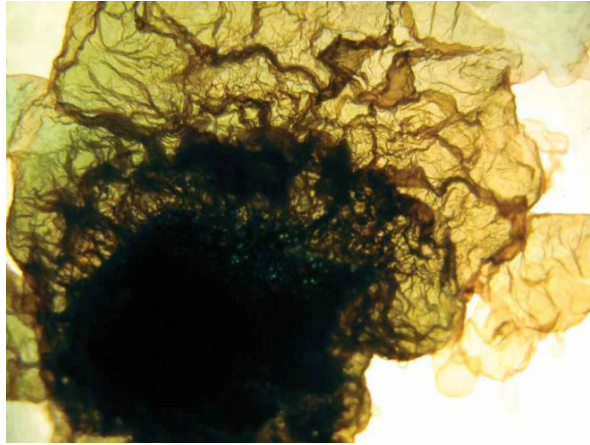


Fig. 5.6.5 Detail of protocell formation: copper sulphate reacts with potassium ferricyanide in solution, yielding a delicate reticulated metallic felt that grows under osmotic pressure

Early works pursued a kind of terrain. The twig-lattice of Haystack Veil made by clearing a farmer's field of alder and then using that material as a tri-axial weave, used as a shelter for organic growth nesting in it and catching turf, building up a kind of resilience. In Endothelium, mounted in Los Angeles, we worked with a similar structure and integrated organic power using latex bladders with aluminium and copper electrodes that made pathetically little amounts of power, organized in series and moving through capacitors, harvesting little bits of power in tiny amounts used for LED lights and vibrators chained to robotic feet configured like porcupine quills burrowing into the earth, seeking its own pattern of fundament over the months of the installation as it died.

More recently we have been working symphonically in layering systems, making light-weight scaffolds, metabolisms, and computation working together. The layered, immersive ground made for the Canadian pavilion at the Venice Biennale built up a series of ripples through individual elements, gently chaining together small increments using air actuation and shape memory alloy actuation. Each element within such an environment has a gentle, small amount of response, and because they are chained together in the hundreds and sometimes the thousands, quite substantial crowd-like responses occur. The elements are generated in large arrays. A hyperbolic meshwork stands above, making a robust force-shedding structural system with peaks and valleys of doubly curved surfaces. Hovering filters pass convective plumes through them, shot through with metabolic chemistry processing and generating new skins. The bladders, traps and glands seen within

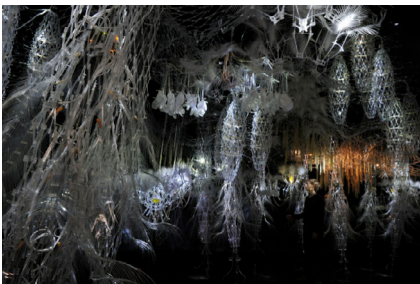


Fig. 5.6.7 View of Hylozoic Ground, Philip Beesley, Venice Biennale for Architecture, 2010

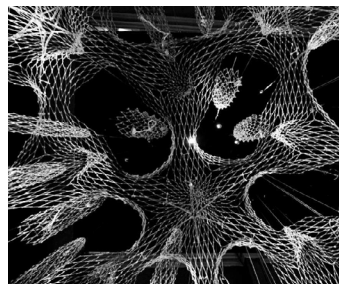


Fig. 5.6.8 Aerial view of hyperbolic diagrid meshwork, structural scaffold core of Hylozoic series sculptures, Philip Beesley



Fig. 5.6.9 Detail view of Sibyl, Philip Beesley, Biennale of Sydney, 2012: scaffold surfaces clothed with reticulum of glass vessels containing salt and sugar solutions

these works form soil-like elements. The computation seen here is very simple: individual elements chained together produce action akin to a chorus of crickets, or a swarm of insects, or perhaps the opening and closing of polyps in a coral reef. Shift-registers provide a means of addressing many masses of actuators while using modest microprocessing power, marching through data sets.



