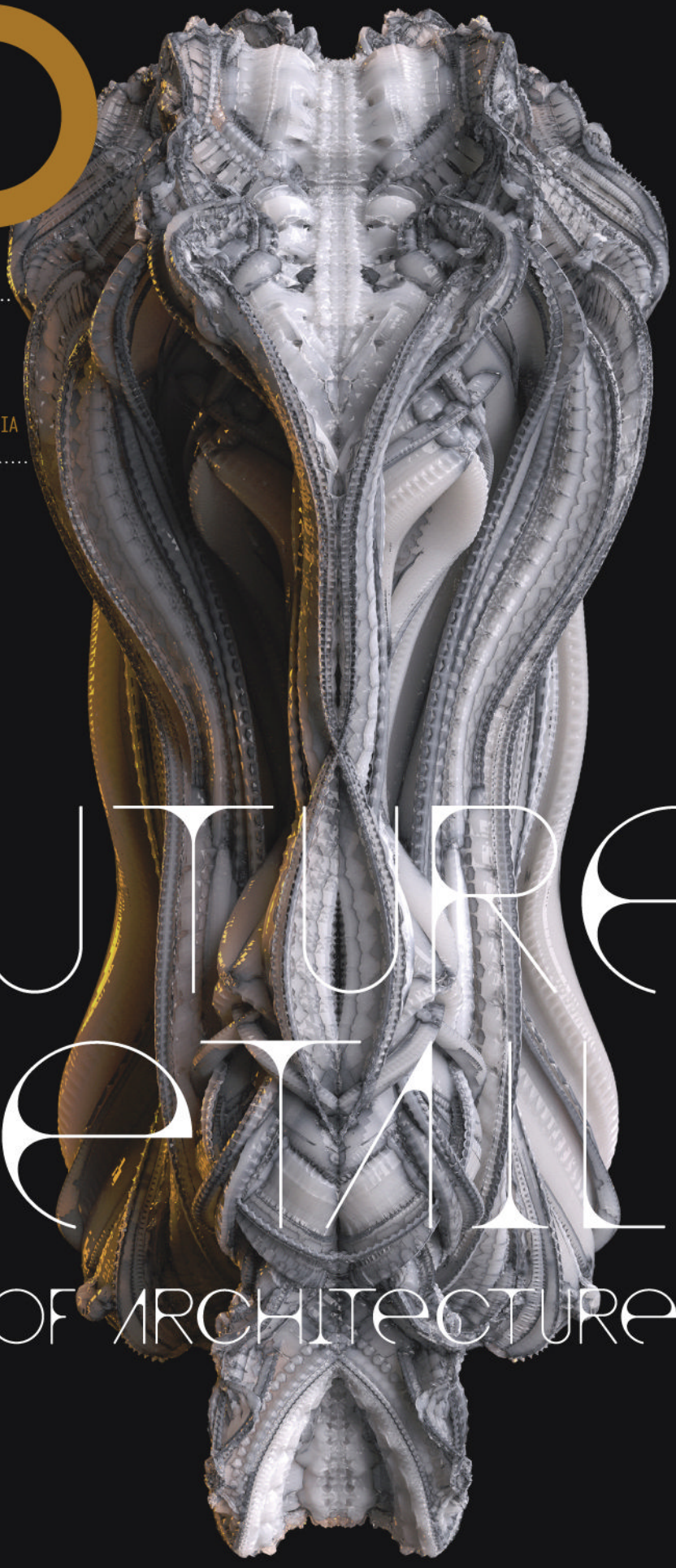
ARCHITECTURAL DESIGN
JULY/AUGUST 2014
PROFILE NO 230
GUEST-EDITED BY MARK GARCIA



# FUTURE DETAILS

## OF ARCHITECTURE

ARCHITECTURAL DESIGN

GUEST-EDITED BY
MARK GARCIA

# FUTURE DETAILS OF ARCHITECTURE

04 / 2014

ARCHITECTURAL DESIGN
JULY/AUGUST 2014
ISSN 0003-8504

PROFILE NO 230
ISBN 978-1118-522530

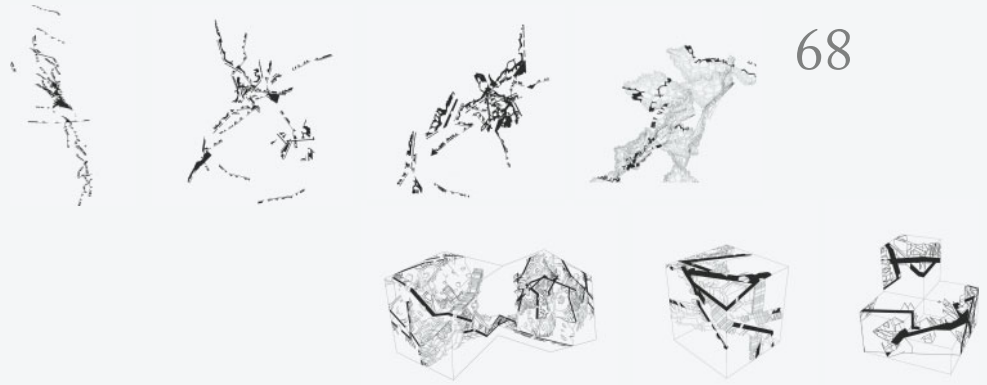
ARCHITECTURAL DESIGN

GUEST-EDITED BY
MARK GARCIA

# FUTURE DETAILS OF ARCHITECTURE



44



68



*I would define the detail as a way of thinking differently about the subject … The detail is almost the opposite of the most abstract aspect of how we analyse architecture. It is instead where scale, theory and the material understanding of architecture come together.*
*— Ben van Berkel*



98

**Editorial Offices**
John Wiley & Sons
25 John Street
London WC1N 2BS
UK

T: +44 (0)20 8326 3800

**Editor**
Helen Castle

**Managing Editor (Freelance)**
Caroline Ellerby

**Production Editor**
Elizabeth Gongde

**Prepress**
Artmedia, London

**Art Direction and Design**
CHK Design:
Christian Küsters
Sophie Troppmair

Printed in Italy by Printer Trento Srl



**Subscribe to AD**

AD is published bimonthly and is available to purchase on both a subscription basis and as individual volumes at the following prices.

**Prices**
Individual copies: £24.99 / US$45
Individual issues on AD App for iPad: £9.99 / US$13.99
Mailing fees for print may apply

**Annual Subscription Rates**
Student: £75 / US$117 print only
Personal: £120 / US$189 print and iPad access
Institutional: £212 / US$398 print or online
Institutional: £244 / US$457 combined print and online
6-issue subscription on AD App for iPad: £44.99 / US$64.99

**Subscription Offices UK**
John Wiley & Sons Ltd
Journals Administration Department
1 Oldlands Way, Bognor Regis
West Sussex, PO22 9SA, UK
T: +44 (0)1243 843 272
F: +44 (0)1243 843 232
E: cs-journals@wiley.com

Print ISSN: 0003-8504
Online ISSN: 1554-2769

Prices are for six issues and include postage and handling charges. Individual-rate subscriptions must be paid by personal cheque or credit card. Individual-rate subscriptions may not be resold or used as library copies.

All prices are subject to change without notice.





**Front and back cover: Michael Hansmeyer and Benjamin Dillenburger, Digital Grotesque, 2014. © Michael Hansmeyer and Benjamin Dillenburger**

**Cover font: Accent font designed by Nelson Balaban/Soulcraft**

**Inside front cover: Peter Macapia, American Mexican Border Currency, 2011. © Peter Macapia**

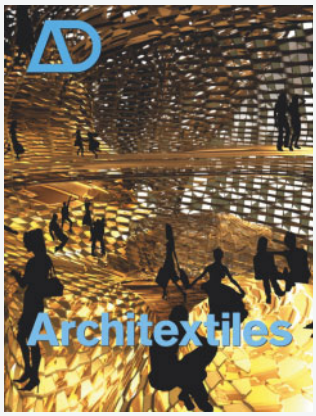
04 / 2014

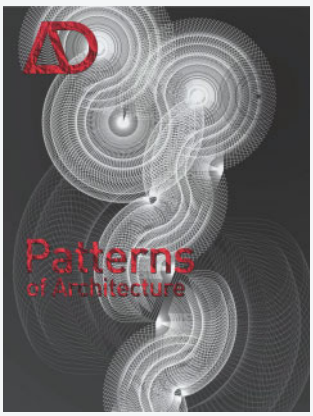
# EDITORIAL

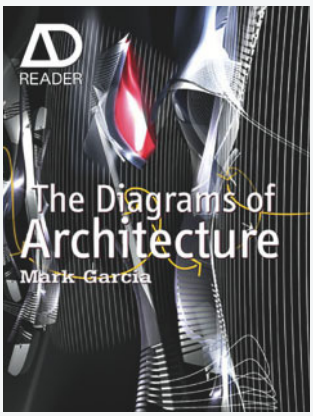
*Helen Castle*

The architectural detail is up for grabs. Never has there been a moment when it has been riper for reinvention. What is to be the place of something so dependent on its physical form in a digital and virtual world? The detail was perhaps one of 20th-century architecture's greatest preoccupations. Modernism substituted ornament and classical elements with highly finessed abstract detailing. Publications fetishised the architectural detail, reproducing the drawings of seminal buildings and their parts: piloti, components, modules, joints and the most discreet of trims. It is difficult to think that it was only a couple of decades ago that architects were obsessing over the High-Tech excesses of the detail – highly visible metallic cabling, pipework, cladding and glazing.

The spotlight that this issue AD puts on the detail – one of architecture's most physical manifestations – is a speculative one. It asks the contributors to fast forward just beyond the present to the near future. This is a canny move on the part of Guest-Editor Mark Garcia, as the detail proves a promising vehicle for rethinking the current condition of architecture. For any discussion of the detail is ultimately about the practice of architecture per se. The wider connotations of the detail are perfectly summed up by Carlo Ratti and Matthew Claudel: 'detail can be thought of as the smallest radical element of architecture that can be imbued with significance', it 'is the most basic unit for conveying an idea in and of itself while simultaneously serving as a building block in elaborating a larger concept' (p 87). This notion of the detail as the most basic building block or unit for meaning keys into the convention of architecture as a language, in which the detail becomes a single word contributing to a greater narrative. Patrik Schumacher highlights the increasing importance of the detail as an integral part of the architect's tectonic toolkit, facilitating social communication. With much of the architect's role as overseer of the physical design and fabrication of architecture now being eclipsed by the engineer, the architect's main *raison d'être* becomes that of meaning purveyor or communicator (pp 44–51). Likewise the focus that Ben van Berkel and UNStudio have put on redefining the detail over the last 20 years recognises the essential contribution of detailing to 'a more intense architecture' (pp 52–61). There is no doubt, though, that the nuts and bolts of the physical detail is in flux: Hernan Diaz Alonso redefines tomorrow's detail as 'the close-up', which places emphasis on resolution and the conceptual rather than highly crafted physical properties (pp 62–7); Ratti and Claudel highlight how the development of the detail at the level of the microchip might lead to the transformation of buildings into highly responsive, human-occupied transmitters (pp 86–91); and Rachel Armstrong recognises the potential of biotechnologies to provide growing living detailing (pp 112–7). Mark Burry closes this volume with a Counterpoint that reminds the reader that the detail can never be severed from a full understanding of making, for to detail is to make a commitment to construction (pp 134–41). He also sums up perfectly the intrinsic relationship between the speculative and the physical that the detail and the practice of architecture encompass: 'It is this tension of reconciling the legitimacy of being afforded a speculative head in the clouds while at the same time needing to ensure its attachment to a body that has its two feet firmly placed on the ground, that adds a certain frisson to any consideration of the detail' (p 136). AD




**Zaha Hadid Architects, New National Stadium, Tokyo, 2013**
Part of a series of Mark Garcia's photographic research into the details of ZHA's models.

**Mark Garcia, *Architextiles*, Nov/Dec 2006**
This researched the intersections of textile design with interior, architectural, urban and landscape design, and included Will Alsop, Dominique Perrault, Lars Spuybroek and Matilda McQuaid.

**Mark Garcia, *Patterns of Architecture*, Nov/Dec 2009**
Examining and updating research around new types and technologies of patterns and pattern recognition in architectural and other forms of spatial design, this issue featured Patrik Schumacher, Hanif Kara and Alejandro Zaera-Polo.

**Mark Garcia, *The Diagrams of Architecture* ( Reader), 2010**
The first historical, theoretical and futurological anthology of diagrams in architecture, this definitive analysis includes essays by Peter Eisenman, Charles Jencks, Hanif Kara, Sanford Kwinter, Winey Maas, OMA, Reiser + Umemoto, Neil Spiller, Bernard Tschumi and Antony Vidler.

Mark Garcia is an author, researcher, editor and academic holding degrees in art history, philosophy and international management. He is currently a senior lecturer in histories, theories and futures, teaching BA and Master's-level students in the Department of Architecture and Landscape at the University of Greenwich, London. He has held academic teaching and management posts at St Antony's College, University of Oxford, and in the Departments of Architecture and Industrial Design Engineering at the Royal College of Art (RCA), where he supervised MA, MPhil and PhD students. He has worked in industry as a manager for Skidmore, Owings & Merrill (SOM), and for Branson Coates Architecture (BCA).

Mark has written for *Building Design*, the *Architects' Journal* and *Architectural Review*. He has guest-edited two previous issues of AD (*Architextiles*, Nov/Dec 2006 and *Patterns of Architecture*, Nov/Dec 2009), and is editor of the book *The Diagrams of Architecture* (John Wiley & Sons, 2010). He has also lectured to business and in universities in the UK, Switzerland and Japan, and collaborated on exhibitions, films, books, design, research and teaching projects with architects, artists, theorists, academics and engineers around the world. He is a member of the Advanced Virtual And Technological Architecture Research (AVATAR) group at the University of Greenwich, and a regular contributor to the university's AVATAR 'Future Cities' conference and publications series. He is currently researching, editing and writing *The Diagrams of Architecture Volume II: The Future Diagrams of Space,* and the first-ever books on the architectural cantilever: *Cantilevers: Flying Architectures* and *Anti-Gravity Architectures and the Spaceship*.

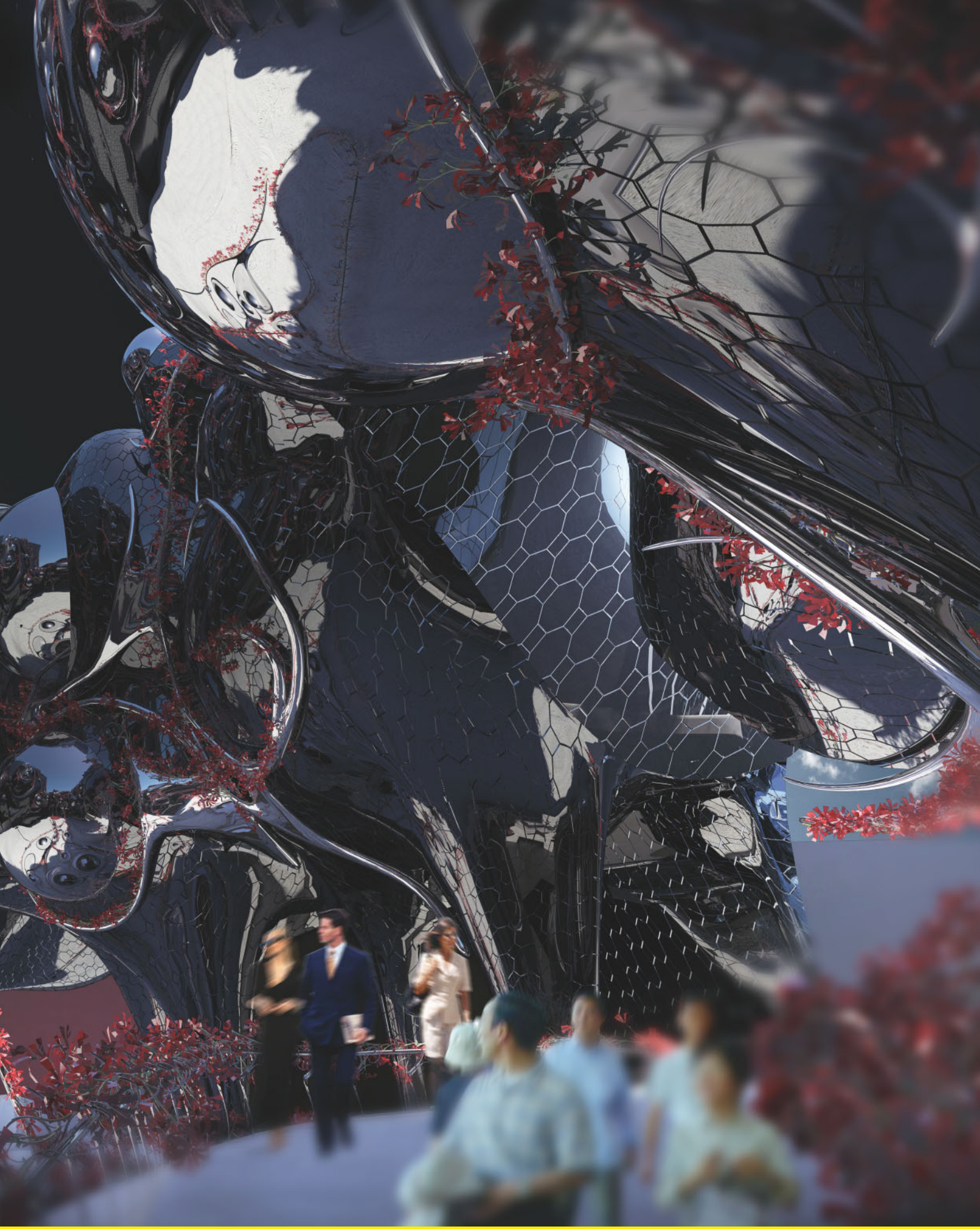
Other research interests include architecture and its futures as well as theory, fine art, photography, pop culture, utopias, diagrams, images, film, digital culture, literature, sports and other forms of mass media. Mark's research is characterised by a fascination with forgotten, lost, minor, strange and neglected spatial and design histories, ideas and innovations. While his research projects are always linked (the architextile, the pattern, diagram and detail are in special circumstances interchangeable), they are always the means to research innovation outside of architecture. As projects they search for a theoretical Archimedes lever: the small and ignored thing that can surprise and move planets. AD

**UNStudio**

**VilLA NM, New York, 2007**
Detail, anti-detail and the slick morphing gradients between them form geometric, sliding and eliding hybrids. Multiple and contradictory dualities between orthogonal and curviform materialities generate the playful flows of details.

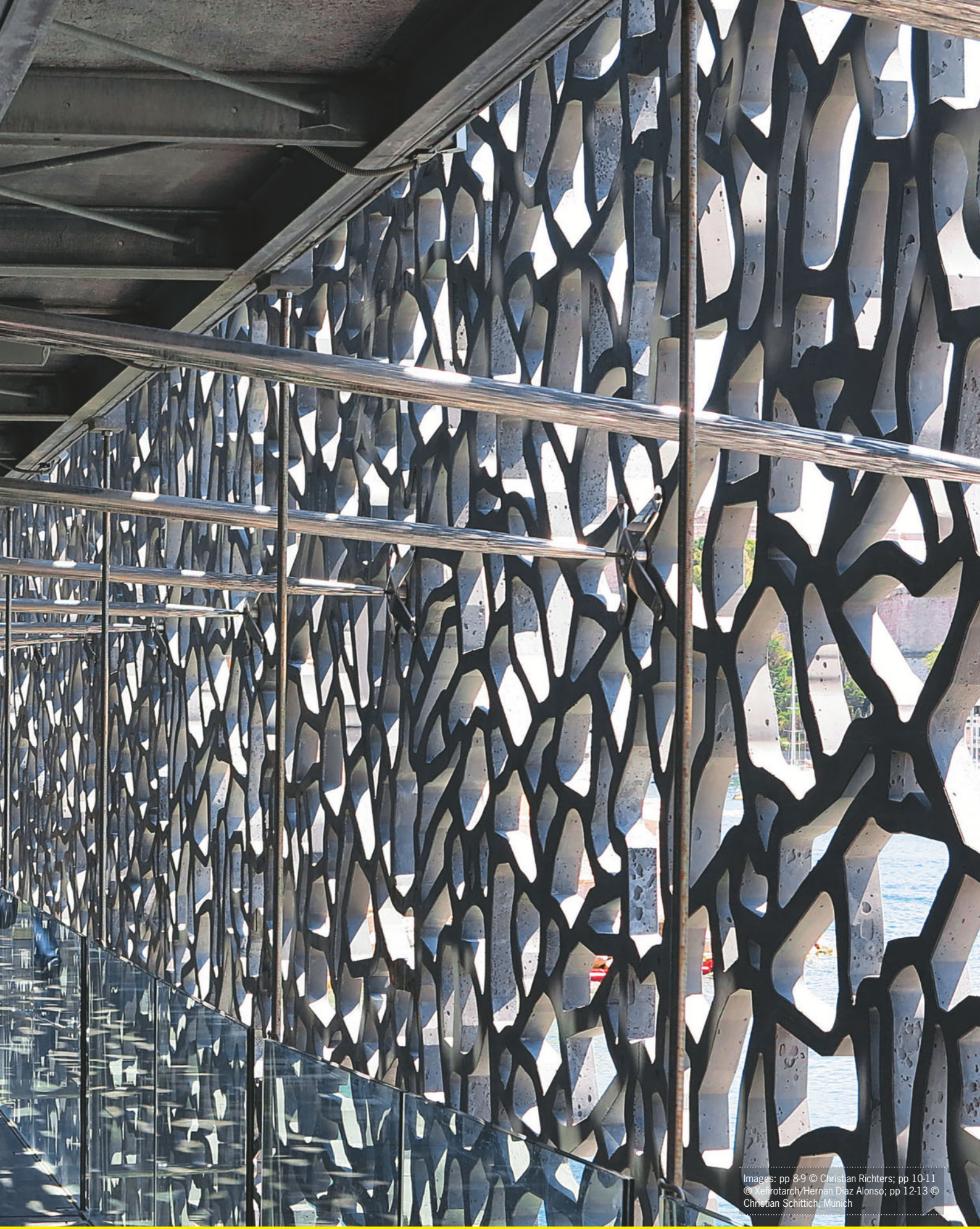
## Xefirotarch

**Teatro Colón, Bogotá, Colombia, 2013**
In the project for the Teatro Colón competition, the hyper-reflective surface treatment produces a mirror-like quality in which people walking in the plaza not only become multiplied and distorted on the surface articulation, but are also placed on a stage where they themselves become the performers within the larger context of the building. This switching of roles between visitor and performer represents a different take on the contemporary role of a theatre.