Fig. 5.6.10 Detail view of *Hylozoic Soil*, Philip Beesley, Montreal Museum of Fine Art, 2007: hyperbolic diagrid meshwork clothed with soil-like layers of polymer vesicles and barbed filters

Alongside data processing, we concentrate closely on making of individual elements, using material qualities. A snap-fit chevron connects to make the dual of a tetrahedron and then can be multiplied to facilitate composite arrays. Hyperbolic meshworks, columnar forms and tapers can be used as scaffolds to be clothed by mechanisms. A reticulum of many chambers forms humid layers, containing fluids and salts that pull and push and generate a blooming atmosphere. Flasks of protocell environments are worked into clusters within this assembly. Traube cell formations feature a delicate copper felt blooming out, working in osmosis and continually pumped around a copper sulphate crystal. These kinds of systems layer together and produce a feedback loop that produce the operation of creating soil.

In the prototype shown in Nottingham and London we moved into a more robust metal structure and also a more explicit carbon-capture process using the Leduc recipe of carbonate precipitation. This process is not yet efficient, but the operation of pumping and of osmosis serves as a kind of machine for generating possibility. This is a raw structure focused on potential rather than an optimum. The weather-like organization is judged by density and potency rather than by clarity.



Fig. 5.6.11 Detail of Protocol Mesh showing Leduc Cells, with carbonate formation in vesicles forming between oil layers of oleic acid and diethyl phenyl phthalate

In the Voltage series, now undertaken with Iris Van Herpen, we have been winding up the intensity of individual components in order to qualify them for expressive clothing. The work is not so much one of day-to-day interchange but rather than one of an occasion that opens where you could go, and who you could be, and the kind of space that you might be able to inhabit. A robust silicone meshwork swarms around the body in a muscular way. Individual elements chained together with small silicone tubes make a diagrid of corrugated mesh with diffusive, viscous performance.

I have complained about the Platonic world, a reductive world in which envelopes are closed, and optimum, and clear, and I am trying to make an argument for an alternate relationship based on diffusion. This painting of Piero della Francesca's *Flagellation of Christ*, painted in the mid 1500's, is often celebrated as a great step forward into humanism, away from primitive conceptions. Similar public forums might be seen in the spaces of Mies Van Der Rohe such as the Berlin Neue Staatsgalerie and Toronto's Toronto Dominion Centre, in which a stripped stage emphasizes freedom for unrestrained social relations. Here in della Francesca's image, we can also see such a quality, not so much in the religious image but rather in the exchange of the Florentine citizens and in the gridded stage that provides freedom, prioritizing the intimate touch between people. The figures of this scene suggest care and imply a kind of lateral social axis, an extraordinary achievement of humanism. Yet this justice and care comes at a cost, speaking of preoccupation with the lateral axis at the expense of other realms. The sense here is that the earth is stripped and rendered inert.

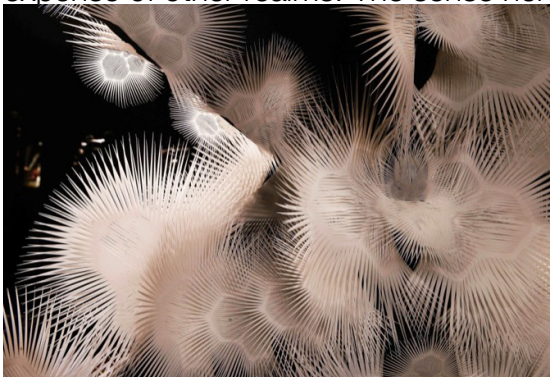


Fig. 5.6.12 Detail of filtering frond fabric from Voltage Series, haute couture by Iris van Herpen, Paris, 2012, collaboration with Philip Beesley

A different kind of surface is offered in a fragment cropped from an Annunciation painted by Fra Angelico, a century before Piero della Francesca. In the floor surface of Angelico's painting we see a depiction of the origin of life. We see an investment in turbulence, and material quality. The material painted is quite deliberately and directly not touched by human will. In dramatic contrast to a handling in which geometry might rule, this work shows a deliberate kind of limiting of human will, a release. The great teacher of Thomas Aquinas, Albertus Magnus, taught a kind of contemplation guided by the terms *dissimilitudo* and *disfiguration* a particular kind of practice informing the hand of the contemplative painter. The result can be seen explicitly in manipulations of paint, such as a rendering of stone depicting the marbles located in the convent of San Marco in Florence. The splashes and blotches within this work are not accidents. Fra Angelico is a master of figuration - the trace of releasing and scattering makes for an extraordinary sensibility. These works can offer strategies for designing with resonance and involvement, pursuing a renewing fertility.

George did Huberman, in his study of Fra Angelico, offers a precise review of terms that could be used for contemporary prototyping. Drawing from Aristotle's discussion of the 'dynamis', the certain power of places, Georges Didi-Huberman explains how Albertus Magnus developed an entire theory of the genesis of forms (*inchoation formarum*) where the place is very far from playing the simple role of a more or less neutral and indeterminate 'container' for the figures. Albertus Magnus vehemently criticized those who maintained that the place 'brings' nothing to figures or is 'extrinsic' to them. Figure-forms do not simply inhabit a place: they are produced by that place. Hence, Albertus Magnus calls the place an 'active principle of engendering': *locus est generationis principium activum*. It is much more than a space understood in its usual, topographical sense; it is a power of morphogenesis, a 'virtue' capable of fabricating, of being useful, and of structuring: the notion of place, writes Albertus Magnus, ought to be understood as a *virtus factiva et operative*. For it is in the place that the power of matter, its 'appetite' for determining itself as form, manifests itself: it is already remarkable at this point to see matter and the place invested with a *virtus causandi*, a causal virtue; Robert Grosseteste, for example, conceded this virtue only to light itself. Hence, the place, the ground, within and through which forms will be formed and figure will detach themselves - this place is potentially an operation of the divine. It works, says Albertus Magnus, at the very constitution of being: *locus igitur ad esse operator*.



Fig. 5.6.13 Detail of Annunciation, Fra Angelico, c. 1440, Monte Carlo, convent of San Giovanni: genesis embodied within rendering of floor surface

These paintings serve as a kind of architecture around the body. A familiar kind of this would be the form of a halo around a divine figure, making a perfect figure, perhaps implying polarized and separated world. But the kind of material that I have been showing offer a different kind of involvement, I hope. I hope they show a release, and an interchange. Perhaps this offers the kind of fertility that I have been sharing. Certainly they speak of a kind of potential.

I have complained about raindrops, and I have admired snowflakes, in spite of them being frilly. I have talked about a design space with subtle phenomena and the exchanges that might be available as a direct practice. Flexible, fragile components combined within composite systems can produce quite sensitive configurations, invested with a new metabolism that open a possibility of working in the future. By working symphonically these design methods can produce robust, involving space, rooted in intimacy and touch. I hope that these are a contribution to the practice of prototyping.



Fig. 5.6.14 Detail of Epiphyte Veil, Philip Beesley, EXIT festival, Maubeuge, 2012. Thermoformed expanded-mesh acrylic spars house a reticulum of protocells



Fig. 5.6.15 Detail of Radiant Soil, Philip Beesley, En Vie, Espace EDF, Paris, France 2013. Organic batteries arranged in series provide incremental trigger voltages for space-sensor activated helical chains of LED lights

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i Arthur O'Shaughnessy 1844–1881, sourced from Louis Untermeyer, 1885-1975 ed., *Modern British Poetry*, Library of Congress 1920

ii Albertus Magnus, c.1193-1280, is considered by scholars including James A. Weisheipl and Joachim R. Söder to be the greatest German philosopher and theologian of the Middle Ages, see for example: Joseph Strayer ed., *Dictionary of the Middle Ages 1*, New York, Scribner, 1982, p. 129

iii Image credits: Photos and diagrams © PBAI, all by Philip Beesley except Fig 5.6.2 Pierre Charron

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