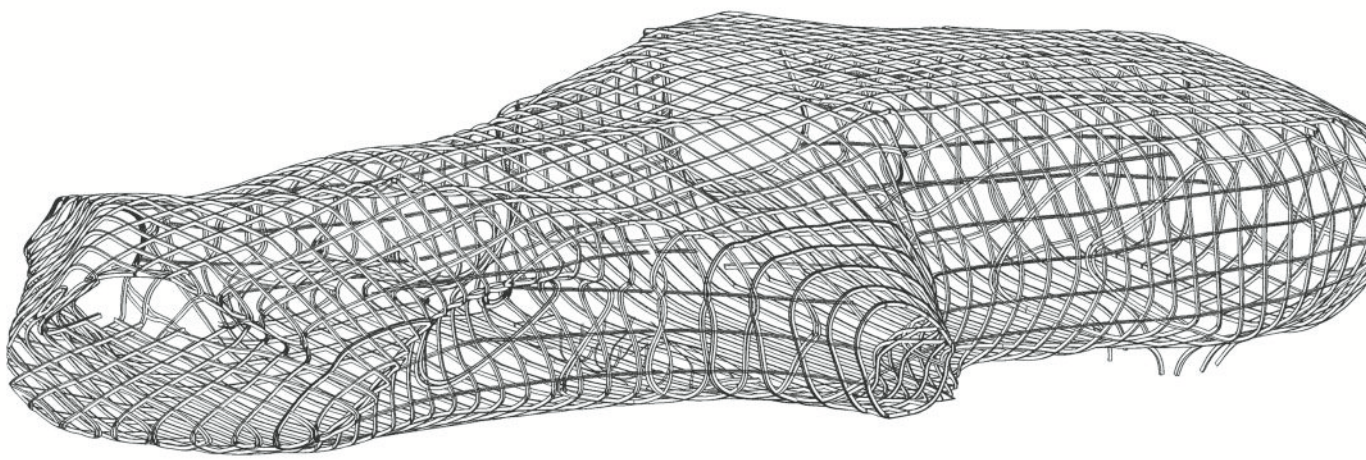
**Rudy Ricciotti**

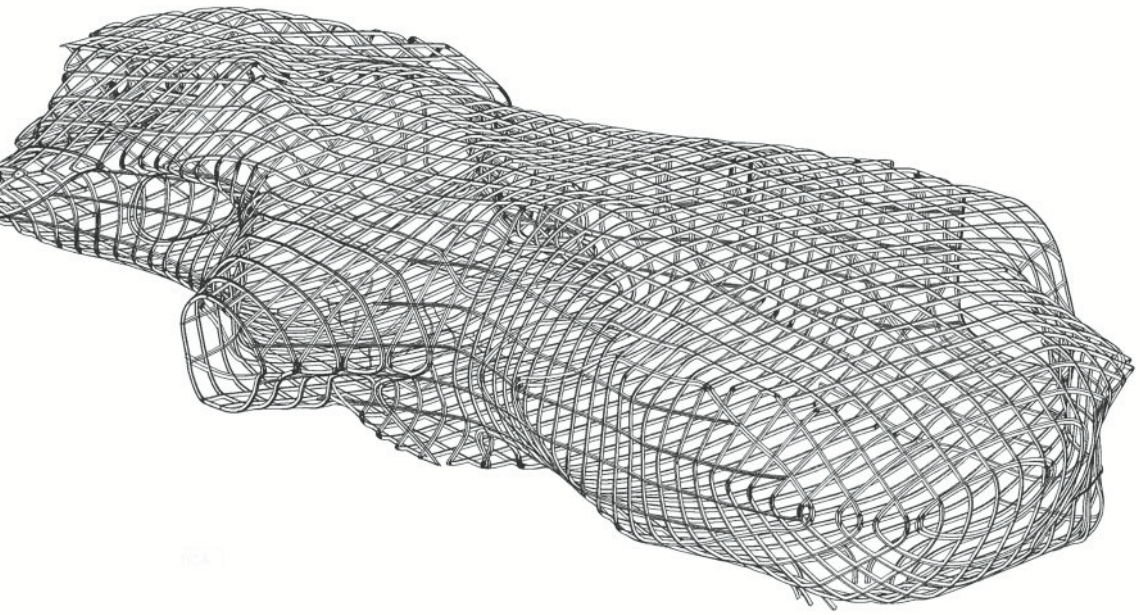
**Musée des Civilisations de l'Europe et de la Méditerranée (MuCEM), Marseille, France, 2013**
The museum is the first building utilising ultra-high-performance concrete (UHPC) on a large scale. The fixation of the net-shaped diaphanous facade elements, however, is by means of 'frog fingers', a traditional method borrowed from glass construction.



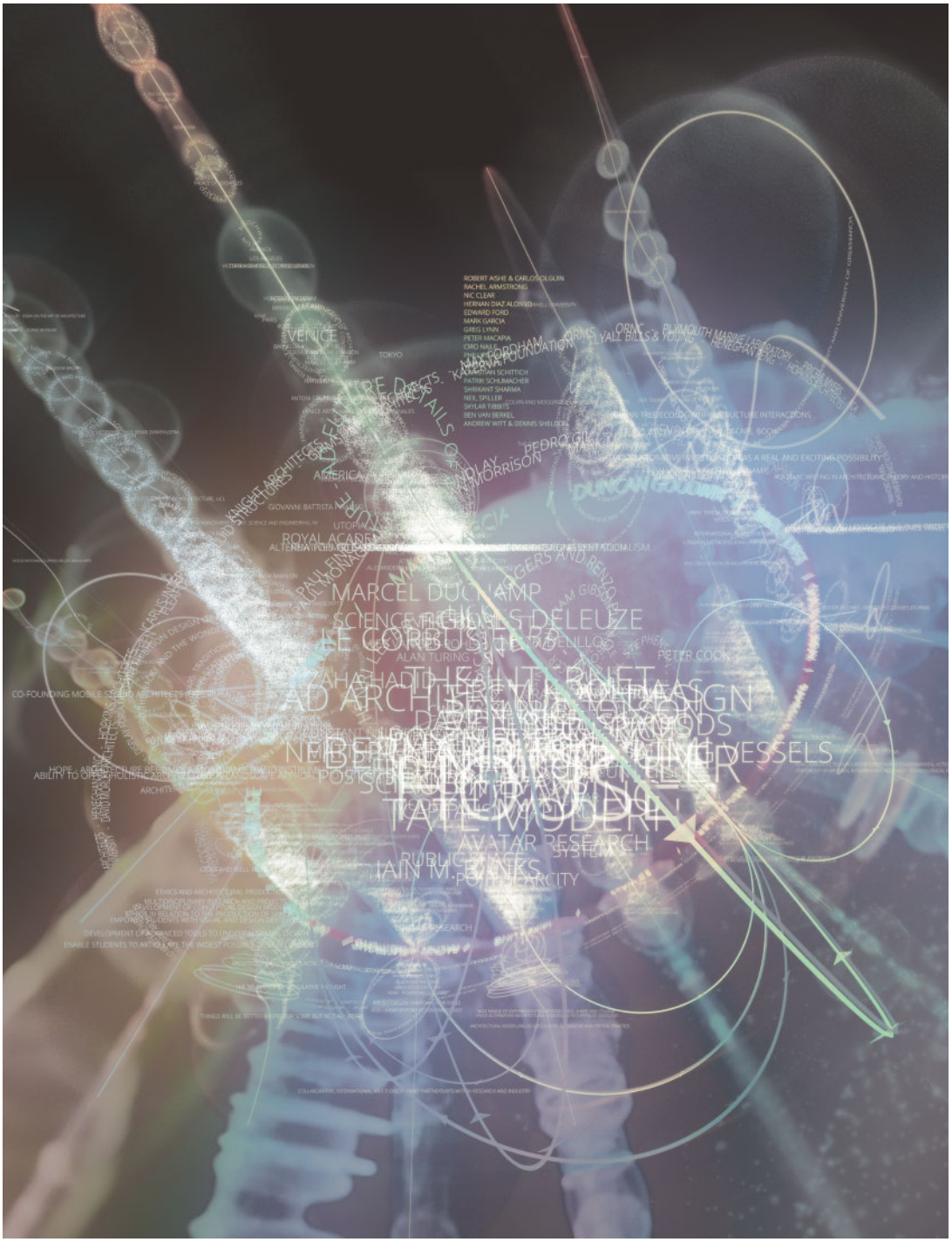
Images: pp 8-9 © Christian Richters; pp 10-11 © Xefirotarch/Hernan Diaz Alonso; pp 12-13 © Christian Schittich, Munich

# HISTORIES, THEORIES AND FUTURES OF





# THE DETAILS OF ARCHITECTURE




**Mike Aling and Mark Garcia, Diagram of the Details of the Histories, Theories and Futures of Architecture at the University of Greenwich, 2014**
This 4D diagram contains and parametrically links over 6,700 separate but interconnected architectural details from 32,000 BC and into the future. The future details of architectures will be diagrams of relationships between architectural details and processes.

In 1906, the architect Hendrik Petrus Berlage announced the death of the joint, and nearly a century later Greg Lynn proclaimed the death of the detail.[1] But a year ago, one of the smallest architectural details was discovered within one of the largest, most expensive, specialised and most detailed works of architecture ever made – though it has never been acknowledged as architectural. This neglect by architecture of the Higgs boson particle itself reflects a history of poor critical and theoretical writings on the architectural detail. For while sometimes acknowledged to be important to architecture as a whole, the detail has not yet been fully explored for the many more design opportunities it offers us in the future. We therefore need to reassemble the histories and theories of architecture to redesign the detail into the 21st century and beyond.

Though the word 'detail' itself is less than 400 years old, its conceptual root is a basic philosophical idea. Its etymology[2] is from the 17th-century French words '*détail*' and '*détailler*'. These consist of the parts *dé-* (connoting separation) and *tailler* ('to cut'), from the Latin '*talea*' ('twig, cutting'), expressing the sense of minor things considered as a whole. A detail is a differentiated, discrete, divisible, distinguished or separated part, piece, point, fragment, individual, element, component or section. Its verb

form has connotations of describing, explaining, relating, cataloguing, particularising, abstracting, reducing, identifying, specifying, stating, presenting, citing and instancing. In an architectural context the detail has been most closely associated with modules, components, units, joints, transitions, connections, conjunctions and seams or, most controversially, details as decoration, style, embellishment, adornment, motif, synecdoche or ornament.

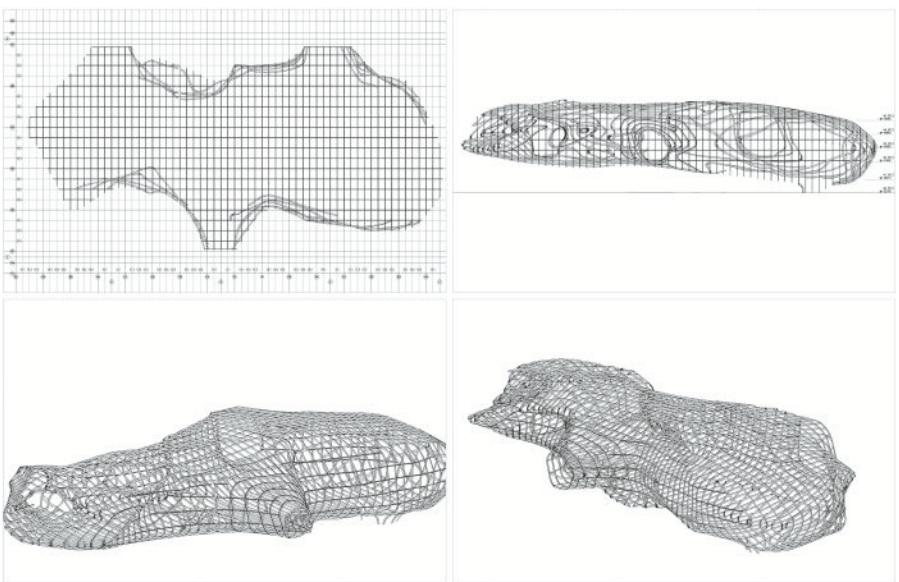
The detail is relational in the sense that it is a close-up and hence not necessarily an objective, physical or material thing. It can be a personal (accidental or intentional), experiential, perceptual, ephemeral, immaterial, subjective, arbitrary or random event, phenomenon or selection, with little or no factual or empirical basis in nature or reality. It is also scalar in a relative, proportional sense in the way an interior is a detail of an architecture, an architecture of a city, a landscape of a galaxy. We can find two contrasting architectural sets of meanings of these forms of the word 'detail'. One suggests a positive architectural strength in control, thoroughness, exactness, resolution, plausibility, precision, depth, exhaustiveness, focus, craft, subtlety, prosperity, abundance, concentration, specificity, meticulousness, accuracy, rigour, scrupulousness, care, diligence, richness, intensity, intimacy, completeness, comprehensiveness, fullness and extensiveness. The other implies more negative architectural weaknesses in myopia, fetishism, pettiness, pedantry, sybaritics, excess, mess, decadence, immorality, neurosis and the small-minded over-attention to the marginal, trivial, banal, pointless and the over-designed. Simplified as 'detail for detail's/detailing's sake', these latter meanings evoke the problems of 19th-century hedonic/epicurean aestheticism.

**Dan Grayber, Cavity Mechanism, 2013**
Architectural details can be autonomous or relational, functional or aesthetic details of spatial engineering as fine art, or all of these and more. Grayber's highly engineered and specific structural and tectonic details are of architecture's fundamental dreams and concepts.

The Aleph's diameter was probably little more than an inch, but all space was there, actual and undiminished. Each thing (a mirror's face, let us say) was infinite things, since I distinctly saw it from every angle of the universe … and I felt dizzy and wept, for my eyes had seen that secret and conjectured object whose name is common to all men but which no man has looked upon – the unimaginable universe.

— From Jorge Luis Borges, 'The Aleph', 1949[3]

**Massimiliano Fuksas Architetto, EUR Congress Centre, Rome, 2014**
*below and previous spread*: Technical construction detail drawings of the monumental cloud/nuvola showing the overall structural primary steelwork details.



## Undetailed and Misdetailed Histories and Theories of Details

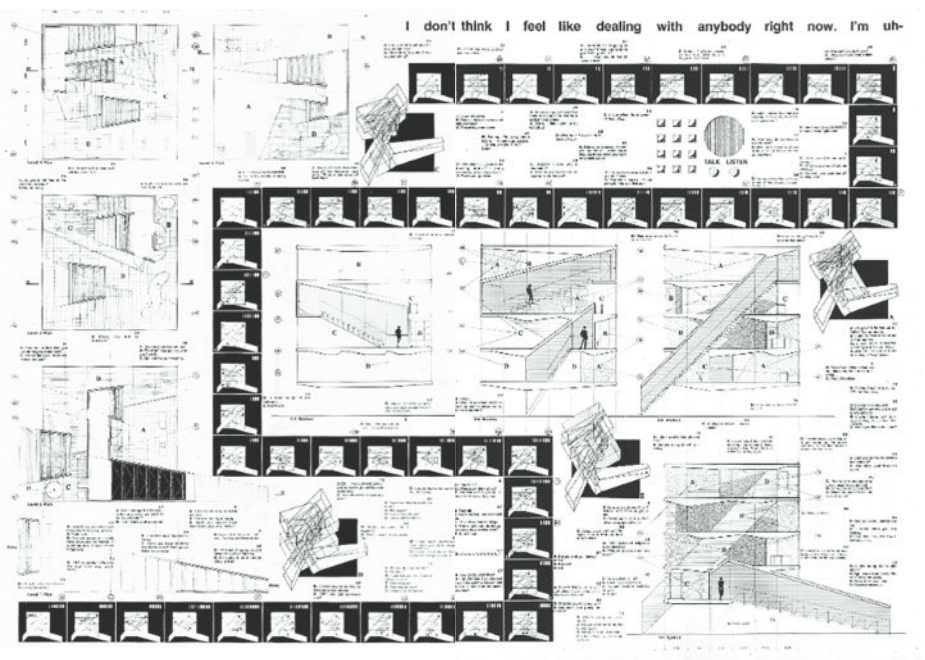
Different periods, styles, movements, architects and architectural theories have distinguished and privileged different sets of details in various hierarchies, principles and types. Despite their differences, all are united in fixing the detail under one over-arching, ontological and metaphysical relationship. The architectural discourse of the detail has always been, and is still, largely overshadowed by the ancient Aristotelian theory of the 'whole being greater than the sum of its parts'. This theory, marginally developed by Georg Wilhelm Friedrich Hegel (1770–1831),[4] grants theoretical priority to the total and unified 'whole' (the building) rather than the 'parts' (details).

Another key historical and theoretical distinction around the architectural detail has been not just that of its qualities or relationship to the whole, but of the quantities of details. This latter point has often split architects and architecture theory between the poles of maximalism and minimalism. Architectural styles and theories have cycled and swung repeatedly between those supporting less or no detail (and generally more rather than less reduction, abstraction, suppression, universality, continuity, unity, clarity, simplicity, coherence, purity, honesty, terseness and homogeneity),[5] and those supporting more detail (and generally more rather than less expression, articulation, eclecticism, ad hoc, variety, complexity, disjunction, specificity and heterogeneity). In the 15th century, Leon Battista Alberti (1404–72) in his *De Re Aedificatoria (On the Art of Building)* (1443–52) cleverly formulated the question of the detail as the problem of the equilibrium of the right amounts and sorts of details in relation to the whole.[6]

Some have used other kinds of architectural theories and principles to sidestep the detail, reducing it to a secondary side effect or prioritising other concepts. This reduces the detail, associating and circumscribing it to a superficial, cosmetic appendage to a design, a byproduct accessory to other less obvious drivers, factors and actors in architecture (like building regulations and laws, hygiene and sustainability). Others have focused on details in the more moral, ethical and political facets of space, design and construction.

The detail has also at times been theoretically ignored or simply taken for granted. Neither architect nor theorist has bothered to devote a theoretical book entirely or explicitly to the subject of the histories or theories of the architectural design detail before the late 20th century, apart from Edward Ford (see his article in this issue on pp 26–35) in his two volumes of *The Details of Modern Architecture* (1990–4).[7] This is odd, because the detail itself (as a sketch, diagram, drawing or photograph) is often to be found among the images within architectural publications,[8] treatises and pattern books. Increasingly from the 1600s onwards, architectural education and the study of architecture focused on drawing the detail and on collection/s of isolated, decontextualised architectural details.[9]

The most obviously hysterical thing about architectural details is that they are always killing and saving lives all around the world. Carlo Scarpa, perhaps the archetypal architectural detailer of the 20th century, died after slipping on a staircase. Criminology, jurisprudence (particularly through forensics),[10] film and fiction can literally hang on the performance or malfunctioning of architectural details. Accordingly, like a theoretical argument an entire building can, like an Archimedes



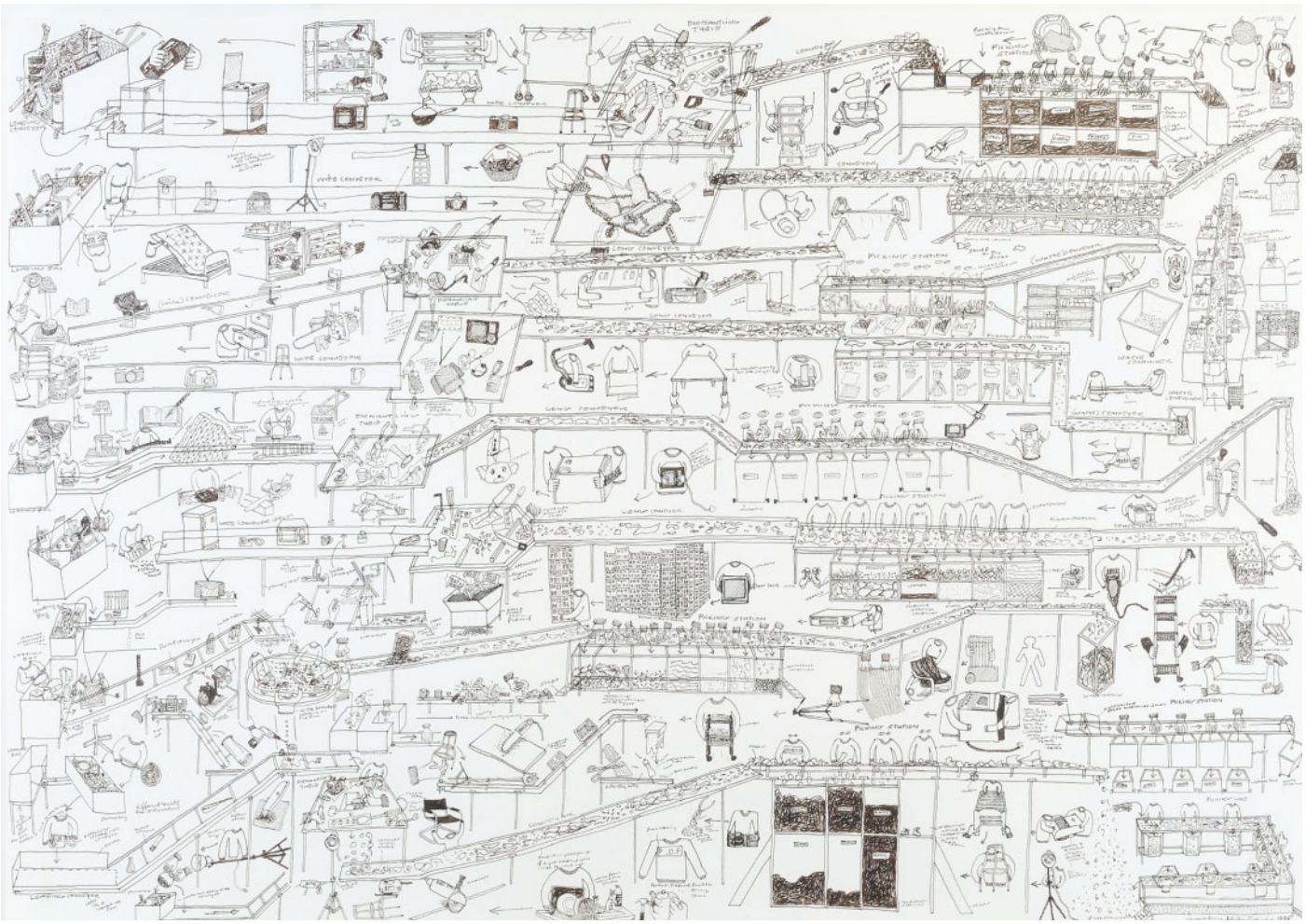

**Taeg Nishimoto, Plot(Ted) House 3, 2001**
Nishimoto subverts the conventions and media of technical, construction and shop detail drawings, which are spectacularly synthesised into a design that maximises the ceaseless deliquescent collisions and congestion of the details of the domestic.

lever, pivot on the fulcrum or crux of the detail. Legal and other regulatory, contractual and quality details mean that failed details (as one or more critical defects, errors, mistakes or snags) can catastrophically destroy a design. Many of these crucial kinds of details, like those of building services (MEP, HVAC, data etc) are generally flagrantly and flamboyantly stylised and mannered into the high-tech, or ignored, delegated or hidden by architects (if they are still under their control). Architectural details also accrue unavoidably from time, weathering, use, material imperfections and contractor substitutions. Detail happens.

This discrepancy in the detail in terms of its status and value, in its relegation as secondary and of less meaning than other aspects of architecture, is also institutionalised in the processes and hierarchies of architectural offices and individual design projects. The misplacement and subordination of the detail is a historical constant that persists into the present. This 'undetailing' and 'misdetailing' is partly a confusion between the relative scale and size of the detail (in relation to the whole) and the power or significance of the architectural effect of the detail in relation to the whole. Despite all of this, the detail was fated for greater fortunes.

## The 20th-Century Detail Revolution

Even the most detail-oriented architects of the previous century made these errors in mistheorising the possibilities of the detail. Today, though exhibitions, publications and websites include architectural details, their treatment of the detail is often partial, lacks innovation and is uncritical. One exception to this situation is the German *DETAIL* magazine (and its related proprietary series of books), which since 1961 has led this market. UK architectural design journals have been largely silent on the issue of the detail,[11] and only Edward Ford has researched the topic substantially. His more recent *The Architectural Detail* (2011) remains the definitive theorisation of the modern architectural detail.[12]

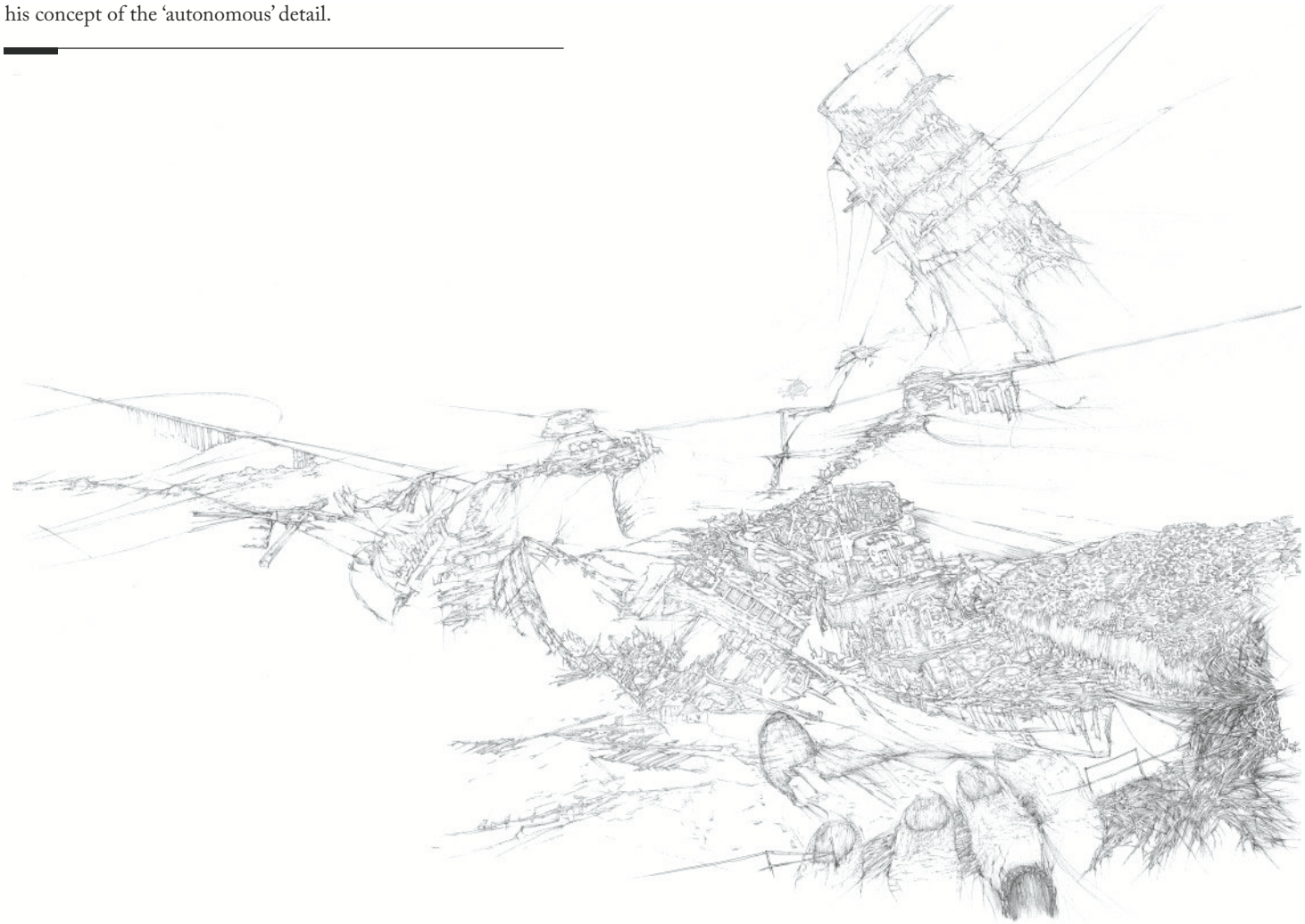


**Michael Landy, Break Down, Oxford Street, London, 2001**
As in this project for Artangel, the future details of architecture will require the creative recycling of the details of architecture that we do not want or need in the most aesthetic and intelligent ways.

In 1919, the manifesto of the Work Council for Art in Berlin (directed by Walter Gropius, César Klein and Adolf Behne) referred to 'freedom over detail',[13] and in the 21st century Edward Ford has argued for the 'autonomous' detail as one of the most significant details in contemporary architecture.[14] Ford theorises the alternative ways in which architects in the 20th century sought to redefine the relationship of the detail to the whole building. He juxtaposes Eduardo Souto de Moura (purposely added detail 'errors') with Eric Owen Moss (whose details were 'both reinforcing and contradictory'). In articulating how the 'empathic', 'exceptional', 'non-conforming', 'heretical', and 'dissonant' details may work as 'counter-themes' to critically and originally 'distance', 'disconnect' from, 'ignore' and 'deny' in relation to the whole building, he illuminates 'the ambiguous, the missing, the over-designed, those that break rules … the sculptural detail'.[15] The details may be 'foreign', 'illogical, disjointed, and irregular for no apparent reason', and might 'actively work against it [the whole building], proposing alternative attitudes' and multiplying possible interpretations both of details and of the whole design.[16]

These notions of the detail are mostly consistent with some Post-structuralist, Deconstructivist and Postmodern theories, but Ford is at his most original and compelling in emphasising the 'mediating', 'articulate/articulating', 'subversive' and 'animate' in his concept of the 'autonomous' detail.

In the 20th century, more bottom-up detailing methodologies were developed around techniques such as collage, montage, bricolage, chaos, disjunction, randomness, absence, subtraction, juxtaposition, chance, de/re-contextualisation, fragmentation and formlessness. The detail had begun to swerve into newly reordered part-to-whole relations. Architects like those associated with the High-Tech, the Metabolists, Cedric Price, Archigram, Gordon Pask, Nicholas Negroponte and Ralph Erskine developed unique approaches to the detail related to component-driven, modular, services-based, flexible, field-based, dynamic, process-based, interactive and participative design-driven detailing. Virtual and digital architecture theories and new media, technologies, materials and techniques further eroded the concepts and values around these senescent details, fixated on the more top-down, universal, rigid hierarchies of parts. Transparent, scientific, objective, mechanical, finished, consistent and unified whole works of architecture have been considered to be the inevitable results of the old top-down, totalising, classical and standard theories of the detail.



## Future Details of Architecture

'Assemblage' as a technique and theory has come to characterise the new and partly alien-species 21st-century details. Though assemblage was mentioned by Yakov Chernikhov in 1931[17] in relation to detail-to-whole relationships, it was only theoretically developed in the last decades of the previous century by Gilles Deleuze and Félix Guattari in their *A Thousand Plateaus* (1988).[18] Their theories of the assemblage swarmed around generative and nomadic diagrams of flocks, folds, packs, patterns, parasites and textiles. These field-type, rhizome and bodies-without-organs kinds of assemblages expanded the supposed powers and spectrums of the detail. Complexity and chaos theories and theories of emergence and self-organisation from the sciences found common conceptual grounds for recent and original theories of the detail within wider network, social and systems theories (such as those of Jürgen Habermas, Niklas Luhmann, Manuel De Landa, Bruno Latour, Jane Bennett and Peter Sloterdijk). These innovative kinds of minute and invisible details became associated with new phenomena, and also sometimes referred to as 'formless'; they include folds, cells, cellular automata, pleats, pliancies, seamlessness, gradients, branches, rhizomes, holograms, fractals, blobs, knots, textiles, fields, bubbles, foams, threads, (point) clouds, nodes, swarms/flocks, shells and monocoques.

At the turn of the millennium, a new generation of architects had implicitly and indirectly theorised, designed and built with some of these new, more 'assemblage' details. New technologies, techniques, materials and media emerged as well as a seemingly ceaseless stream of new devices and their details related to new architectural and urban typologies and programmes that a new generation of detail-hypersensitive architects had begun researching and designing with.[19]

The largest and littlest scales and types of details have now become increasingly high-definition, high-resolution and zoomable as well as more precisely designable and controllable by the architect and the inhabitant. Details are now the super-details (massive quantities and qualities), hyper-real (ultra-realistic), info-details (massively digital, virtual or augmented reality or otherwise informationalised), infra-details (invisible/intangible/immaterial details) of architecture. These include nano-details, biogenetic/genetically engineered and neurological and cognitive details of space. The detail has now become more minutely designed, valuable and powerful than we previously imagined. This is also one reason why architectural patents, often of architectural details, have become more prevalent and extensively used in the past decade, with designers like Rem Koolhaas filing multiple versions and coining the phrase 'No Money, No Detail' (or in other details: #@®©™=/£₿€$¥). In the previous centuries, architectural details at the visible, human and product level were the most powerful. Now the most miniscule, immaterial and invisible architectural details can do the most architectural work and have the greatest architectural effects.

Other fields such as biology, computing, information sciences, interaction design, materials sciences, new media, literature and fine art have all made notable contributions to the exploding spectrum of architectural details over the past two decades. Architects like Michael Hansmeyer, for example in his Digital Grotesque (2013–14), which is on the front and back covers of this issue, are using state-of-the-art voxeljet multi-material 3D rapid prototypers that can control transparency, colour, form and materiality to unprecedented levels of accuracy and resolution. Such precision allows for increased detailing, creating new effects and different forms and aesthetic systems at different distances or 'zooms'. This innovative super-polyvalent zoomability for the architectural detail (unknown in previous centuries and having only previously existed in fiction) is now a reality. Across every dimension of architecture, the detail is becoming exponentially detailed.

**Adam Bell, The Restored Commonwealth Club, St James's, London, Unit 16, Department of Architecture and Landscape, University of Greenwich, 2014**
*opposite*: Using AR entire interiors, architectures, landscapes and their key events are generated through a detail. The ashtray conceals the reassembling ruins of the British Empire, forming a new Empire/Commonwealth. In the bottom right, Margaret Thatcher's grip on an ashtray animates a simulation of the sinking of the General Belgrano during the Falklands War in 1982.

**Michael Hansmeyer and Benjamin Dillenburger, Digital Grotesque, FRAC Centre, Orléans, France, 2013**
*top*: The first solid, human-scale enclosed structure printed from sandgrains using a multi-material, multicolour and multi-transparency 3D voxeljet rapid prototyper. Architects can now achieve resolution up to 1/10 millimetre. The new voxeljet printers create a structural sandstone-like material and the highest detail resolution architectural prints ever fabricated. None of the 260 million surfaces are identical in this 30-billion-voxel space at the threshold of the human perception of architectural detail and resolution. As such, its details create the effect of zoomable polyvalence, with many different meanings and affects contingent on scale and subject.

**Chris Kelly, Rubix, Unit 15, Department of Architecture and Landscape, University of Greenwich, 2013**
Terrestrial anti-gravity architectural details will kinetically reassemble existing architectural and urban details into an even more powerfully detailed and perpetual space-time machine.

Architectural details are now also being designed as multifunctional, informational and networked relations and memes (as in parametrics and generative design) between details, and as the potentials, forces and becoming spaces, absences and associations between architectural and non-architectural entities. So wireless connections and transmissions between architectural details are also now details of architecture and require design. Details are now more like foci of intangible and immaterial effects, singularities and attractors, intensities, concentrations and compressions of forces, or as Robert Somol and Sarah Whiting describe, details of atmospheres, ambiences, moods and affects.[20] The details of architecture are then also scripts, softwares, interfaces, diagrams, microchips, files, smart phones, bytes, pixels, voxels, encryptions, IP addresses, servers, social networks, Google, websites and RFIDs. They can be found on the Internet, in the periodic table and in quantum states. They are 0 and 1, + and –, C, G, T, A and DNA, protein foldings, fibre-optic cables, algorithms, sensors, actuators, LEDs, city-sized and 3D/interactive screens, GPS devices and recombinatory spatial design systems of the above. These are now becoming so ubiquitous and pervasive in architecture and space that, through new technologies like computer-aided design and manufacturing (CAD/CAM) and building information modelling (BIM) they have become in many ways essential and inseparable mediators of certain kinds of highly innovative and significant contemporary architectures. These 21st-century details exist and are reorganising and reassembling themselves and their spatial hierarchies in the process. But there is also a danger here.

We are already seeing the most advanced architectural technologies being used to spawn architectures with plagues of the dullest, degenerate and deceptively zombified kinds of digital and default drone-clone details. BIM, parametrics and versioning now have 'terratocarcinogenic' powers to proliferate and metastasise a myopically repressive, relentless and neo-Malthusian tsunami of dumb, trivial and periodic or generically aperiodic architectures. We do not need more of these predictable, homogeneous and monotonous identikit-replicant and completely inhuman details, however bottom-up, top-down or mongrel-mixed of these they are detailed.

This is not just a virtual problem. Coupled with the growing numbers of rapid prototypers, fabbers and other digital 3D/4D printers, such default digital detailing makes the neo-junkspace dystopias and morass-continents of the dross detail in such visions as Chuck Palahniuk's *Damned* (2011) and *Doomed* (2013) seem uncomfortably close. Paradoxically, then, it is at exactly the moment of possible zenith or epiphany for the detail, when we are most creatively empowered and freed-up by technologies from the most mundane forms of details/detailing, that we and architecture itself become most vulnerable to the crisis of the most horrific forms of malignant, aug-(de)mented and psychotic details and detailing.

Notwithstanding this, we could be at an event-horizon of the architectural detail in which the detail itself will exceed all of these precedents to become something almost entirely alien, other and unknown. At this unique convergence (or conscilience) of digital, artificial intelligence (AI), nano-, genetic-, neuro/cognitive and other technologies, a number of emerging technologies and technological phenomena are now poised to produce a brand new class of details. Big-data (the pattern-recognition algorithmic data mining of building and urban information systems and databanks), everyday augmented-reality technologies (such as Google Glass), BIM (the BIM models of real buildings are details of those built architectures), social media (architecture and buildings that exist partly as presences on the Internet), the Internet of Things, tracking and recording technologies, fibre-optic sunlight transmission and storage, crowd-sourcing (participative, real-time design), kinetic and animate architectures (for example, ONL and Greg Lynn), biomimetics and robotics (Boston Dynamics, FESTO and the MIT Media Lab), bioprinting and biopixels (PET and F/MIR scanning), 8K megapixel hyper-reality screens and cameras, foglets and smart dust, programmable matter, physics simulations and engines, non-invasive building sensing and imaging technologies like FLIR and PMI, quantum-computers, quantum levitation, tunnelling and entanglement, maglev and other electromagnetic architectures (where architectural materials do not touch), stem cells, Dyson spheres, synthetic hormones, cold fusion, dark matter, dark energy technologies, anti-gravity and graviton-controlled spaces – these are only the start. Though some may be doubtful red herrings and Macguffins, some may not. And the detail will become the eye of the needle through which all design must pass to become a new architecture. In the 20th century, forms and functions followed details. In the 21st century, the formless and functions follow details.

The future details of architecture may well be biological-machinic hybrids or post-human architectural details.[21] Being so dependent on such infinitely detailing and redetailing details, architectural wholes take on a different status in relation to the details that will be perpetually producing and reproducing them. We can therefore now articulate a new theory of future architectural details in which they are continuously assembling/reassembling architectures. This describes a new 'part-to-whole' relation for the architectural detail. We can speculatively and prospectively extend the logic of this argument to explain the detail as surpassing the generative, intelligent, autogenic, self-evolving, multifunctional, interactive and enigmatically permutational powers of humans, their cities and societies. In terms of its architectural powers, then, the architectural detail will be greater than the sum of all possible wholes generated or possible from it. The reassembling details of the 20th century are destined to morph into the sublime, transcendental (in Kant's sense of the word) details of 21st-century architecture. This is the ultimate limit and might of the architectural detail in relation to a whole architecture. It frees us to reformulate a more imperative, less critically problematic and practical reconceptualisation of the design of architectural details as the prerogative of 'detail for innovative detail's sake'. Self-evolving formlessnesses and functions will follow a detail.

**Jason Hopkins, Abhominal: Post-Human Structures III, 2012**
*above:* The future details of architecture will be post-human and bio-machinically engineered.

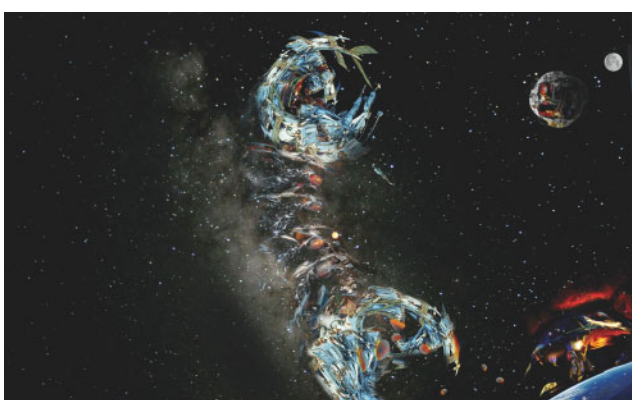
**Phil Watson and Jonathan Morris, Outerspace, Project Persephone, AVATAR research group, University of Greenwich, 2013**

Architectural details are now also being designed as multifunctional, informational and networked relations and memes (as in parametrics and generative design) between details, and as the potentials, forces and becoming spaces, absences and associations between architectural and non-architectural entities.

## Reassembling Future Details of Architecture

This issue of AD collectively engages with the most crucial dimensions of the futures of the architectural detail. Expert Edward Ford (pp 26–35) gives us an authoritative and evolutionary vista across the histories, philosophies and theories of the detail, while Christian Schittich (pp 36–43) offers us *the* professional, up-to-the-present editorial scan on the contemporary built, technical and high-performance engineering finished detail. From the core of avant-garde digital design, Patrik Schumacher (pp 44–51), Ben van Berkel (pp 52–61) and Hernan Diaz Alonso (pp 62–7) reveal their most recent, advanced and presciently detailed projects. With brilliance and foresight in their more forensic and instrumental focus on recent architectural details embodied and operationalised in experimental design case studies and research projects, are Peter Macapia (pp 68–77), Philippe Rahm (pp 78–85), Carlo Ratti and Matthew Claudel (pp 86–91), David Benjamin, Danil Nagy and Carlos Olguin (pp 98–103), Dennis R Shelden (pp 92–7) and Skylar Tibbits together with his collaborative team led from the Massachusetts Institute of Technology (MIT) (pp 104–11). Finally, towards the end of the issue, from the meridian at the University of Greenwich in London, Rachel Armstrong (pp 112–17), Neil Spiller (pp 118–27) and Nic Clear (pp 128–33) turn up the warp drive on three sublimely projective speculations. As proleptic and oracular as they are panoramic and oceanic, they after-burn across the full spectrum of future details that portend the architectural imagination of the 21st century. Expectant, anticipatory and foretelling, these are the future details of architecture, but not as we knew them.

This is a new 21st-century diagram of historical, theoretical and futurological research that points to both an ancient yet now more relevant cynosure: that the most significant, powerful and innovative details of architecture will be the humans and post-humans, eternally and synergistically re-detailing and being infinitely re-detailed through the details of our future spaces. Almost nothing is becoming almost everything. These are the *Future Details of Architecture*, as they reassemble the times. AD



**Phil Watson and Jonathan Morris, Outerspace, Project Persephone, AVATAR research group, University of Greenwich, 2013**
Space dust, space junk and other details of matter and materials are collected over time and reassembled into the ever-evolving details of architectures, cities and planets of the future.

**Notes**

1. See Edward R Ford, *The Architectural Detail*, Princeton Architectural Press (Princeton, NJ), 2011, p 226.
2. Stanford-Binet Dictionary of Etymology: www.etymonline.com/index.php?term=detail&allowed_in_frame=0.
3. Published in English in Jorge Luis Borges, *The Aleph and Other Stories 1933–1969*, EP Dutton (New York), 1970. © 1968, 1969, 1970 by Emecé Editores SA and Norman Thomas di Giovanni; Copyright 1970 by Jorge Luis Borges and Norman Thomas di Giovanni. Reproduced by permission of Penguin Books Ltd. © 1998 by Penguin Putnam Inc. Used by permission of Viking Penguin, a division of Penguin Group (USA) LLC.
4. GWF Hegel, *Aesthetics: Lectures on Fine Art*, trans TM Knox, Clarendon Press (Oxford), 1975.
5. Such as Paul Rudolph, Rem Koolhaas, Greg Lynn and Ben van Berkel.
6. Leon Battista Alberti, *De Re Aedificatoria*, 1443–52. See Leon Battista Alberti, *De re aedificatoria: On the Art of Building in Ten Books*, trans Joseph Rykwert, Robert Tavernor and Neil Leach, MIT Press (Cambridge, MA), 1988.
7. Edward R Ford, *The Details of Modern Architecture, Vols I and II*, MIT Press (Cambridge, MA and London), 1990–4.
8. See Mary A Vance, *Architectural Details: A Bibliography*, Vance Bibliographies, 1981.
9. For example, Wunderkammers, John Soane's house, and the 19th- and early 20th-century cast courts of museums and schools of architecture (central to the École des Beaux-Arts in Paris).
10. Eyal Weizman, *Forensic Architecture: Notes from Fields and Forums*, Hatje Cantz, 2012 and Sam Kubba, *Architectural Forensics*, McGraw-Hill Professional (New York), 2008.
11. Exceptions are the *Architects' Journal*, which in 1996 (Vol 204, No 17) focused on T*he Details of Modern Architecture*, and a special issue of *Praxis*, which in 2000 (Vol 1, No 1) titled its launch issue *Detail: Specificity in Architecture*.
12. Ford, *The Architectural Detail*, op cit.
13. Ulrich Conrads, *Programmes and Manifestoes on 20th-Century Architecture*, MIT Press (Cambridge, MA), 1970, p 44.
14. Ford, *The Architectural Detail*, op cit, Chapter 6: 'The Autonomous Detail'.
15. Ibid, p 89.
16. Ibid, pp 236–61.
17. Catherine Cooke, *Chernikhov: Fantasy and Construction*, AD Profile, 54, 1984.
18. Gilles Deleuze and Félix Guattari, *A Thousand Plateaus*, Athlone Press (London), 1988.
19. Included among those who are not featured in this issue are Daniel Libeskind, Herzog & de Meuron, Will Alsop, Jean Nouvel, Santiago Calatrava, Lars Spuybroek, Junya Ishigami, SANAA, Toyo Ito, Kengo Kuma, Sou Fujimoto, Nicholas Negroponte, William Mitchell, Eric Owen Moss, Diller Scofidio + Renfro, ONL, Mark Goulthorpe, Greg Lynn, Enric Ruiz-Geli, Marc Fornes, Gramazio & Kohler, Neri Oxman and Evan Douglis.
20. Robert Somol and Sarah Whiting, 'Notes around the Doppler Effect and Other Moods of Modernism', *Perspecta*, 33, 2002, pp 72–7.
21. Ariane Lourie Harrison, *Architectural Theories of the Environment: Posthuman Territory*, Routledge (London), 2012.

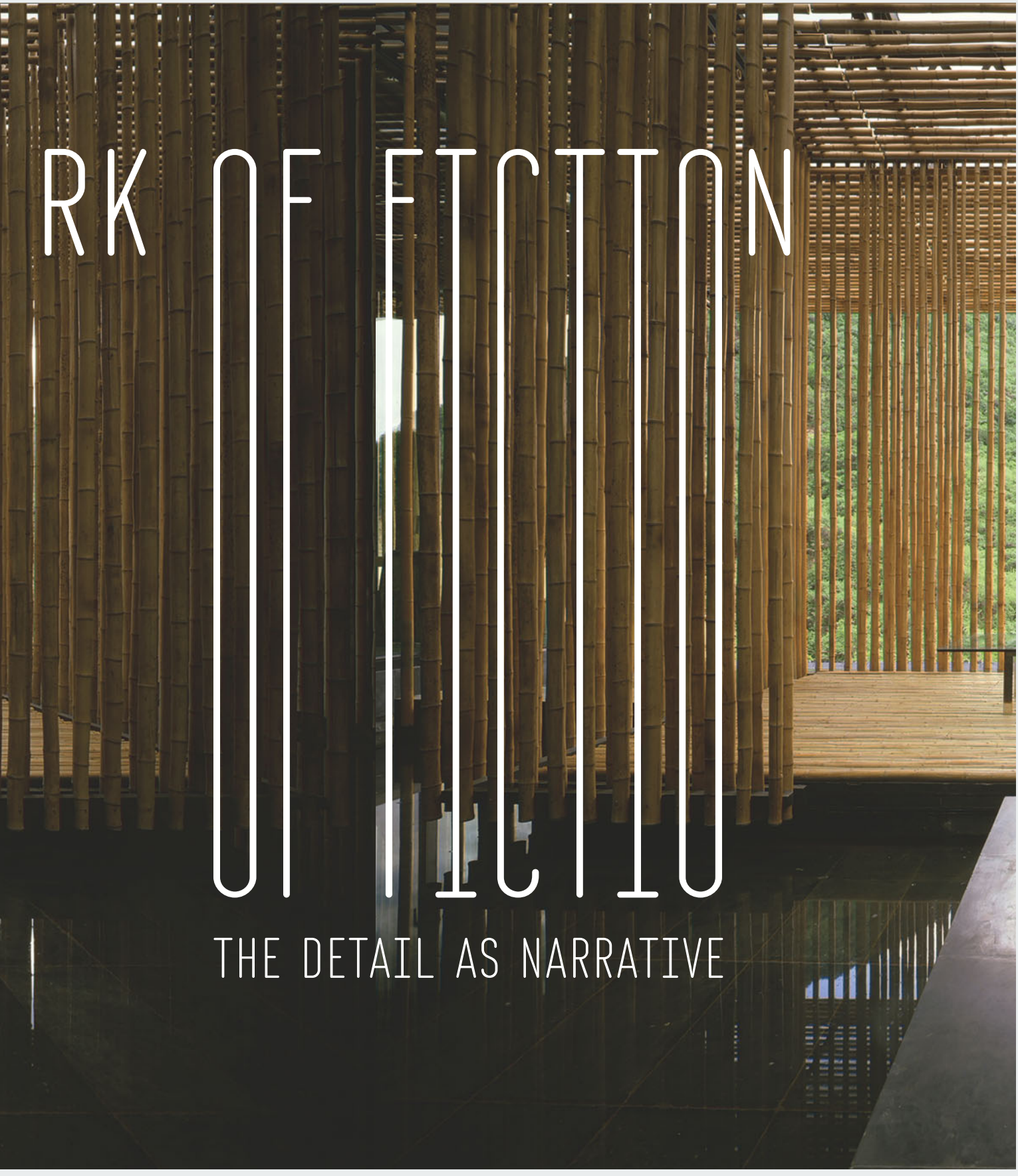
Edward Ford

# THE GRAND WO

Kengo Kuma & Associates, Great Wall (Bamboo) House, Beijing, 2003

# RK OF FICTION

## THE DETAIL AS NARRATIVE



The steel and wood frame is barely visible behind the bamboo screens.

**OMA, Kunsthal, Rotterdam, 1992**

According to OMA's Rem Koolhaas, the condition of the joining of a wall and roof or any other surface should not create a third element, a 'detail', but in reality the stone wall has a small cap.

A practising architect and Professor at the University of Virginia School of Architecture, **Edward Ford** is the leading expert on the architectural detail and the author of three seminal books on the subject. Here Ford explains that, though the decision 'to abstract or to articulate' architecture 'may be largely subconscious', it is never 'arbitrary'. For 'in the well-designed building, it is done in the service of the creation of a larger narrative, a unity of vision'.

> Architecture .. is a grand work of fiction based on 'truth in the details.'
> — Kunio Maekawa, 1985[1]

I am not certain what Rem Koolhaas meant when he said that 'how the roof meets the wall can never be an idea'.[2] Given the context in which he said it, defending the detailing of his Rotterdam Kunsthal (1992) by criticising Carlo Scarpa, I think he meant that the junction should not be an object, that the meeting of these two parts should not generate a third. Much of the detailing in the Kunsthal could be called collaged, or rather a collision. Two surfaces of different materials simply run into one another. To Koolhaas, the modern joint is 'clamped, folded, glued, or fused'. He wrote: 'detailing … is now a transient coupling waiting to be undone, unscrewed, a temporary embrace with a high possibility of separation … the abrupt end of a system'.[3]

To many the desirability or absence of this third object, trim, is a discussion of no consequence, or at least soon will be. Lorenzo Marasso writes:

> Building form is traditionally understood from the assembly of discreet building components. Today digital variability … disengages form from the economy of repetition and makes smooth curvilinear composite structures feasible. We may consider form to be a composite whole and no longer the sum of parts.[4]

One could write a long, rather technical article examining and probably questioning this premise, and asking whether the 'composite whole', if technologically possible, is technologically desirable given thermal expansion, post-construction shrinkage and expansion, and contemporary practices of open-jointed, porous screen walls. Likewise, one can argue that Koolhaas's joint as collision is no less the product of carefully orchestrated planning and execution than an Ionic volute, requiring a good deal of concealed, albeit less precise, construction. It is no less a detail than the cornice of Scarpa's Bank of Verona (1993). This, however, is not the issue.

This discussion, like many over the detail, centres on the issue of joints, but the critical question is not whether the composite whole, the material collision or articulated trim, as universal solutions, are technologically superior, but where and when they are good architecture. To answer this question we must recognise some realities and realise that we are asking the wrong question.

### Articulation

Detailing, as an act of design, requires the selective presentation of information. In any building a myriad of technical problems must be solved. In most cases there are multiple solutions. Some details solve the problem in a way that leaves no visible result, inside or out. These details are abstract. Others will solve the problem in a way that is visible, creating an architectural element in the process. These are articulated details. Given the overwhelming number of such conditions in the modern building, most detailing is abstract and involves the suppression and not the expression of information. Only a small number of details can be articulated, and only a small fraction of solutions can be demonstrated.

What type of information the articulated detail articulates varies – the hidden gutter versus the exposed one, the hidden window frame versus the oversized one – and the information presented may be exaggerated, simplified, misleading or fictitious – and often is. Although the process of deciding to abstract or to articulate may be largely subconscious, it is not arbitrary. In the well-designed building, it is done in the service of the creation of a larger narrative, a unity of vision. As a result the typical modern building is a constructional reality wrapped with a constructional narrative that simplifies, omits, exaggerates and often deceives. Many of these narratives are about concealing rather than describing programme, construction or even spatial layout, but many, and arguably the most important, articulate some aspect of the building's assembly, details that tell us about the building's construction and how we perceive the relation of the part to the whole. The exteriors of Kengo Kuma's buildings are narratives of wood, thatch, stone and other traditional materials, but they clad

**Greene and Greene, Gamble House, Pasadena, California, 1908**

The structure in the foreground is a handcrafted, heavy timber frame, while the shingles in the background cover a standard wood stud wall of the day.

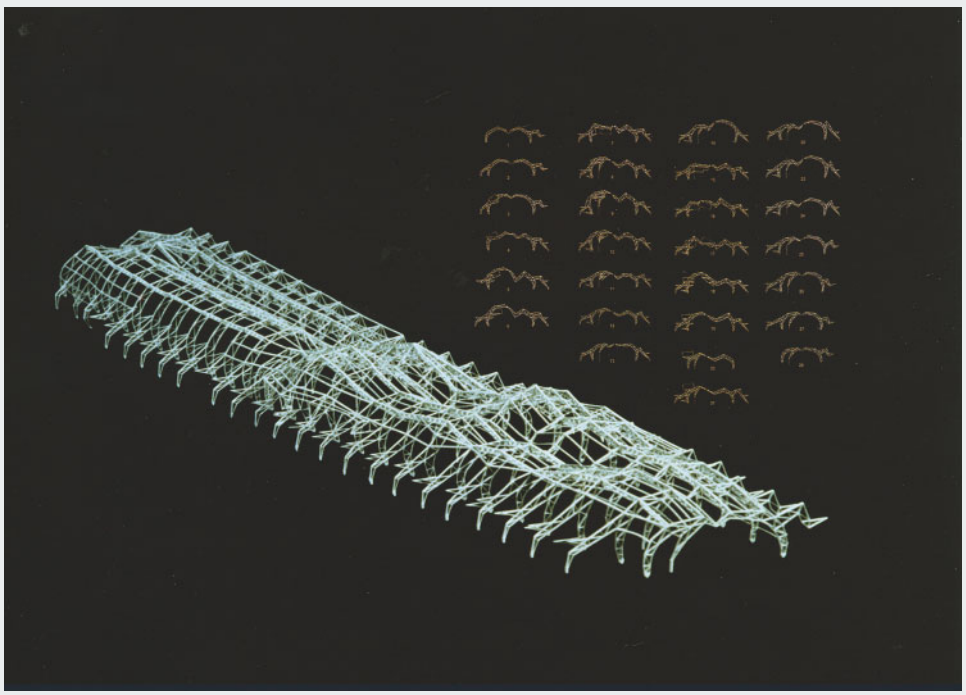
frames of heavy timber, concrete or steel that are sometimes completely and often partially concealed. The frame is the constructional reality, but it is clad by narrative outer layers of context and tradition.

Modernist narratives of the architectural detail focus on the appearance of consistency, on making the detail conform to the totality. This is understandable. Architecture abounds with buildings with strong concepts compromised by poorly chosen or poorly executed details – the transparent wall that appears opaque, the curved wall that is crudely segmented, the Minimalist volume that bristles with oversized trim. But often the motivation for this consistency goes well beyond visual coherence to an insistence on details that are not only formally, but also ideologically, consistent. This invariably is some version of a technological zeitgeist, the spirit of the times. The process is simple. The architect seizes on a technological development – mass production or digital fabrication – then creates a series of architectural forms based on projecting this trend towards its complete realisation. To Le Corbusier, the zeitgeist of mass production demanded standardisation, so the typical sliding windows of the Villa at Garches (1927), the Villa Savoye (1931) and the Swiss pavilion (1930) are a single, identical size. To Reiser + Umemoto, the zeitgeist of digital fabrication demanded that all parts be unique, so all the frames of their Yokohama Port Terminal competition entry (1995) are different. Other areas of focus have included energy self-reliance (for example, the Solar Decathlon House competitions sponsored by the US Department of Energy), material efficiency (Buckminster Fuller) and off-the-shelf products (Charles and Ray Eames), but each forms the basis for deciding what details are articulated and which are abstracted.

The fact that these predictions have proved partially and often completely wrong seems to matter not at all, since the results provide a compelling if invariably inaccurate set of images. The executed buildings that result from this process are consistent only in appearance, masking more complex realities, and the technological trends on which they are based rarely develop into the anticipated systems. Think of Greene and Greene's Gamble House (1908), a crafted timber exterior interlocking with an internal normative platform frame. The reality of modern construction is almost universally the hybrid: the steel house filled with wood, the digitally fabricated ceiling in the conventionally framed box.

These narratives of detail are inevitable in a building of any size, and technology alone will not determine their nature. The problem is that we fail to recognise their existence and in many cases we are debating a representation rather than a reality of construction.

Modernist narratives of the architectural detail focus on the appearance of consistency, on making the detail conform to the totality.



**Reiser + Umemoto, Yokohama Port Terminal, Yokohama, Japan, 1995**

Digital fabrication makes it possible to make each transverse truss unique.

**Herzog & de Meuron, MH de Young Memorial Museum, San Francisco, 2005**

A seamless wrapper of long, perforated, apparently jointless copper panels covers a normative construction of steel framing, metal studs and gypsum board.

## Two Examples

Herzog & de Meuron's MH de Young Memorial Museum in San Francisco (2005) and Tod Williams Billie Tsien's Barnes Foundation in Philadelphia (2012) appear to be very different buildings, constructed in very different ways and embodying very different narratives of joinery. One has highly articulated joints; the joints of the other are continuous.

The design of both facades draws on patterns that are contextual. The pattern of perforations of the de Young wall is based on a pixelated photograph of the nearby tree canopy, translated into a fine grain of circular perforations and dimples. The wall is composed of long, horizontal copper panels and appears continuous, and the pattern of dimples and holes for the most part ignore the joint locations. While both facades are panellised, the joints of the de Young are suppressed and are barely perceptible from a distance.

The character of the Barnes wall can be attributed to the architects' desire to make reference to the walls of the older classical home of the institution's collection, but they also wanted to express both the joints of the wall and its porosity. The pattern of stone joints in the Barnes is also contextual in a way, drawn from Kente cloth, a textile from Ghana reminiscent of the African art in the collection. The wall is formed of limestone panels in sizes that vary from roughly 0.5 x 3.5 metres to 3.5 x 3.5 metres (2 x 12 to 12 x 12 feet), each composed of six to 10 smaller stone panels. While the larger panels are separated by wide stainless-steel strips or recessed windows, the joints of the smaller panels can be seen only because of the veining of the stone. At one point exposed bronze clips were considered to demonstrate the connection of the 5-centimetre (2-inch) stone veneer to the steel behind. In contrast to the de Young, the joints of the Barnes are articulated in dramatic fashion, but in a selective way.

An examination of the totality of these two assemblies reveals a different story. Their similarities greatly outnumber the differences. Both use steel frames hidden between the exterior and interior finish layers. Both have suspended gypsum-board ceilings, above which are located the major services: mechanical, lighting and wiring. Both have exterior surfaces supported by tightly spaced steel studs. Both have precisely constructed exterior finish surfaces connected to imprecisely constructed interior frames with fasteners, hidden from view, that allow for adjustment. The differences in the technical narratives are limited to the outermost 5 centimetres (12 inches) of each building's volume. The reality is that in terms of joining methodologies, both are hybrids of joint types, mixing the separated, the articulated and the continuous. While there are different philosophies of detailing and joinery in these two buildings they are confined to a thin surface layer and represent modes of detailing very different from the normative construction of what is enclosed. They are constructional narratives, not realities.

So if the detail is not the result of technological inevitability, how is it determined? How does one decide what to articulate, and particularly, how does one decide when to articulate a joint?

## Three Axioms of the Detail

### THE GOOD JOINT IS OFTEN THE IMPERFECT ONE.

Advocates of the digital millennium speak with the assumption that the perfect is its own reward. The seamless and the jointless are virtuous in themselves. Writers of the Arts and Crafts era, William Morris or Mackay Hugh Baillie Scott, spoke with the assumption that irregularity is virtuous. The joint was the embodiment of labour, the evidence that others had had a role in the making – the trace of the hand. The slight irregularity and the mark of the tool were the evidence. Imperfection has other types and other virtues. There are the imperfections of nature – the weathered surface, the wood joint that creeps open due to shrinkage, the concrete joint that cracks with curing. These add character and the sense of material reality to abstraction, but more importantly they enable buildings to embody labour and history as much as they embody capital. The perfect joint leads only to abstraction and distancing from reality, the imperfect one to a consciousness of craft and material. The modern structure may not bear the trace of the hand, but it may show the marks of its realisation.

### THE AFFIRMATION OF SCALE IS A NECESSARY CONDITION FOR ARCHITECTURAL UNDERSTANDING, REQUIRING THE PERCEPTION OF PARTS, THAT IS, ITS JOINTS.

Peter Rice, engineer of the Centre Pompidou (Paris, 1977), said of the building that the joint was the essence of the solution, arguing that it was the quality of joints that gave traditional buildings their 'friendly feel'.[5] To the Japanese Metabolists of the 1960s, such as Kisho Kurakawa, the individual parts of their structures did not just accommodate the individuals that made up a society; they were its concrete representation. These are arguments for the articulation of parts, the ability to perceive a building as an assembly, in large part because it makes possible an association between the building and ourselves.

The perfect joint leads only to abstraction and distancing from reality, the imperfect one to a consciousness of craft and material. The modern structure may not bear the trace of the hand, but it may show the marks of its realisation.

**Tod Williams Billie Tsien Architects, Barnes Foundation, Philadelphia, 2012**

Wide, deeply recessed panels of stainless steel are set between the joints of some, but not all of the limestone panels to highlight the joinery and the porosity of the wall.

THE UNDERSTANDING OF A BUILDING REQUIRES NOT JUST AN UNDERSTANDING OF THE PARTS, BUT OF THE FORCES BETWEEN THEM.

The historian Paul Frankl saw the semi-autonomous parts of buildings like Donato Bramante's Tempietto (Rome, 1502) as not just friendly, but 'happy'. He writes: 'They confirm the naïve belief that it could be given to a man to determine his own fate, to move effortlessly through this world, to be unoppressed, to be in control of himself without effort.' This is a result of their highly articulated partiality, that they are 'active, independent and generators of forces'.[6]

Beyond the issue of scale is the issue of empathy, the concept that we understand a building in relation to ourselves not just in terms of the size of the parts, but also in terms of internal forces between them. Heinrich Wölfflin wrote: 'Physical forms possess a character only because we ourselves possess a body. ... We read our own image into all phenomenon,'[7] meaning that the act of self-projection involves not just size, but weight, and this is a necessary condition for architectural understanding. The appreciation of a building involves not just identifying a building, not just seeing a building, but feeling it, and the method for doing this is the animation of the joints. The Ionic volute is an example of sculptural animation, but Modernism abounds with structural animations, from HP Berlage to Renzo Piano, in which the movement is quite real.

## Narratives and Realities

That building technology has become exponentially more sophisticated in the last 100 years is undeniable, but the assumption that these developments are driving the development of style is at best an oversimplification. When such influence does occur it is often metaphorical and literally superficial, as in the two cases described above.

One could write an illuminating history of Modernism based on which of the three types of detailing narrative described above – the articulated element, the seamless joint or the material collision – was dominant at any given point. Even a cursory glance at the 20th century reveals that while architecture underwent the greatest technical transformation in its history, at this time the prevalence of one or the other of these approaches to the joint occurred in a fairly cyclical way: continuous (Anatole de Baudot's concrete structures); animated joints (Victor Horta and early Berlage); continuous (late Berlage and Frank Lloyd Wright); fragmented (Constructivism, Gerrit Rietveld); continuous again (the International Style); articulated (High Tech); fragmented again (Deconstruction); and continuous again (parametric design). Technical explanations for these changes fall apart rather rapidly under examination. While technologically enabled they were not technologically driven. They are the result of aesthetic preference, not technical progress. We ended the century with a radically changed technology. Stylistically we are back where we started.

But in any case we are discussing the narrative of the building, not the reality. The true technological revolutions are taking place below the surface, blithely indifferent to our unified visions of the technological future. The normative condition is the hybrid and while its specifics may change, the particular technology of a building will always be in a transitional condition.

If architecture is to embody ideas and values it must transcend architectural understandings based on glib association, superficial 'readings' and pop symbolism. A richer palette of details would make possible a wider range of architectural understandings independent of some overriding, oversimplified, inaccurate narrative of the technological present. Should we not pursue deeper understandings that come by perceiving that a building is an assembly of forces in a precarious equilibrium, constructed of parts of a comprehensible size, crafted by both the hand and the machine?

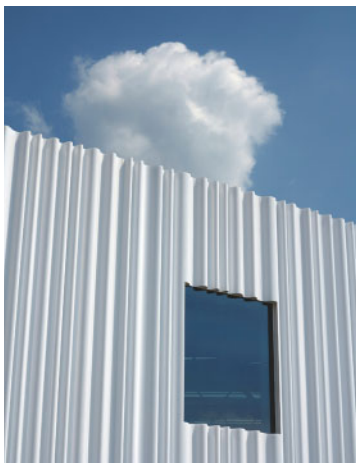
As to the future of the detail, it is, in its technical specifics, a mystery, but as to whether it is to be Koolhaas's collision, Scarpa's ornament or simply nonexistent, whether it is to be continuous or fragmented, precise or irregular, sophisticated or archaic, organic or mechanical, we can say with a certainty that at various times it will be all of these. The future of detail is not a technical question any more than is the future of architecture. ⍙

**Notes**

1. Kunio Maekawa, *Kosumosu tu hoho (Cosmos and Method)*, Kenchiko Sekkei Jimusho (Tokyo), 1985, pp 209–10. Quoted in Fumihiko Maki, *Nurturing Dreams*, MIT Press (Cambridge, MA), 2008, p 200.
2. See Arie Graafland and Jasper de Haan, 'A Conversation with Rem Koolhaas', *The Critical Landscape*, 010 Publishers (Rotterdam), 1997, p 229.
3. Rem Koolhaas, *Content*, Taschen (Cologne), 2004, p 164.
4. Greg Lynn and Mark Foster Gage (eds), *Composites, Surfaces, and Software: High Performance Architecture*, Yale School of Architecture (New Haven, CT), 2010, p 56.
5. Peter Rice, *An Engineer Imagines*, Artemis (London), 1994, p 26.
6. Paul Frankl, *Principles of Architectural History*, MIT Press (Cambridge, MA), 1968, p 130.
7. See Harry Mallgrave and Eleftherios Ikonomou, *Empathy, Form and Space*, Getty Publications (Santa Monica, CA), 1994, p 151.

Christian Schittich

# DETAILS AROUND THE



**SANAA, Vitra production hall, Weil am Rhein, Germany, 2013**

The design was based on the dominating idea of enclosing the round 20,000-square-metre (215,000-square-foot) hall with a facade, giving the impression of a white curtain blowing gently in the wind.

# CORNER

Emanating an ethereal aura, the five softly shimmering rectangular structures of the Louvre Lens merge with the landscape and sky of Northern France. The incredibly light and delicate structures, created in 2012 by the founders of SANAA, Kazuyo Sejima and Ryue Nishizawa, for this outpost of the Paris museum in the Pas-de-Calais, do not aim to achieve any kind of sculptural self-representation. The sense of dematerialisation continues inside the Galerie du Temps, with no apparent supports disrupting a length of 120 metres (390 feet).

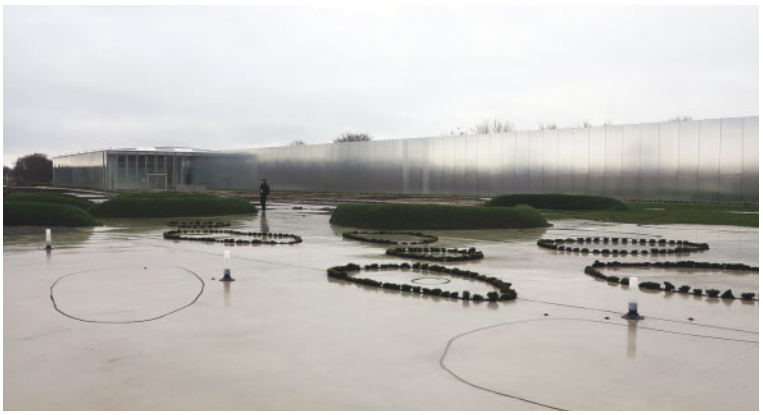
Although the architecture seems to be very simple with an absolute reduction of all visible details, it involved complex constructions and intricate planning processes. While the entire world is talking about SANAA's great achievement reflected by this architectural favourite, it is less known that the planning of detailing was carried out by Bollinger Grohmann Ingenieure based in Frankfurt.

The structural and facade engineers had to interpret the idea of delicate transparency and dematerialisation as an architectural concept, and express it in a European planning context in line with locally applicable standards such as the strict French energy savings regulation. This illustrates very aptly that details are often created through interaction of the different parties involved – in more complicated structures at least – and that every detail fulfils an aesthetic function in addition to its technical components. After all, details play a vital role in establishing the overall character and appearance of a building, and the (further) development of details is often driven by design concepts.

Munich-based *DETAIL* magazine is an internationally renowned architecture and construction publication, uniquely focused on the architectural detail. Here, its Editor-in-Chief **Christian Schittich** acknowledges how design concepts provide the key driver for architectural detailing, as details combine to provide the overall character or aesthetic quality of a building. However, how might an increasingly diverse design team collaborate on the execution of high-quality detailing when designing large-scale schemes?

**Details: Essential to All**

This interplay between aesthetics and construction has also been the philosophy of *DETAIL* magazine for over 50 years. Its concept of demonstrating the connection between design and technology using outstanding examples has made it one of the most popular architectural publications in the world, read in more than 80 countries and found in most leading offices in the field. Although the scope of specifications may be very broad, it is essential that all architects concern themselves intensively with details. Detail solutions developed internationally vary tremendously due to differences in climate, requirements and the resulting diversity of laws, regulations and technical standards. In Central Europe, building envelope details are often complicated by the continuous insulation layer specified for prevention of thermal bridges, while construction in Southern Europe is comparatively easier – although energy standards are becoming more stringent there too. Thermal protection and prevention of thermal bridges is much less important in Japan, allowing a more delicate style of design. The typical Minimalism of Japanese architects such as Sejima and Nishizawa, Sou Fujimoto or Junya Ishigami that is admired all over the world is not least a result of this fact.



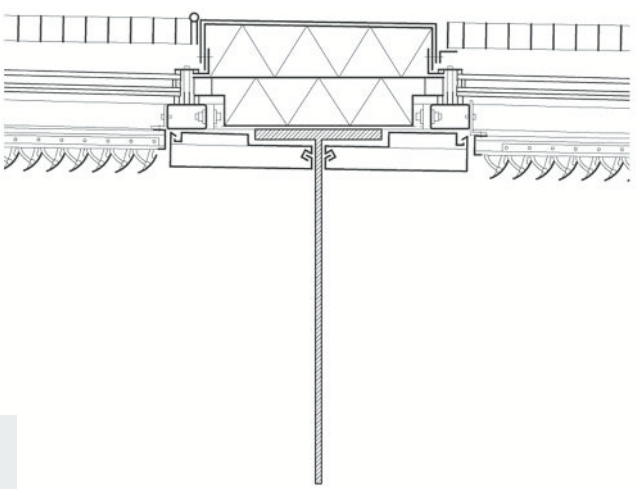
**SANAA, Louvre Lens, Lens, France, 2012**

*top*: The detail planning was carried out by Bollinger Grohmann Ingenieure who had to interpret the architects` idea of delicate transparency and dematerialisation as an architectural concept, and express it in a European planning context, in line with locally applicable standards.

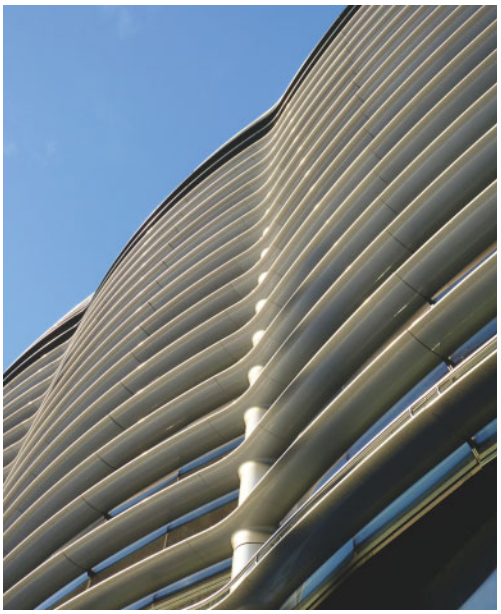
An international specialist magazine such as *DETAIL* naturally has to explore such issues. Of course details typical for Spain cannot simply be transferred to Germany, and solutions developed for Central Europe are often much too complicated and expensive for many other parts of the world. A carefully compiled selection of architectural examples relating to a particular topic is therefore presented in each issue: a variety of building types, different construction methods, small and large structures, simple and complicated ones, as well as solutions originating from various countries. Most architects can identify with the smaller and simpler projects reflecting their own tasks, while the 'icons' created by the stars of the architectural world (often serving as guiding models) also have to be represented.

Architects in charge of smaller and simpler projects often handle most of the detail planning and drawings required themselves. Depending on the particular culture, solutions may even be developed while talking to craftsmen on the building site, without any retrospective documentation.

As far as larger projects are concerned, however, hardly any detail is the work of an individual or built exclusively in accordance with the plans of the architects. Modern constructions and building processes are far too complex for that. The more heterogeneous and differentiated that building methods become, the larger the group of persons involved, typically including the design originators, specialised engineers, as well as manufacturers and executing firms. Especially when services such as facade construction are very complicated, the final execution drawings are generally produced by the relevant experts. This interaction makes work on the magazine exciting and complex: extensive research is often required to be able to present the details of a structure in a standard image and as coherent building sections – editors spend a significant proportion of their working time on this.



*above and right*: The sense of dematerialisation continues inside the Galerie du Temps, with no apparent supports disrupting a length of 120 metres (390 feet). The cloth-like planar beams proposed by the architects were to consist solely of an upright web; they initially appeared unfeasible, but were in the end realised in a manner quite close to the architects' design. The system only became practicable by integrating the secondary structure, which supports the glass panels, in such a manner that it becomes primary structure.



**Details in the Future**

From design to manufacture, today's digital tools offer possibilities that were inconceivable some years ago. They permit increasingly unusual formal ideas and ever more complicated geometries to be planned, visualised with true-to-detail animations, and realised (in an ideal case) with reasonable production expenditure. However, the much acclaimed digital chain rarely works perfectly as yet. Almost all of the spectacular computer-generated projects admired in professional circles could only be realised with enormous expenditure. It often appears as though computer-aided design (CAD) is miles ahead of manufacturing, as illustrated, for instance, by the parametrically generated louvres made of glass-fibre-reinforced polymer wrapping Foster + Partners' Walbrook building in the City of London (2010), which were finally made by hand in an Eastern European low-wage country. Nevertheless, computer-aided design and manufacturing promise unexpected possibilities for detail development, for example in facilitating the cost-effective manufacture of small series of individual connection elements.

**Foster + Partners, The Walbrook, London, 2010**

*above top*: The computer-generated louvres wrapping the building are made of glass-fibre-reinforced polymer that was laminated by hand in Eastern Europe.

**Atelier Bow-Wow, BMW Guggenheim Lab, New York, 2011**

*above bottom*: The mobile temporary pavilion demonstrates that new building materials may not necessarily lead directly to new details. It is the very first building structure of extruded carbon-fibre composite, but all of its connections follow classical steel construction.

Also, the use of new materials and construction methods almost inevitably leads to new details, illustrated, for instance, by membrane construction (such as the trussed skylights in GMP's Olympic Stadium in Kiev, Ukraine (2012)). One should not, however, overestimate the potential advances associated with the utilisation of new building materials as these may not necessarily lead directly to innovative details. An example from antiquity is the Greek temple for which the details from wood construction were copied in stone. The same phenomenon can be observed in very recent examples such as the mobile BMW Guggenheim Lab by Atelier Bow-Wow erected in New York, Berlin and Mumbai during 2011 and 2012. A structural skeleton of extruded carbon-fibre composite was used for the very first time here. This strong and expensive lightweight construction material was previously mainly reserved for sports equipment, yet no new cutting-edge detail solutions were developed in this case: all connections follow classical steel construction for reasons of approval by the authorities.

Furthermore, detail solutions have a huge impact on the character of a building, which also makes them subject to fashions and trends. In the era of high-tech architecture during the 1970s and 1980s, connection nodes were designed as angle sections, tensioning ropes and clearly visible bolt and screw connections as manifestations of a technical look, while smooth and flush connections have regained popularity today. SANAA's Louvre in Lens is an extreme example of this.

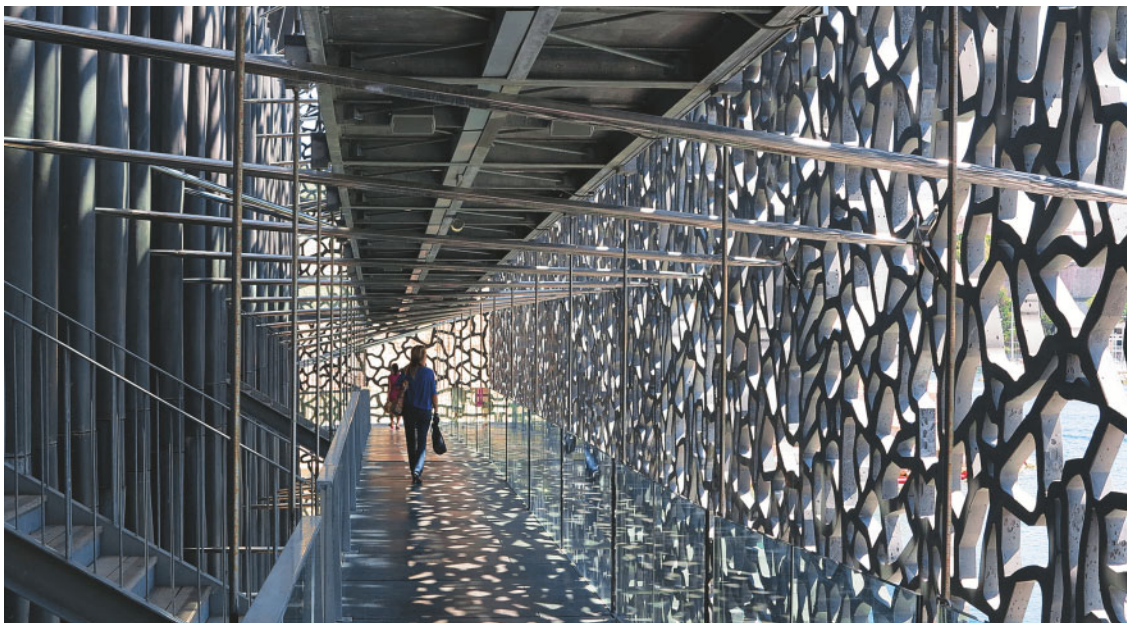
In the era of high-tech architecture during the 1970s and 1980s, connection nodes were designed as angle sections, tensioning ropes and clearly visible bolt and screw connections as manifestations of a technical look, while smooth and flush connections have regained popularity today.

**GMP, Olympic Stadium, Kiev, Ukraine, 2012**

Membrane construction is a field that shows how new materials and construction methods can create innovative details, such as the trussed skylights in the new roof of the Olympic Stadium in Kiev which was conceived in close collaboration with engineers Schlaich Bergermann & Partner (sbp).

The ultimate driving force behind further development of detail solutions can in fact generally be attributed to aesthetic concepts. This is clearly illustrated by innovative silicone-based glued connections in the production hall of the furniture manufacturer Vitra in Weil am Rhein, Germany, completed by SANAA a few months ago. This was based on the dominating idea of enclosing the round 20,000-square-metre (215,000-square-foot) hall with a (continuous circumferential) facade, giving the impression of a white curtain blowing gently in the wind. Any fastening element visible from the outside would have destroyed this powerful image. At the same time, a flexible way of retaining the wave-shaped acrylic glass panels (given their wave shape in a specially developed oven) had to be found that allowed for changes in length in the material caused by temperature fluctuations. What looks so simple now also required a lot of effort and many series of experiments, in addition to all the necessary tests specified by the German regulations for approval.

The Musée des Civilisations de l'Europe et de la Méditerranée (MuCEM) by Rudy Ricciotti is – not only from an architectural point of view – one of the more interesting buildings in Marseille related to the European Capital of Culture 2013. It is the first building utilising ultra-high-performance concrete (UHPC) on a large scale. This applies to the organically shaped tree supports of the structure (as well as the two filigree) connection bridges, and especially to the net-shaped diaphanous structure with which the architect encloses the building in order to create a fascinating interplay of light and shade in addition to the required sun protection. Fixation of the innovative facade elements, however, is by means of 'frog fingers', a traditional method borrowed from glass construction.

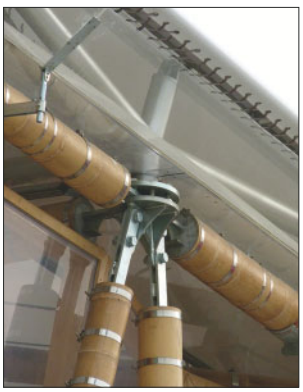


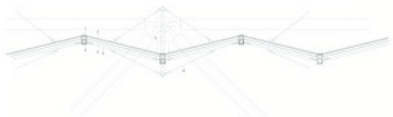
**Rudy Ricciotti, Musée des Civilisations de l'Europe et de la Méditerranée (MuCEM), Marseille, France, 2013**

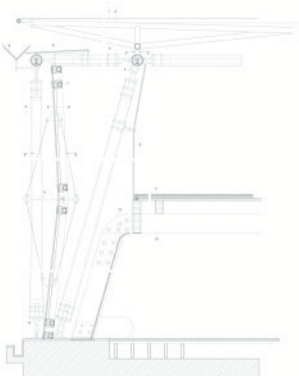
The museum is the first building utilising ultra-high-performance concrete (UHPC) on a large scale. The fixation of the net-shaped diaphanous facade elements, however, is by means of 'frog fingers', a traditional method borrowed from glass construction.

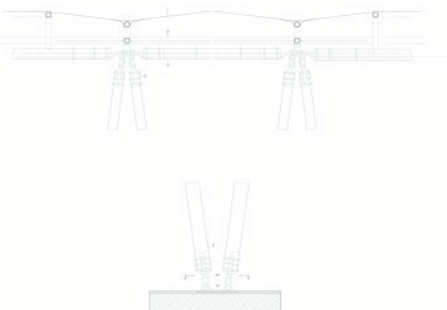
This is in direct contrast to the approach adopted by the Munich-based artist Markus Heinsdorff in the design of the German-Chinese House for the Expo 2010 in Shanghai. Together with engineers Schlaich Bergermann & Partner (sbp) and executing firms, Heinsdorff developed entirely novel connecting elements to be able to make contemporary use of a material that has been used for construction for thousands of years: bamboo. Stainless-steel flange fittings were cemented into the ends of up to 4.3-metre (14-foot) long giant bamboo canes. Through special holes, these could be attached to round connection nodes using threaded bolts.

The resulting flexible construction permits the necessary distribution of forces and offers an element of reuse. This example in particular demonstrates that innovative detail solutions are not necessarily developed in association with complex constructions. In fact, increasingly simple solutions may well be in demand in the future. ▵



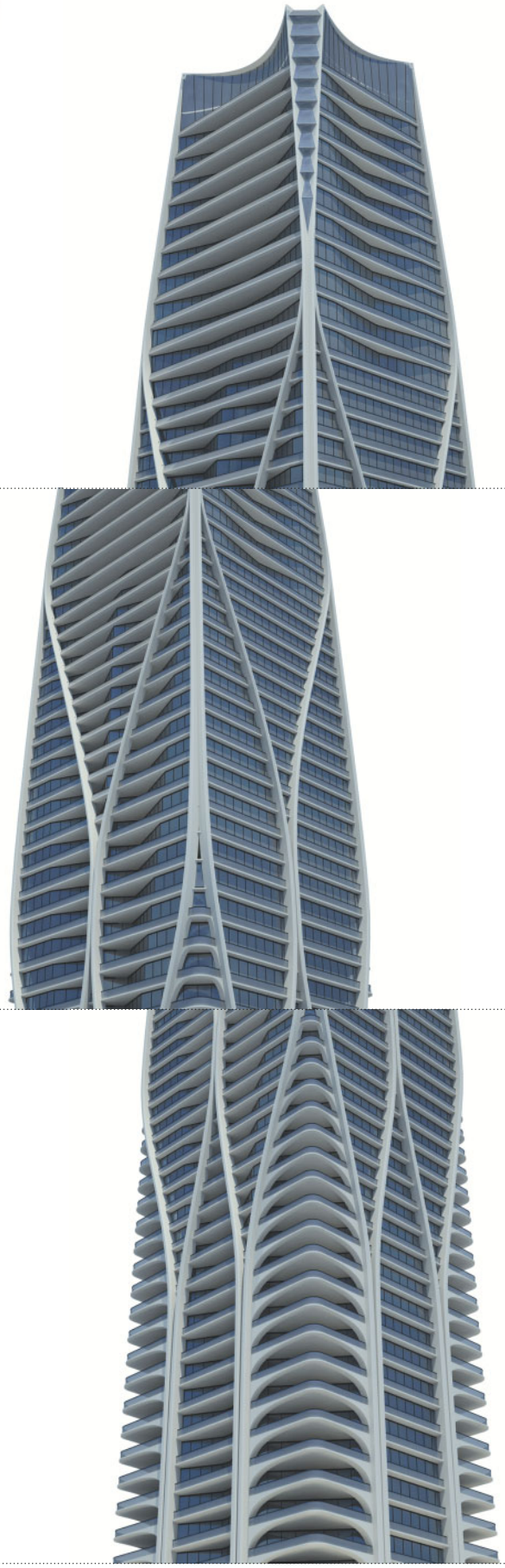






**Markus Heinsdorff, German-Chinese House, Shanghai Expo 2010**

Together with the sbp engineers the architect/artist developed entirely novel connecting elements in order to make contemporary use of the ancient building material bamboo. The resulting flexible construction permits the necessary distribution of forces and offers an element of reuse.



Zaha Hadid Architects, 1000 Museum residential tower, Miami, Florida, 2013

# TECTONIC ARTICULATION

## MAKING ENGINEERING LOGICS SPEAK

As much of the responsibility of a building's physical design and fabrication has increasingly shifted to engineers, spatial communication has remained the sole and significant preserve of architects. **Patrik Schumacher**, Partner at Zaha Hadid Architects (ZHA), explains how tectonic articulation through architectural design – the selection and employment of technically engineered forms and details – enables the legible enunciation of a building's forms in a manner that has the potential to give it social meaning and expression.

Detailing has been the last preserve of architects, until this responsibility too has shifted to engineering specialists, in this case facade engineers (who are by now also responsible for the constructional detailing of all interior constructions). This poses the question of what the role of architects is if it has finally been set free from all concerns with the physical constitution of the built environment.

Architecture has finally been isolated and distilled from all engineering admixtures. The question of its societal role must therefore be approached via its demarcation from engineering, which rests on the distinction of the built environment's social functioning from its technical functioning.[1] While the technical functioning considers the physical integrity, fabrication constraints, on-site constructability and physical performance of the building in relation to its users, understood as physical-biological bodies, architecture must take into consideration that a building's social function, as an ordering and guiding communicative frame, is functioning via its appearance and legibility.

The core competency of architecture is therefore the task of articulation to communicate the purpose and character of the offered spaces. This core competency – spatial communication – and its underlying distinction of social versus technical functionality, should also guide the architectural discourse on the selection and design of details such as profiles, material textures, tessellations, corners, joints and transitions. Architects remain involved in the design of details, as they are in the design of a building's visible structure and visible environmental devices, for example windows and brise-soleil systems. However, architects are primarily concerned with the visual and tactile appearance of these structures as means of communication.

The complexity of dense urban sites and contemporary briefs requires complex spatial arrangements where many events come into view simultaneously. This dense and diverse offering and the connections between such offerings need to be visually ordered and articulated. This task privileges the use of complex geometries with modulated curvatures and gradient transitions, which in turn leads to the use of algorithms to describe and subdivide such surfaces, and virtual parametric details (associative components) that are self-adapting with respect to their local deployment variables. Such local adaptations are a technical necessity, however their purpose may also be that of visual accentuation. The use of associative modelling in the design of details, and algorithms in the design of tessellation patterns, is therefore not only a matter of technical efficiency, but affords a new nuanced repertoire of articulation that can help with the task of maintaining legibility in the face of an increasing spatial complexity.

Legibility involves two aspects: the perceptual palpability and the semantic-informational charge. Accordingly, the general task of articulation bifurcates into the two specific tasks of phenomenological articulation and semiological articulation.[2] Both need to guide the designer's decision-making process in the context of the proliferating options that emerge from the engineering discourse. Semiological articulation presupposes a successful phenomenological articulation, whereas phenomenological articulation pursues the visual decomposition of the (increasingly complex) urban scene by making the relevant functional units (units of interaction) conspicuous. This concern with the visual decomposition of a complex composition has been the motivation behind Zaha Hadid Architects' work with shell structures, such as the Qingdao Cultural Centre competition entry (2013). Here, the perceptual identification of functional units and their interrelations is facilitated by the use of shells, and the use of convex and concave surfaces with various degrees of curvature gives useful orienting information. Structural form-finding logics disciplines the spatial morphologies in ways that are advantageous for articulation, for elaborating a systematic spatial language. Semiological articulation can then map significant programmatic distinctions onto conspicuous morphological distinctions so that differences make a difference. Tectonic articulation is therefore proposed as the concept for the strategic articulatory utilisation of the morphological differentiations that emerge from the logics of structural, environmental and facade engineering.

**Zaha Hadid Architects, Qingdao Cultural Centre, Qingdao, Shandong Province, China, 2013**
*above and opposite*: Phenomenological articulation: the perceptual identification of functional units and their relations is facilitated by the use of structural shells. Convex bodies, concave spaces and curvilinearity in general are advantageous for the visual decomposition of a complex scene.

## Tectonic Articulation

The relationship between the technical and the articulatory dimension of the built environment leads to the general concept of *tectonics,* here understood as the architectural selection and utilisation of technically motivated engineered forms and details to articulate legibility for the sake of social communication. The history of architecture abounds with examples where architectural elements and features with technical functions become the object of articulatory or ornamental endeavours. However, we need to understand the instrumentality of ornament – we need to grasp ornament not in contrast to performance, but as a special type of communicative performance.

A technically efficient morphology therefore also assumes an articulatory, communicative function. The articulatory integration of the morphological consequences of technical requirements is always the more elegant solution than the attempt to fight and deny them by hiding or obfuscating them. This latter stance would require the invention of additional communicative features because social distinctions desire and require expression. However, the use of initially technically motivated morphological features for the characterisation of spaces is not only more economical, but also leads to a higher level of credibility of the communication because the morphological signifier is already an index rather than a merely arbitrary symbol. So in the terminology of Peirce, tectonic articulation transforms indexical signs into symbolic signs. This process also gives degrees of freedom to the designer in the selection of the indexical features that might be heightened and systematised to become elements of a semiological system of signification.[3]

To pursue tectonic articulation, architects need to guide and orchestrate the engineering investigations and then select the engineering options that most suit their primary task, namely to fulfil the posed social functions via framing spatio-morphological communications. The adaptive differentiation of loadbearing structures as well as the adaptive differentiation of volumes and envelopes according to the building's environmental performance (with respect to its exposure to sun, wind, rain etc) and differentiations that stem from fabrication logics (tessellations, expression of joints) afford many opportunities for differential tectonic articulation. A lawfully differentiated built environment would therefore be much more legible and navigable than the Modernist, isotropic order of repetition.

The development of sophisticated computational design tools within both architecture and engineering disciplines and the construction industry means the scope for nuanced tectonic articulation has much increased. The adaptation of structural morphologies to the force distribution within a structural system offers a fantastic opportunity for architectural articulation. In turn, the more complex architectural orders proposed within contemporary architecture are reflected and potentially accentuated by sophisticated, adaptive structures. The realisation of this potential requires an intensified collaboration between innovative architects, engineers and fabricators. Although there can be no doubt that architecture remains a discourse that is distinct from engineering and construction, close collaboration with these disciplines as well as the acquisition of reliable intuitions about their respective logics are increasingly important conditions for the design of contemporary high-performance built environments. A clear understanding of the distinct agendas and core competencies of architects, engineers and fabricators facilitates their effective collaboration.

**Zaha Hadid Architects, 1000 Museum residential tower, Miami, Florida, 2013**
The structural differentiation of the exoskeleton corresponds to the differentiation of apartment types, and is further accentuated by subtle differences in the articulation of the glazing line in relation to the slabs.

### Semiological Form-to-Function Correlations

The exposure of the primary structure can be very effective in giving an identifiable character and atmosphere to the different spaces within a building. The orchestration of the engineering and design agendas might take the form outlined here. The design process might proceed with the following sequencing of concerns: spatial ordering, technical performance/materialisation and articulation (it is only the second concern where engineering input must be integrated). Here, the materialised organisation, materialised according to the concerns of technical efficiency, produces a certain morphology with a certain appearance. Before adding an additional material layer for the purposes of articulation, it therefore makes sense to investigate whether this technically given material morphology is suited to serving the required articulatory function.

The recent capability of computationally based structural engineering techniques in offering parametric variation and nuanced parametric differentiations of structural systems is congenial with the rule-based approach and the general aesthetic principles of the contemporary style of parametricism. The structural engineering logic of orienting members and adapting member sizes in proportion to stresses can be taken up within an architectural strategy of articulation. The internal ordering of large spaces might be facilitated by the lawful differentiation of the structural system: the different (longitudinal versus transversal) directions of the space might be indicated by the direction of the primary beams, and the centre of a large space might be indicated by the greatest depth of the beams etc. These features might serve as orienting clues within a large, otherwise visually partitioned space (for example, a market hall).

Another example might be the skeleton of a tower that is being expressed on the outside as an exoskeleton. It might be differentiated along the vertical axis, describing a gradient transformation from massive to filigree. This structural logic might be visually accentuated to become perceptually palpable and then systematically correlated with an occupational logic so that the structure's articulation might in turn come to signify the occupational distribution. The sequence of structural changes from massive to filigree might therefore come to signify the programmatic stacking from retail (massive) via workspaces, to residential spaces (filigree). A more simple alignment of the structural differentiation of a tower's exoskeleton with its programmatic differentiation has been achieved in Zaha Hadid Architects' design for the 1000 Museum residential tower in Miami (2013). Here the skeleton thins out from the three-bay structure at the lower part of the tower via a two-bay structure in the middle section to become a single-bay structure at the top. This structural transformation is correlated with the division of the floor plates into three apartments in the lower part, two apartments per floor in the middle section, and single penthouse-style apartments at the top segment of the tower. Through this correspondence the exoskeleton expresses the differentiation and distribution of the programme (apartment types) within.

## Accentuation and Suppression

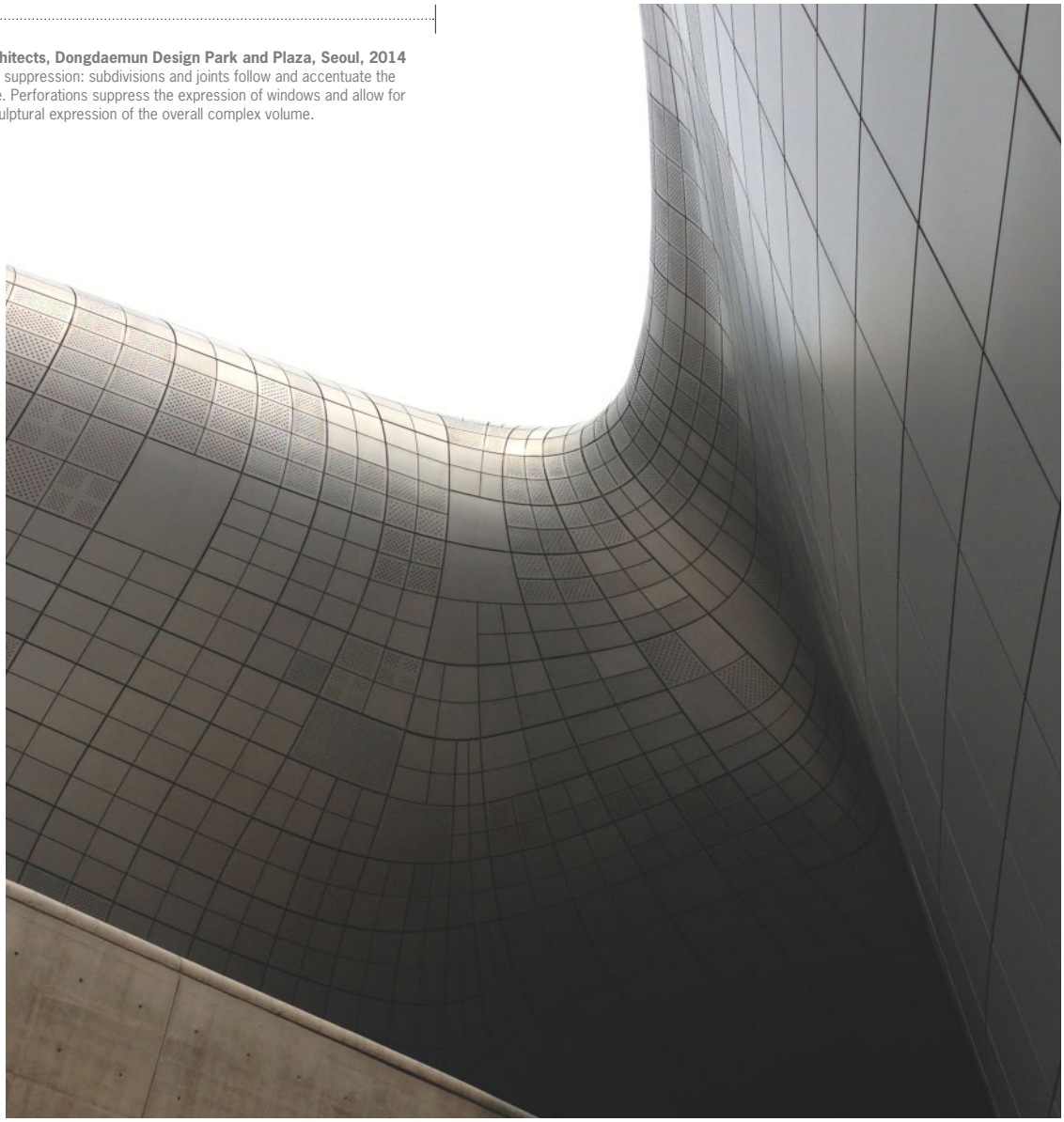
The task of articulation can be understood independently of engineering concerns as that of orienting users by means of expressive morphologies. The specific strategy of tectonic articulation as defined and proposed here is burdening the task of articulation with the constraints of engineering logics. This means that the repertoire and universe of possibilities for designers has been constrained. However, contemporary engineering capabilities have recently expanded to such an extent that there remain sufficient degrees of freedom for designers to exercise their core competency of articulation despite the constraints of tectonic articulation. In particular, as analytic and generative computational engineering tools (physics engines) become more readily available to architects, they are enabled to explore this more disciplined universe of possibility with the eyes and intuitions of a designer, while simultaneously keeping engineering constraints in play.

Designers can explore various engineering logics and morphologies in search of a medium of articulation that allows them to characterise and differentiate the social functions that need to be organised and articulated. This process always involves both the visual accentuation of the selected morphological features as means of expression on the one hand, and the visual suppression of all other technical features on the other. The raw, unedited imposition of pragmatic engineering and fabrication priorities does not deliver legibility. In fact, an unsightly visual chaos is likely to ensue, especially as there are usually multiple engineering concerns that need to be negotiated. Designers must not allow these concerns to agglomerate without aesthetic control and orchestration. Visual order needs to be imposed via a ruthless formalism and aesthetic principles that guide the accentuation and suppression of features. Tectonic articulation implies that the selected formalism has been derived from a selected engineering logic. However, the transformation of the engineering logic into a formalism is necessary to constitute tectonic articulation as architectural strategy.

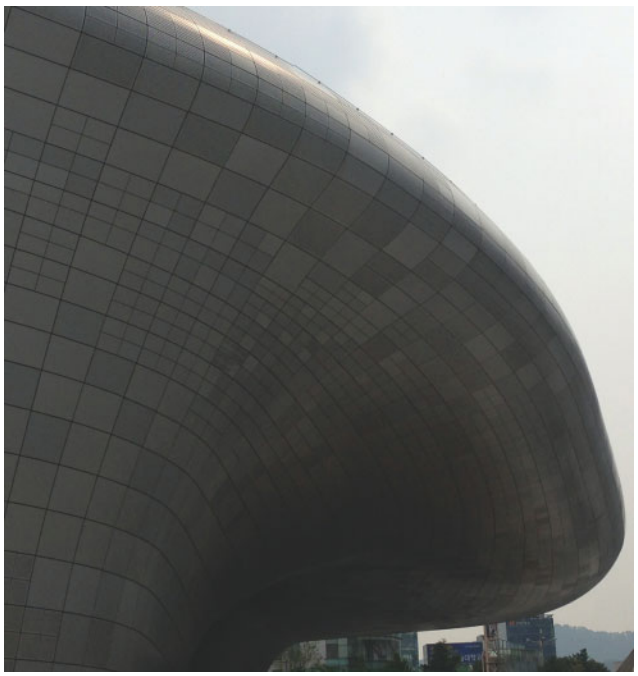
Visual order needs to be imposed via a ruthless formalism and aesthetic principles that guide the accentuation and suppression of features.

The differentiated parametric articulation of the tower structure follows the principles of parametricism. The eloquence of parametric articulation stands out against the mute, monotonous seriality of the Modernist context.

**Zaha Hadid Architects, Dongdaemun Design Park and Plaza, Seoul, 2014**
Accentuation and suppression: subdivisions and joints follow and accentuate the surface curvature. Perforations suppress the expression of windows and allow for the monolithic sculptural expression of the overall complex volume.



The tessellation of the aluminium facade follows a rule (script) that converts the smooth differentiation of degrees of curvature into the (stepped) differentiation of degrees of subdivision.



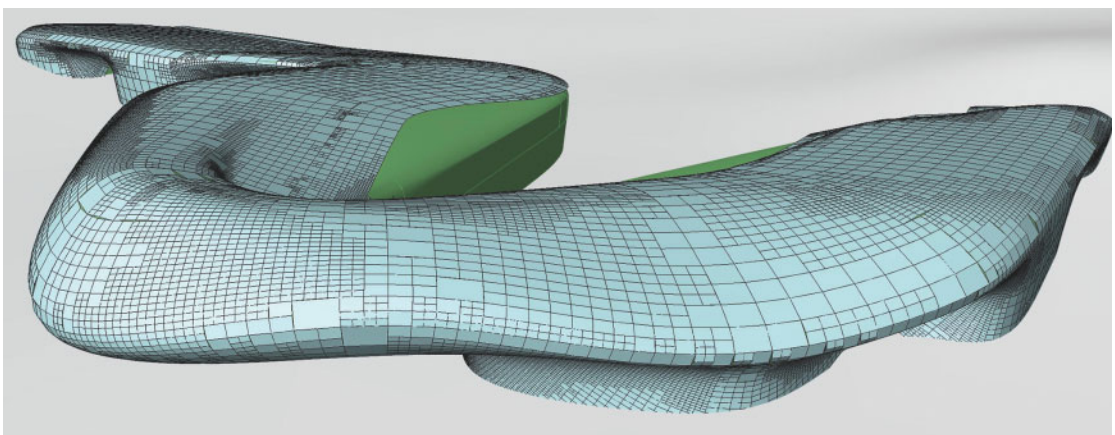
Both accentuation and suppression are at play in Zaha Hadid Architects' facade design for the Dongdaemun Design Park and Plaza in Seoul (2014). The tessellation of the aluminium facade follows a rule (script) that converts the smooth differentiation of degrees of curvature into the (stepped) differentiation of degrees of subdivision. Tighter curvature leads to smaller panels. This makes sense with respect to the material fabrication constraints of sheet metal, even though a reprogrammable mould (pin machine) was used to press the panels into a double-curvature shape. In the areas of tighter curvature the algorithm produces a finer tessellation that made more joints available to fit the panels to the overall curvature. However, beyond this technical rationality the rule-based tessellation strategy delivers a heightened visual plasticity and thus legibility of the building's form. The turning points in the surface are being accentuated by the denser tessellation. The volume's shape becomes perceptually more palpable, also from a distance and under less favourable lighting conditions. The second plasticity enhancing detailing strategy is the utilisation of isocurves as tessellation lines. These curves follow and therefore accentuate the flow of the surface rather than being arbitrarily imposed onto the surface.

Suppression is also at work here. The major spaces of the design centre do not need any daylight, therefore a solid facade is an appropriate response. However, the various ancillary spaces do require windows, and rather than allowing these windows to disrupt the fluidity of the overall form, their existence is radically suppressed by letting the smooth envelope continue uninterrupted across them. The need for light was accommodated by perforating the metal sheets that hide the windows. Moreover, the location of the windows is further dissimulated by avoiding any one-to-one correlations between windows and perforated panels. Instead, the distribution of the perforated panels across the facade has been to some extent randomised, adding to the overall organic expression of the building. The windows would have disrupted the architectural figure and drawn more attention to themselves than their function merits. Cuts within the envelope have been reserved for the entrances, which are thus conspicuously communicated. Legibility in the service of quick, intuitive orientation and navigation – prerequisites of the building's social functionality – are the accomplishments of these strategies of tectonic articulation.

To conclude, the works and arguments elaborated here point to the following agenda for the future of architectural detailing: that of computationally driven tectonic articulation in the pursuit of a complex, legible spatial order with a clearly understood communicative purpose. AD

**Notes**

1. Patrik Schumacher, 'The Necessity of Demarcation', *The Autopoiesis of Architecture, Vol 1: A New Framework for Architecture*, John Wiley & Sons (Chichester), 2010, p 144–66.
2. Patrik Schumacher, 'The Phenomenological Vs the Semiological Dimension of Architecture', *The Autopoiesis of Architecture, Vol 2: A New Agenda for Architecture*, John Wiley & Sons (Chichester), 2012, pp 142–5.
3. A certain drawback here is that the articulatory repertoire is thereby somewhat constrained, so that this strategy might not succeed if the task of articulation is very complex. The concept of indexical signs (as distinct from symbolic signs) was introduced by the founder of semiotics Charles Sanders Peirce. While the symbolic sign is arbitrary with respect to the concept it denotes, the indexical sign is motivated by a causal connection to the object/concept it denotes, like smoke is a sign of fire.



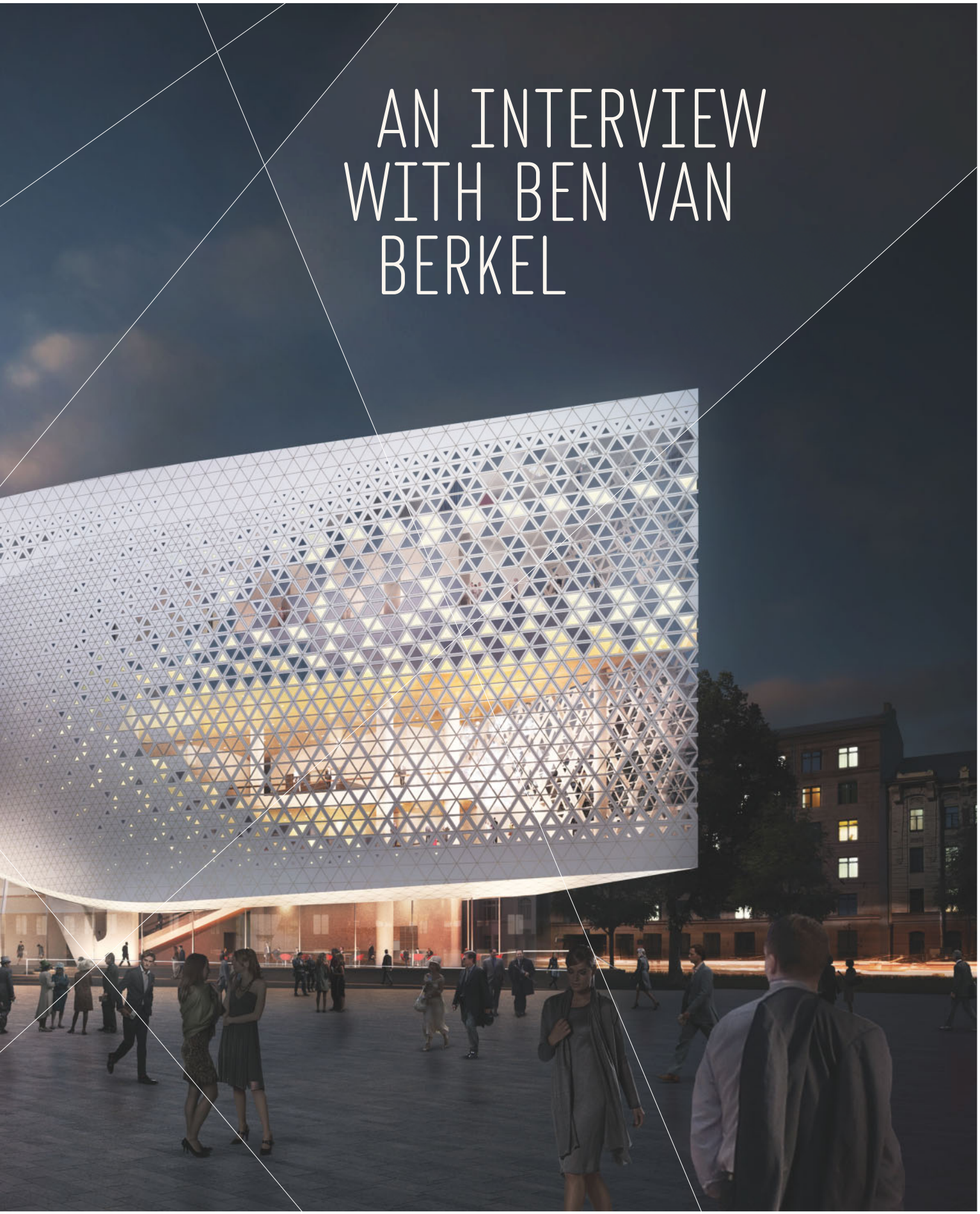
The tessellation follows a rule that correlates curvature with subdivision. This makes sense in terms of fabrication, and is also a strategy of phenomenological articulation, accentuating the plastic features of the form and therefore enhancing its perceptual palpability.

Mark Garcia

# FUTURE DETAILS OF UNSTUDIO ARCHITECTURES

**UNStudio, Dance Palace, St Petersburg, Russia, due for completion 2016**
Large details, the monolith and the twist in UNStudio's detailing strategies.

# AN INTERVIEW WITH BEN VAN BERKEL



In the mid 1990s, **Ben van Berkel** of UNStudio brought the world's attention to the plight of the architectural detail, calling for it to be redefined. Some 20 years later, guest-editor **Mark Garcia** caught up with van Berkel in London and at his studio in Amsterdam, in order to explore with him fully his interest in the detail over time in both his built work and design research. As Van Berkel seeks out the production of 'a more intense architecture' through the development of advanced computational and organisational techniques, where does it leave the detail and non-detail? Can a good detail still save a building?

**UNStudio, MUMUTH House for Music and Theatre, Graz, Austria, 2008**
Large detail of twist simultaneously detailing circulation and structure.

UNStudio are known for the complex and non-standard morphologies of both their buildings and their details. Their architectures are informed by a range of theoretical, material and technical research from an unprecedented breadth of disciplines including the arts, business and management, science and industry. Co-founder and principal Ben van Berkel's research project into the detail was first documented in his essay 'Storing the Detail' in the 1994 publication *Mobile Forces*.[1] There, he and his co-author Caroline Bos confronted the seeming lack of adequate architectural theorisation of the detail, complaining that 'it is one of those shameful "facts of life" that get swept under the carpet … why has there been no room for the detail in any architectural discourse for several decades?' Manifesto-like, the essay continued: 'It has become essential to define it anew. Its classical meaning, as a part of the whole, as articulation, has become obsolete … but that the notion of articulation has been abandoned too, comes as a shock … That's why detail has ended up abruptly in a black hole; architecture itself denies its ability to exist.'

New details provide an incredible opportunity to rethink architecture, the detail gives us a new opening … I think details could become more significant.
— Ben van Berkel, 2014

In response, Van Berkel, in a direct reference to Le Corbusier's 'Five Points Towards a New Architecture' manifesto (1926), set out his 'Four Points of the Detail'. The first of Van Berkel's points is 'the detail of omission', which is 'entirely a matter of excluding'; one that 'consists of an absence, a conscious discarding of a superfluous articulation'. The second point is that of the 'imaginary extension … the stretching of lines caught from the corner of the eye, the unfurling of accidental pockets of leftover space in corners of the site, and the dragging up of parallels with half-hidden substrata'. The third point is that of 'finding and storing the detail', and the last point 'relates to a new ordering to replace classical composition … a detail extended to exclude everything else.'[2]

## UNStudio's 21st-Century Details

Much of Van Berkel's designed and built work has borne out this argument, and while his 2013 lecture on the future of architecture at the Southern California Institute of Architecture (SCI-Arc)[3] updated and refined these points, it went further in addressing a number of new themes to his theories of the detail. The focus of his most recent theorisations of the detail gravitate around four key concepts: the non-detail, large detail, the light monolithic and the twist. As he explains: 'Over the last four to five years we have developed another set of interests … I would define the detail as a way of thinking differently about the subject, as an instrument you use when you focus into a space, a way of examining architecture from the inside out to discover more of architecture than that which could be discovered from a distance. The detail is almost the opposite of the most abstract aspect of how we analyse architecture. It is instead where scale, theory and the material understanding of architecture come together.'

**UNStudio, Changi Airport Complex, Singapore, 2012**
The 'light monolithic' – deliquescent transparencies, colour, smoothness, seamlessness. The double aspect of the merging play of details between lightness and heaviness also has historical architectural references: the fortress, the bunker, but also temples (Mayan, Chinese and Japanese) where the monolithic is used to inspire awe.

UNStudio details fit into a spectrum between three points on a gradient: the non-detail; the transition to the detail/s or between details; and the detail/s itself/themselves. The non-detail acts paradoxically as the triangulating foil to emphasise the new kinds of 'not-non-details' in other spaces of the architecture. This is one way in which the UNStudio detail mediates between the most salient intensities, concentrations and loci of innovation in designed spaces and the most empty of spaces. The two are inextricably linked by their details and the relationship (however seemingly absent) between their more articulated, distinct, clear, significant and innovative designed details.

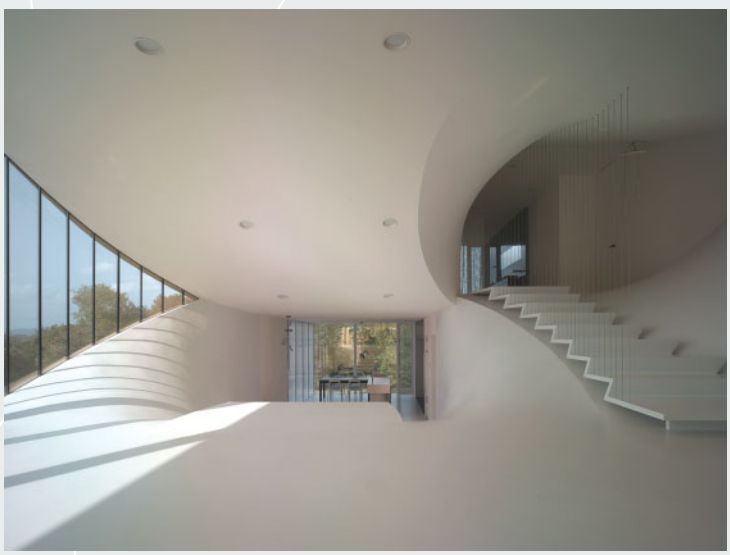
A cynosure of Van Berkel's most recent reinterpretation of the detail is that it is 'the major aspect of architecture … you only need two or three larger details to explain the whole concept of the building. If you have 20 ambitions and you would like to express them all in one building, then probably you can't afford it or you don't have the time, or it would never work in a single building. So maybe you can only have two or three major details on which to hang these ambitions. Only then can you make it affordable, sustainable and adaptable etc.'

This begs the question of whether a good detail can save a bad building: 'Yes, if you have a mistake in the facade structure, say, or you have to substantially reduce costs in the base of the building. But at the same time if you have a beautiful, incredible, overwhelming ceiling that organises the building and guides you from the entrance to the upper floors, then that ceiling *is* the project. You can save the main concept of a building with a detail … Only with the large detail is it possible to conceptualise and integrate the full principle of what you would like to communicate with your architecture. Today there are so many complex restrictions on architecture, not only regulations but also those that go hand in hand with technology, advanced ways of managing architecture, politics etc. So maybe by redefining or redesigning a compositorial set of ingredients, we can handle and discipline these complex questions in a far more radical manner. This would enable us to guide architecture through these difficult restrictions that we often have to deal with.'

## Computational Detail Innovations

In this context, the organisational strategies and methods of individual details in the detail-to-whole relationship come into sharp focus. UNStudio often use the computer to undertake one of the most innovative, still highly evolving and under-theorised operations of contemporary architecture: computational morphing. Van Berkel notes that in his work this relationship is articulated through the theories and techniques of 'collage, montage, bricolage … I often refer to a collage diagram, the Manimal, which is a hybridised detail. But sometimes you can't hybridise certain details, like with a concrete facade; when it comes inside it needs isolation, so you need a montage strategy. It is similar to parametrics – it has its limits, and certain details cannot be parametric. But there are some good hybrid examples, such as our "twists".'

Van Berkel's SCI-Arc lecture also dealt with UNStudio's 'detailing' as part of the process in the practice's recent business, management and organisational shift to an innovation management culture. The detail and detailing in the context of an architectural business thereby become the spatialisation of knowledge management and the management of spatial knowledge. Inevitably, accelerated and facilitated by the computational capacities of social networking, collaboration systems and digital participative design tools, Van Berkel is ahead of the curve here, as these kinds of advanced organisational, management and business process re-engineering tools are mostly the preserve of big, multinational businesses, management consultants and other knowledge-intensive governmental organisations. As he points out: 'I've seen how to use the computational to restructure the collaborative system more towards a knowledge-based practice, and innovation is maybe the next step. I'm interested in how you can bring super-intelligence together through new techniques and how that can generate a far more intense architecture.



**UNStudio, VilLA NM, New York, 2007**
Detail, anti-detail and the slick morphing gradients between them form geometric, sliding and eliding hybrids. Multiple and contradictory dualities between orthogonal and curviform materialities generate the playful flows of details.

**UNStudio, Arnhem Central – Transfer Hall, Arnhem, The Netherlands, 2014**
*top*: The large twist detail mediates the structure, circulation, visual connections, light, acoustics and other programmatic, functional and environmental forces.

**UNStudio, Burnham Pavilion, Millennium Park, Chicago, 2009**
*left*: Pavilions for UNStudio are design research experiments in the innovative detailing of their architectures. In the Burnham Pavilion, these large details as structure are intensive, smoothly morphing geometrically plasticised perturbations in the centre of the space, permitting the plinth and roof to cantilever simultaneously as ground/floor and ceiling/roof.

**UNStudio, Mercedes-Benz Museum, Stuttgart, 2006**
UNStudio's most expensive and knowledge-intensively designed details were the different structural twists in the stacked trefoils used here.

**UNStudio, Star Place, Kaohsiung, Taiwan, 2008**
In this void of the Star Place department store, the detailing articulates a double-speed transporting, delirious and displacing effect of Piranesian intensity.

'Collaborating with others to speculate on the detail using these new computational tools is part of our current research. With our Arnhem Central Station project [The Netherlands, 2014] I was already very aware of what the computational and parametric design could do for architecture. I worked with user groups and statistics in diagrammatic organisational strategies that used quantities of people per square metre in a volume to map flows. In that way the architecture could come from a series of analytical diagrams of details. The diagram then starts to turn the architecture into a series of formal strategies for how to deal with and link both the details of the research and the formal details. I think parametrics can go much further in terms of working with more elements, multiple layers of information crossing each other, the cross-combination of information and the unfolding and instrumentalisation of design. This is a more adaptive architecture. Crowd-funding is an example of this kind of intelligent design thinking – knowledge communities and details can also come out of this process.'

The computer is also increasingly allowing for Van Berkel's 'complex forms, textures and quickness of detailing. We have always been interested in the computational and generative computing. We can go beyond form-making and the articulation of architecture and begin to see the computational as pure and beautiful knowledge.'

The process by which Van Berkel generates details using the typology of the pavilion is another aspect of UNStudio's linked design and knowledge management methodologies. Here, 'the pavilions became the extension of the diagram and the design model. In the earlier stages of projects, before we apply details to buildings, pavilions provide a testing ground for prototypical and larger details. So the pavilions are the details of certain buildings.' This deliberate methodology of detailing design research is sometimes reversed and a building, once built (perhaps accidentally), can, for Van Berkel, suggest a detail that can become a pavilion: 'There are many examples of that: the Burnham Pavilion [Chicago, 2009], VilLA NM [New York, 2007] etc, where the twist was developed. The most complex twist we are working on now is in the Arnhem Central Station project which has almost four mathematical Seifert surfaces.'

Many of UNStudio's details function as intensively designed singularities in geometrical systems and spatial patterns. Patterns in architecture are affiliated to production and manufacturing, which therefore relates the detail, through pattern, to cost, finance, economics and, ultimately, to business, capital and capitalism itself. Detail is thus partly an index of cost. Van Berkel's response to the question of valuable architectural details and capital draws on two of his recently completed projects: the 135-metre (140-foot) high Ardmore Residence apartment complex tower in Singapore (2013) and the Mercedes-Benz Museum in Stuttgart (2006). He explains that 'my most expensive detail is the twist in the Mercedes-Benz Museum. Fortunately we found a trick to repeat the casting techniques and make it affordable. In a way these twists are morphed columns, they carry the cantilevers of the building and become a new form of column-free carrier. So one of the twists was perhaps expensive, but many of them made it affordable again. I have been criticised for doing "high-end" work, high-end housing and work for top brands like Mercedes and Alessi, but I always argue that the knowledge we gain through our high-end work is immediately applied to affordable housing, affordable furniture. In the Ardmore Residence project, we use only seven different details.'

Such a strategy of perturbing the standard relationship between capital and the detail using aperiodic patternings of a finite set of details implies the possibility of more public, richer detail/detailing. Van Berkel relates this public dimension to his long-running fascination with infrastructure: 'In the MUMUTH Music Theatre [Graz, Austria, 2008], the twist is proved socially; people gather underneath it, it is an attractor, a compressor, combiner and catalyst – similar to how the void also operates in a lot of our work.'

The void and the twist in UNStudio designs are also the product of a strong strand of spatial research into the way certain kinds of architectural details generate powerful and emergent but rare optical and spatio-psychological affects. These are dual or polysemic readings, kaleidoscopic sensations, gestalt shifts, images and Rorschach inkblot-like conceptions of space. Such notions are associated with the infinite or the sublime in spatial aesthetics, which as Van Berkel explains 'goes beyond aesthetics, or is ultimate aesthetics … I like the idea that details in designs can shift concepts, you think that you are in a department store and suddenly you are in a museum, a displacement of meaning occurs.'

**UNStudio, Arnhem Central – Transfer Hall, Arnhem, The Netherlands, 2014**
Multifunctional large twist detail model. UNStudio's detail designs often blur the distinctions between the diagram and the model, and the material and immaterial dimensions of the detail, disrupting and reconstructing ideas of types and functions of geometry in architecture and the spaces of its details.

I like the idea that details in designs can shift concepts, you think that you are in a department store and suddenly you are in a museum, a displacement of meaning occurs.
— Ben van Berkel

**UNStudio, Mercedes-Benz Museum, Stuttgart, 2006**
The artificial tornado being tested here is generated by 144 jets and 28 tonnes of air. It holds the Guinness World Record for the 'strongest artificially generated tornado in the world'. The 34.4-metre (113-foot) high smoke cyclone is sucked out through the roof of the building and permitted open gallery spaces through the removal of fire doors. An internationally innovative, sublime, hybrid, light-monolithic, twisted large detail/non-detail of 21st-century architecture.

## UNStudio's Future Details

The future of the detail is, as Van Berkel conjectures, 'about the joining forces of existing materials and new materials, turning (without even realising it) the interiors to exteriors and the exteriors to interiors. I work with a lot of students to explore complex geometries, computational, generative and mathematical models that can be architecturally multifunctional, for example new kinds of structural details (like the 'V-Walls' I have used in certain projects) that carry forces in complex ways as well as absorbing other, different kinds of architectural ingredients. These are geometrical articulations that can absorb more than the grid. I am working on a book at the moment, one chapter of which will focus on categorising the principles of the larger detail. But my most important goal for the future of the detail is to make it more adaptive and responsive to changing qualities and uses of space – how it could react to the weather conditions, environmental aspects, the creation of new atmospheres, acoustic details, LED and other light phenomena (including sunlight). Light will become a more important architectural detail and I think bodies will be able to change the details of architecture more. I'm also interested in phenomena surrounding health and details that can clean the building. After working on projects like surgical operation rooms, scientific laboratories and research centres, I've learnt about details and detailing techniques that architects do not normally use outside of these programmes.

'We also do some highly speculative materials research, most intensely into foils, glass and recently Gorilla Glass. Our work on interactive design details in interactive facades will continue and of course 8K megapixel screens will also change architecture. These screens will change the whole volume, substance and the perceptions of architecture. They will change architecture into an effect that we now know only from cinema and computer games. I was one of the first architects to build a large interactive media facade with our Galleria Department Store in Seoul [2004], so I'm interested in this, not in a hyper-reality way, but in a more abstract, fine art way that suggests dynamic worlds. The computer is also used to help us design material affects, through dynamic simulations we do in collaboration with engineers … In the future we will be able to interact more directly with materials also, to directly change their details and the details of their material effects. Houses may be renovated every week. Architectures will generate energy through their uses and adapt in more intelligent ways. Finally, like you, I wish to diagram the diversity of facets that are attached to the detail, that supercomplex network.' ◘

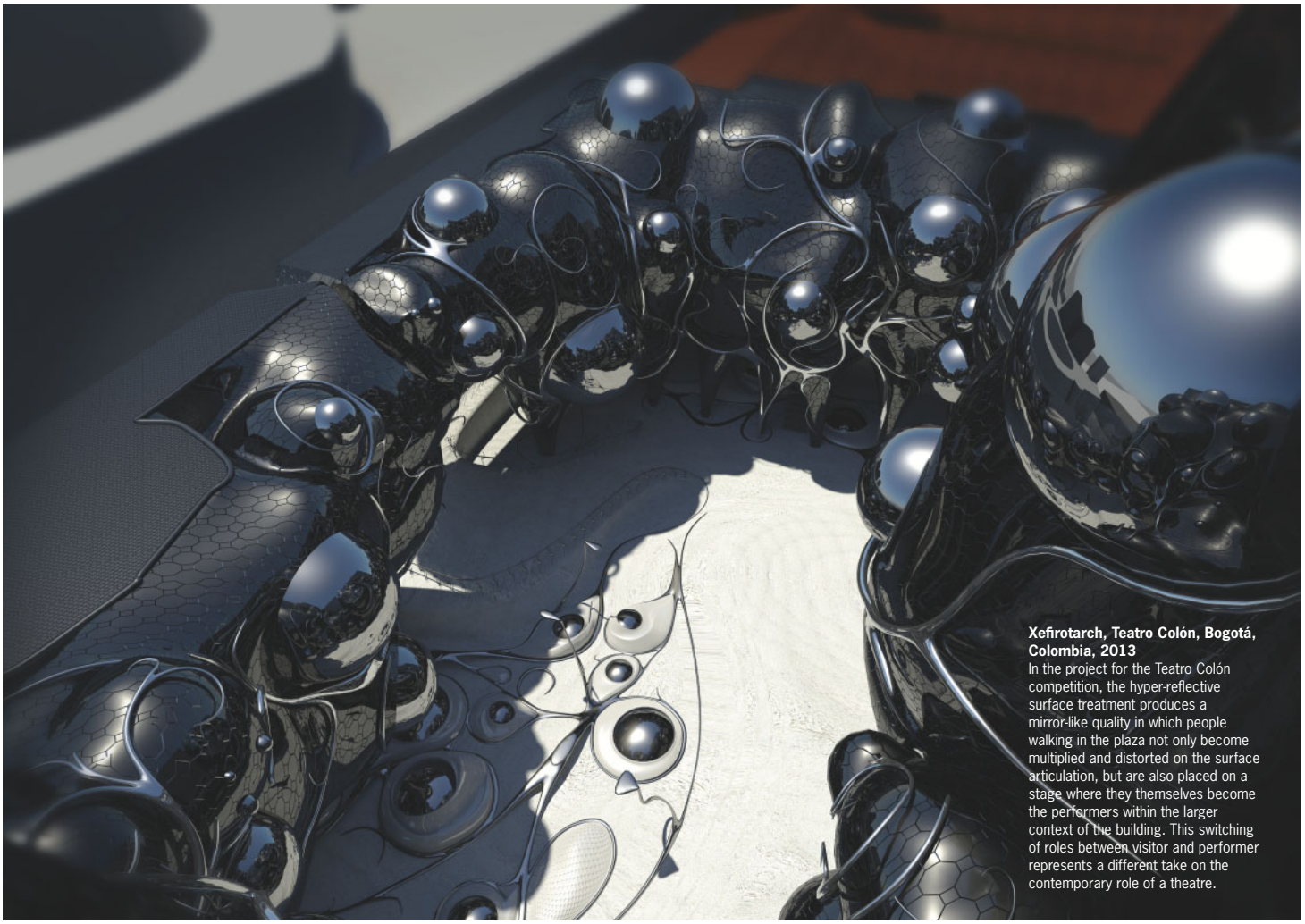
*Interviews with Ben van Berkel were conducted in London (28 November 2013) and Amsterdam (22 January 2014).*

*With many thanks to Karen Murphy at UNStudio for all her help.*

**Notes**
1. Ben van Berkel and Caroline Bos, 'Storing the Detail', *Mobile Forces*, Ernst & Sohn (Berlin), 1994.
2. Ibid.
3. Ben van Berkel, 'Architecture and its Future', SCI-Arc, Los Angeles, 20 February 2013: http://sma.sciarc.edu/video/ben-van-berkel-architecture-and-its-future/.

**Xefirotarch, Helsinski National Library, 2012**
The building takes over the adjacent lot, creating a new public space based on the same logic used to design the library. The lines pull the public space into the library while the bladder spaces provide an extension to the library in the park.

In this detail, the pieces play with material qualities to emphasise their formal aesthetic. Porosity, shine and panellisation codify and augment their performance.



**Xefirotarch, Teatro Colón, Bogotá, Colombia, 2013**
In the project for the Teatro Colón competition, the hyper-reflective surface treatment produces a mirror-like quality in which people walking in the plaza not only become multiplied and distorted on the surface articulation, but are also placed on a stage where they themselves become the performers within the larger context of the building. This switching of roles between visitor and performer represents a different take on the contemporary role of a theatre.

The last two decades have brought with them unprecedented technological changes that have had a far-reaching impact on design ethos and culture. **Hernan Diaz Alonso**, Principal of Xefirotarch and Professor of Architecture at the Southern California Institute of Architecture (SCI-Arc), reflects on the nature of these changes: observing that as 'criticality in architecture' is 'replaced by talent' or 'virtuosity', there is a greater 'focus on specific architectural or design problems'. This brings with it a shift from the design detail, reliant on technical expertise and precision, to 'the close-up' that is more concerned with resolution and the conceptual, bridging the gap between the intellectual and the physical.

*The world is full of obvious things which nobody by any chance ever observes.*
*— Sherlock Holmes in* The Hound of the Baskervilles, *1902*[1]

Over the last two decades, the design ethos that has grown out of the digital turn has triggered key shifts in architecture. The far-reaching effects and consequences of this phenomenon are hard to spell out – and perhaps still too recent to be fully theorised (despite many attempts to do so). However, I think that some of the main shifts that have occurred in our field can be summarised as follows: representation to simulation; composition to systems; collage to pixelation; geometry to image; close reading to virtuosity; and details to close-ups.

I have an ongoing personal interest in all of these aspects of design, but for the purpose of this article[2] I want to explore the last two a bit more carefully, mainly because I see them as framing, and in a sense implying, the other four themes on my list.

**Close Reading to Virtuosity**

The first shift, the one from close reading to virtuosity, is about a broader revolution that affected architecture. It is of course related to the versatile nature and flexibility of the digital media, but it also contains a statement about the cultural mutations this change implied. Actually, it asks a really fundamental question, which could be outlined in these terms: Can architecture still be critical? Is there any value in resuscitating the critical approach in the current cultural climate?

It is probably impossible to give a definitive answer to these questions. What matters to me, though, is that while close reading definitely dominated the disciplinary side of architecture for most of the 20th century, this is no longer true in the 21st century. Jeff Kipnis and I recently argued, at one of our sessions at the Southern California Institute of Architecture (SCI-Arc), that because of the increasing atomisation of the discipline into genres and niches of technical expertise, close reading might be too obsolete a tool to be useful. Or it might be useful to certain niches, but not to others – still, its pivotal role is dangerously questioned.

What is rather more compelling and polemic than close reading is virtuosity, which is another way of saying that criticality in architecture is being replaced by talent. I am aware this is a controversial thing to say – and I know a lot of people who would disagree with me. But I am still convinced this is what is happening. It is important to point out that the transition from close reading to virtuosity does not absolve architects from thinking and certainly not from being critical about their individual virtuosities. In fact, the complexity of their current task is so high that they have to think harder than ever before. But what is required is a different kind of thinking. And the latter is no longer rooted in the formalist paradigm; rather, it is a kind of thinking that is more intrinsic to the media involved and specific architectural or design problems. It is not the end of thinking, but the beginning and, perhaps, the reaffirmation of a new kind of thinking.

**Details to Close-Ups**

The second shift I want to talk about is that from details to close-ups. This is more specifically related to the physical side of our field, even though 'physical' in architecture (at least according to my own definition of architecture) always also means 'cultural' or 'speculative'. This link that I am making between the practical and the intellectual should start to show how the so-called digital revolution has (and is having) consequences that go far beyond the mere introduction of innovative software or fabrication equipment. In line with the view of architecture I endorse, every time any such innovation enters disciplinary boundaries, it is automatically evaluated and problematised as a cultural object as well.

Perhaps paradoxically, the shift from details to close-ups indexes a polarisation of what used to be purely material-related problems towards the conceptual side of things. What is interesting, however, is that this is done from within a disciplinary milieu

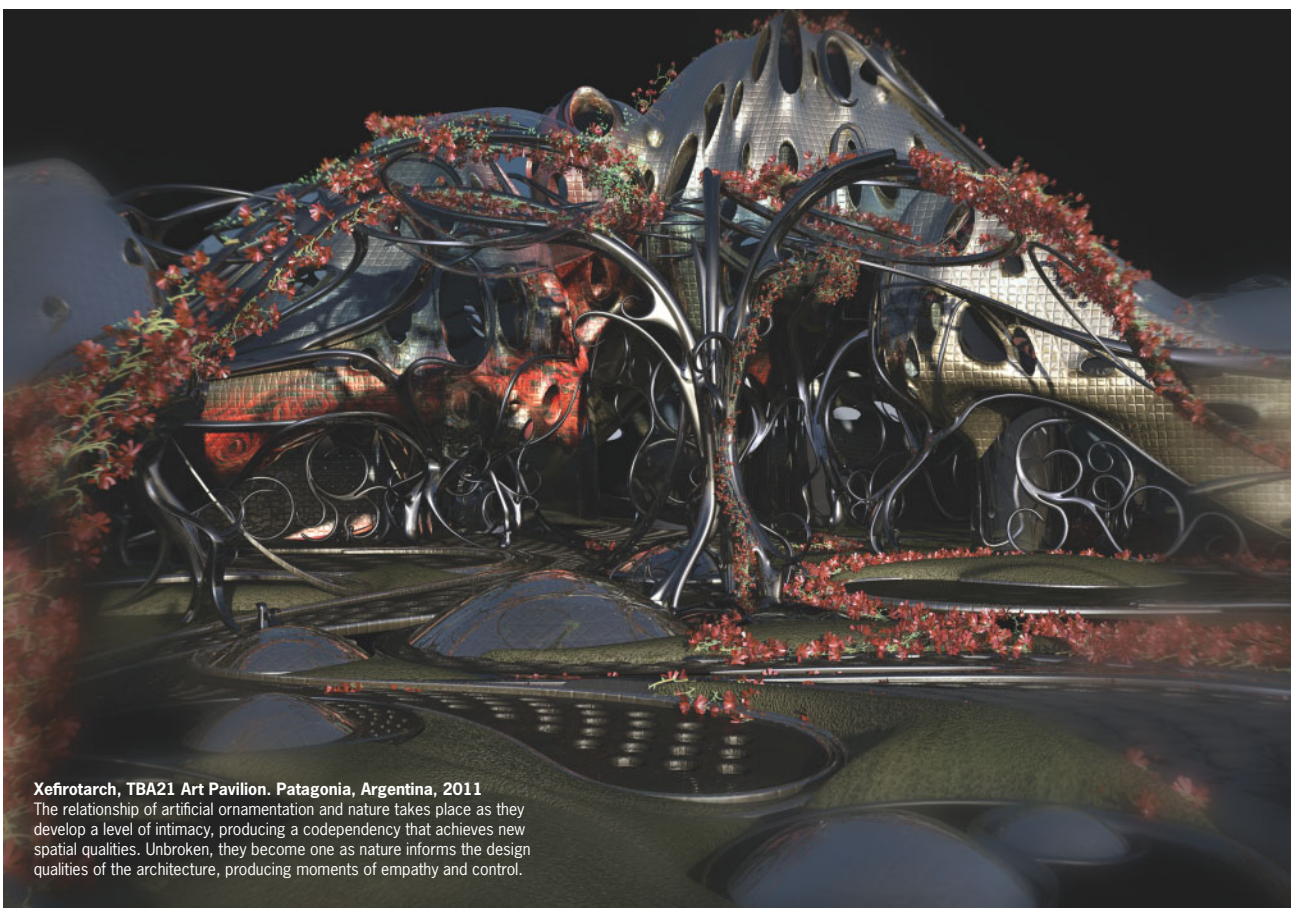
(for example, simply in tectonic terms) and without resorting to external devices such as criticality. So, it could be said that tectonic virtuosity also shifted from a concern with (more or less) abstract concepts referring to structural inventiveness or talent in material compositions, to a more global dexterity in grappling with whole architectural problems that are, at once, both physical and intellectual. This is to a considerable extent due to the versatility achieved by operating in a highly digitalised environment – and to the ease with which virtual representation and material fabrication intertwine.

Precisely because it was never so easy to master the realisation of such highly sophisticated and precise objects, it is no longer possible to justify virtuosity purely in terms of detail expertise. Once again, and obviously, this does not mean that the value of expertise in architecture is lost. Quite the opposite actually. Expertise is more important today than ever before. But the role of expertise has migrated from the realm of pure craftsmanship to a concern with resolution.

In other words, because technological advancement has made the production of complex objects almost trivially easy, the mere ability to produce those objects alone can no longer be a virtue of the architect.

Think about any design product. Ten, even five years ago, every bit of state-of-the-art technology was showed off prominently in most high-end objects. New technology was boasted almost without restriction. Today, this is suddenly very different. If you look at the iPhone, an incredibly sophisticated (maybe the most sophisticated) and advanced design product, you will notice that all the technology, all the detail, is hidden. What remains as a trace of that technology is resolution – resolution of the functions and images that are the result of that amazing and esoteric technology and that allow you to marvel at its beauty without ever needing to know what it looks like or what components make it up. Broadly speaking, I think this exemplifies well the idea of a transition from detail to close-ups in design.

*Expertise is more important today than ever before. But the role of expertise has migrated from the realm of pure craftsmanship to a concern with resolution.*



**Xefirotarch, TBA21 Art Pavilion. Patagonia, Argentina, 2011**
The relationship of artificial ornamentation and nature takes place as they develop a level of intimacy, producing a codependency that achieves new spatial qualities. Unbroken, they become one as nature informs the design qualities of the architecture, producing moments of empathy and control.

How does this translate more directly for architecture? Well, the transformation of the approach to tectonics, as mentioned above, provides a potential good example. We could suggest that in Modernism, say for Mies van der Rohe, detail was a product of architectural speculation, with the precision, the craftsmanship and beauty of the detail representing those arguments. In the new digital paradigm, tectonics itself is a form of speculation, not merely its product, and this, I believe, is because of the dramatic blurring of boundaries between the virtual and the real. Tectonics now is a form of thinking expressed through its own resolution both in abstract and material terms. And in this sense, it is interesting for us mainly as a result, as a statement, and not necessarily in terms of the physical parts that compose it or of its complicated technical assembly. Indeed, a lot of the time we prefer that those aspects be concealed to leave room for the clarity of the architectural statement made in terms of resolution, or close up.

So, to summarise, while detail created a separation between the intellectual and the physical, in which technical expertise and precision were used to represent an abstract concept, the close-up bridges this gap. From the perspective of close-ups, construction and assembly are reinvented as a form of tectonic speculation in which materials and concepts are deeply interconnected, rather than being dialectically opposed.

## Architectural Speculation as Cultural Advancement

Architecture underwent a major transformation through the shift brought about by the digital revolution. Its aesthetics, as well as its building, fabrication and design principles were equally affected. In the shifts described above I have tried to show how two key modes of understanding of the discipline (its conceptual and tectonic sides) changed.

**Xefirotarch, *Still Flesh*, 2012**
The reconfiguration of the butchered fleshy parts into a new animal produces a new level of understanding of the singular pieces and their relationship to each other in forming a new distorted whole.

The virtually unlimited range of possibilities engendered by this shift forced architects to rethink the philosophical as well as ethical motivation of their endeavours. In this milieu, idealistic or even utopian goals are replaced by a revived curiosity for and unapologetic interest in progress, often pursued for its own sake. A new commitment to the 'useless', to a body of work and to projects in which cultural advancement and technological refinement are at the centre, emerges.

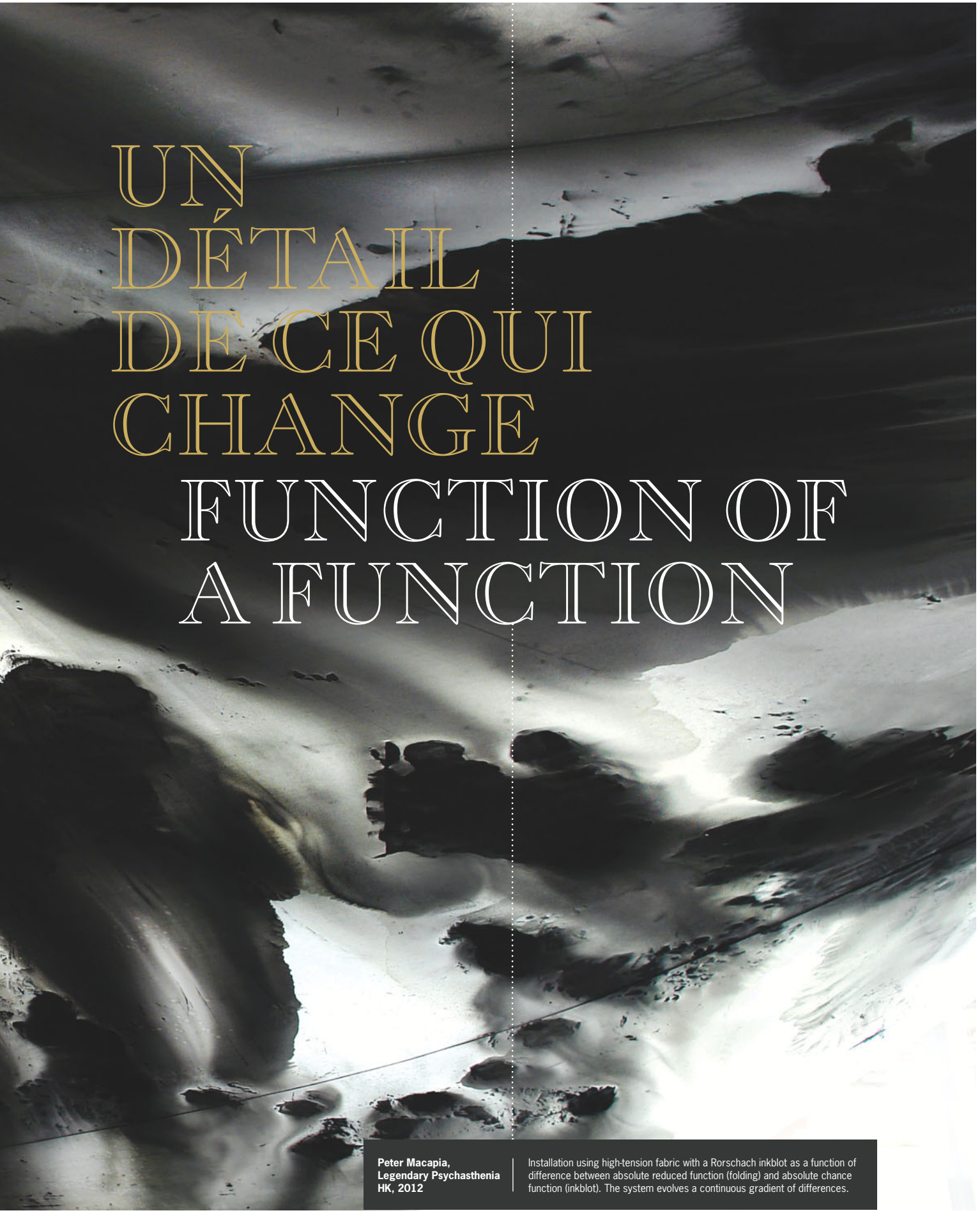
Despite what the old idealists or 'world improvers' might think, some practitioners take this new sensibility very seriously. In this time of great confusion for our discipline, architectural speculation as cultural advancement seems to be a good thing per se. There is no doubt in my mind that the major intellectual contribution that the computational paradigm shift has brought to architecture is the relentless capacity to produce new forms of coherence at the core of what, in the past, might have been regarded as contradictory ideologies.

**Notes**
1. *The Hound of the Baskervilles* is the third of the four crime novels written by Sir Arthur Conan Doyle featuring the detective Sherlock Holmes. It was originally serialised in *The Strand Magazine* from August 1901 to April 1902.
2. Written with the collaboration of, and editing assistance from, Stefano Passeri, 2013 Design Theory Fellow at the Southern California Institute of Architecture (SCI-Arc).

Peter Macapia

# UN DÉTAIL DE CE QUI CHANGE

# FUNCTION OF A FUNCTION



**Peter Macapia, Legendary Psychasthenia HK, 2012**

Installation using high-tension fabric with a Rorschach inkblot as a function of difference between absolute reduced function (folding) and absolute chance function (inkblot). The system evolves a continuous gradient of differences.

# TRUTH

Detail today tends towards one of two directions: on the one hand an increasingly precise fabrication through computation; and on the other infinite plasticity, interlacing structure, ornamentation and surface into finer and finer undulating networks also achieved through computation.

What are the forces of computation, and what are they in their details? One applies functions, and functions become recursive, moving through different platforms. Techniques act on other techniques, embed their functions, modify them, reference them to others and multiply their effects. Analytic functions and generative ones alternate, turning forces into other functions through functions of other forces: precision and force now combine. This also means that making one part of a building relate to the whole achieves a new standard of precision in detail. But this does not describe the relation between detail and force or its history.

In ancient Greek architecture, emphasis on ratio introduces 'agreement' between part and whole. Calibration becomes a cosmological principle: proportion falls under symmetry, which falls under order and beauty, which fall under perfection, which falls under truth.[1] Agreement of part to whole is the principle of identity as a principle of truth. In Gothic architecture, identity in the part leads to the totality of the whole. The principle *Manifestatio* extends directly from Scholasticism: the observable relations of parts through categorisation in conformation with kind, appearance and class.[2] From the cross-section of the pier we discern the '*organization* of the whole'.[3] Between these two systems details impart identity and order intelligibility establishing the unity of truth. What the detail represents is truth.

But what of details for which no representation exists? The advent of Classical sculpture is marked by the appearance of a detail neither inside nor outside the canon of proportions and which cannot be distinguished as a part. It is the slightest shift of axis, the tilt of the hips, appearing as asymmetry in the *Kritios Boy* (*c* 480 BC). This gesture is an inflection. But it belongs to no symbol, it cannot be measured, and it is random.

Why should computation be leading to a bifurcation in architectural detailing, resulting in a simultaneous, and opposing, tendency towards either greater precision in fabrication or increasing plasticity? Architectural designer and theorist **Peter Macapia** asks what is driving these propensities in computation, and what in turn historically might be the relation between the detail and force. What comes into play now, though, when architectural style is no longer identified by a taxonomy of parts, or a vocabulary of orders, but rather by a network of forces and functions correlating actions? How might economic and political power be interacting with force, the diagram and function in contemporary design?

**Peter Macapia, American Mexican Border Currency, 2011**

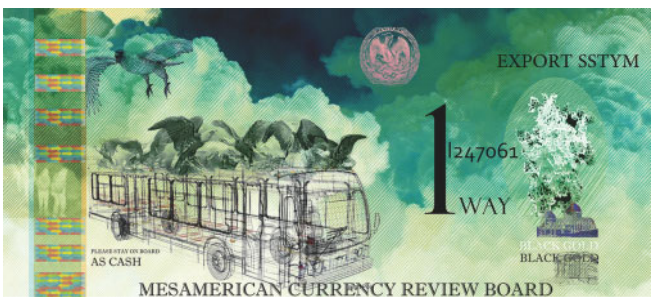
*opposite top*: The American Mexican Border Currency, the Export Sstym, is a one-way ticket back to Mexico from the US, after the completion of up to four jobs, as a function of Republican lobbying.

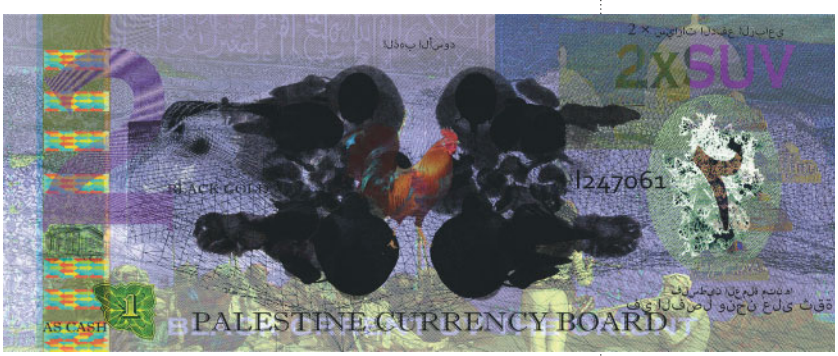
There are other details that similarly evade representation. In Post-structuralism and Deconstruction, detail is not an object or a meaning or a part; it is the meaning displaced by the word or the object, which is now only a gap. Similarly, the arrangement of the letters A, Z, E, R and T on the French keyboard, Foucault tells us, is a random detail, but when repeated it forms a statement.[4] From this repetition emerges the incorporeal power to bind; to bind the function of discourse to the creation of details, extracting from them laws of regularity, spatialising them and establishing forms of knowledge.

These random details form other spaces defined as problematic. They are literal, but their origins are indistinct. They speak an order but do not represent a truth. They are diffused throughout the system, known only by the effects they introduce and the things they bring to light.

Vitruvius discusses entasis separately as a detail that is not a detail. Entasis is not a part of a building, only part of its design, an effect introduced by bowing. But neither is it a higher principle like symmetry or a truth formed by analogy. It is among a class of practical, purely non-ideal mathematics to introduce curvature to the stylobate or the columns. Why? In order to adjust them and regulate their identity with respect to the whole (*scandente oculi speci*).[5] Entasis introduces a force that is necessary, but not a countable part.

The question of force here is not random. Lucretius reintroduced pre-Socratic and Epicurean atomic concepts of force in *De rerum natura (On the Nature of Things)* just 10 years before Vitruvius. In *Book II*, Lucretius addresses which details among the essential and accidental are essentially accidental. Atoms fall through the void, deflect a bit in space, at a quite uncertain time and uncertain place.[6] We must understand that this thesis stands against the 'whole' as a transcendental unity. Epicurus refines this idea in the *clinamen*, the swerve or deflection. The cause or destiny of force is not outside the atoms, but rather an effect of their differences.





**Peter Macapia, Palestinian Israeli Currency, 2011** | *centre*: The Palestine Currency Board 2xSUV is valued at 2 SUVs, but only in the West Bank or the Gaza Strip, and only as a function of exchanging land for labour with Israel. The exchange system is intended to modify the flow of diasporas and the flow of oil as inverse functions of each other.

**Peter Macapia, Israeli Palestinian Currency, 2011** | *bottom*: The Israeli Currency Board 2xSUV is valued at 2 SUVs in Israel, as a function of labour for land exchange between Israel, the West Bank and the Gaza Strip. Palestine is prohibited by international law from having a currency.

The history of force has been close, and adjacent to, but never constitutive of architectural thinking. At least not until the 19th century, when the concept of detail re-emerged as an entirely different order of meanings in relation to complexity in architectural theory.

By the end of the 18th century, the problem confronting architecture was history: Classical mimesis had over-determined architecture, and was now being questioned in the work of Étienne-Louis Boullée, Claude Ledoux and others. In the early 19th century it was fundamentally refuted. JNL Durand called the Classical theory of proportion impractical and historical fiction. Karl Bötticher and Heinrich Hübsch defined 'style' as that which originates from atomic forces of matter or formative factors, as opposed to representational ones. Eugène Emmanuel Viollet-le-Duc introduced biological forces, and John Ruskin economic ones. Each of these principles are expressed in relation to detail and in increasingly abstract ways. But detail does not mean less. Having now been transcribed from an object or representation into something profoundly obscure, it in fact means infinitely more; not symbolically, but as a function of other forces and other functions, multiplying various needs that architecture is now understood to perform.

The encyclopedic array of details in Gottfried Semper's *Der Stil* (1861)[7] suggests an infinite variation of infinite artefacts and their attributes. This richness of detail in detail, is comparable to Ruskin's study of Venetian Gothic and the infinite elaboration of the same thing, namely ornamentation. But this merely prefaces the primary task, which in Semper is to exchange the details of style for a calculus of forces ($U = C\,x,y,z,t,v,w$), and in Ruskin, to understand architecture as an expression of the sum of social relations. Similarly, in *Der Stil*, to the extent that Semper's Carribean hut speaks to architecture in its generality, it is not because it is an exemplary composition, but rather an anthropological counterpoint to Classicism and Marc-Antoine Laugier's primitive hut; architecture is not a representation but rather *work* and a network of actions organising matter.

Beginning with the 19th century, detail lost its identity as a representation of truth and was forced in two directions simultaneously: on the one hand, towards that which is hidden and buried in the ontology of action; and on the other, as a form of notation that undertakes a heretofore unknown abstraction. During this time architectural form did not massively change, even though it acquired more specific spatial functions. There was not yet a principle of design consistent with the abstraction of forces that remained embedded in analysis. One could only meticulously modify its parts, as in Viollet-le-Duc. This began to change by the late 19th century when Auguste Choisy introduced something previously unknown in architecture – a vector curve in a series of drawings analysing the Acropolis. The illustrations ruptured a crucial and longstanding archaeological conviction: that asymmetry in the Acropolis is an effect of historical accidents that have befallen what was originally a symmetrical organisation. Choisy's drawings introduce movement, directions and inclinations, and lines of sight. Together they demonstrate that the apparent force of asymmetry in the Acropolis is in fact the very principle of its design, a function of the '*pondération des masses*'.[8] The dashed vectors are a notation at once abstract, heterogeneous and novel to architectural representation. As with Semper's Caribbean hut, they function not as representation, but rather as a diagram. Le Corbusier republished them no less than three times in *Towards a New Architecture* (1923)[9] and they served as the basis for his architectural promenade.

The pre-Socratic world was thus inverted, no longer atoms falling through the void, but rather forces and functions.

This animating law of production that emerged for each discipline as its new unfolding in the 19th century traversed biology, economics and the study of languages, no less for the early Marx, who re-stratified Hegel's dialectic of identity by folding consciousness back onto itself through the atomism of Epicurus, than for Nietzsche, for whom the 'measure' of being is the unique difference between forces as defined by Heraclitus.[10] It is no doubt here that the contemporary politicisation of being in terms of force begins. From here forwards, detail becomes literal (empirical), but also non-representable. Hence the emergence of the diagram in 19th-century thought as a different kind of whole relative to the sum of its parts. Architectural style is no longer identified by a taxonomy of parts, or a vocabulary of orders, but rather by a network of forces and functions correlating actions.

The history of force has been close, and adjacent to, but never constitutive of architectural thinking.

**Peter Macapia, TokTw Tower, Tokyo, 2010**

*opposite and p 74:* Tower design using a nest-list algorithm graphed with spring dynamics, spatialised with a cellular automata algorithm to produce combinatorial functions for the prefabricated structural elements that are then enclosed with composite fibre membrane.

The question is, how do these concepts of function re-emerge within the logic of more recent architectural practices, since they are now only shadows of earlier 20th-century concerns with functionalism as such? The original concept of function (*functionibus*) is of course quite different. Leibniz's revision of Greek atomism makes of function neither element, quantity nor content, but rather a difference that performs a special duty. Identity has thus left the object for an ontology of force.[11] Force and function establish cosmos and calculus simultaneously: beings form a continuous chain 'like so many ordinates of one and the same curve'.[12] Atomism is inflexion and includes even the 'monstrous'. The 'principle of change' ['*un détail de ce qui change*'] is the basis of 'multiplicity in the unit [*unité*] or in that which is simple', that is, identical to itself and changing.[13] The detail that resists assimilation also engenders space.

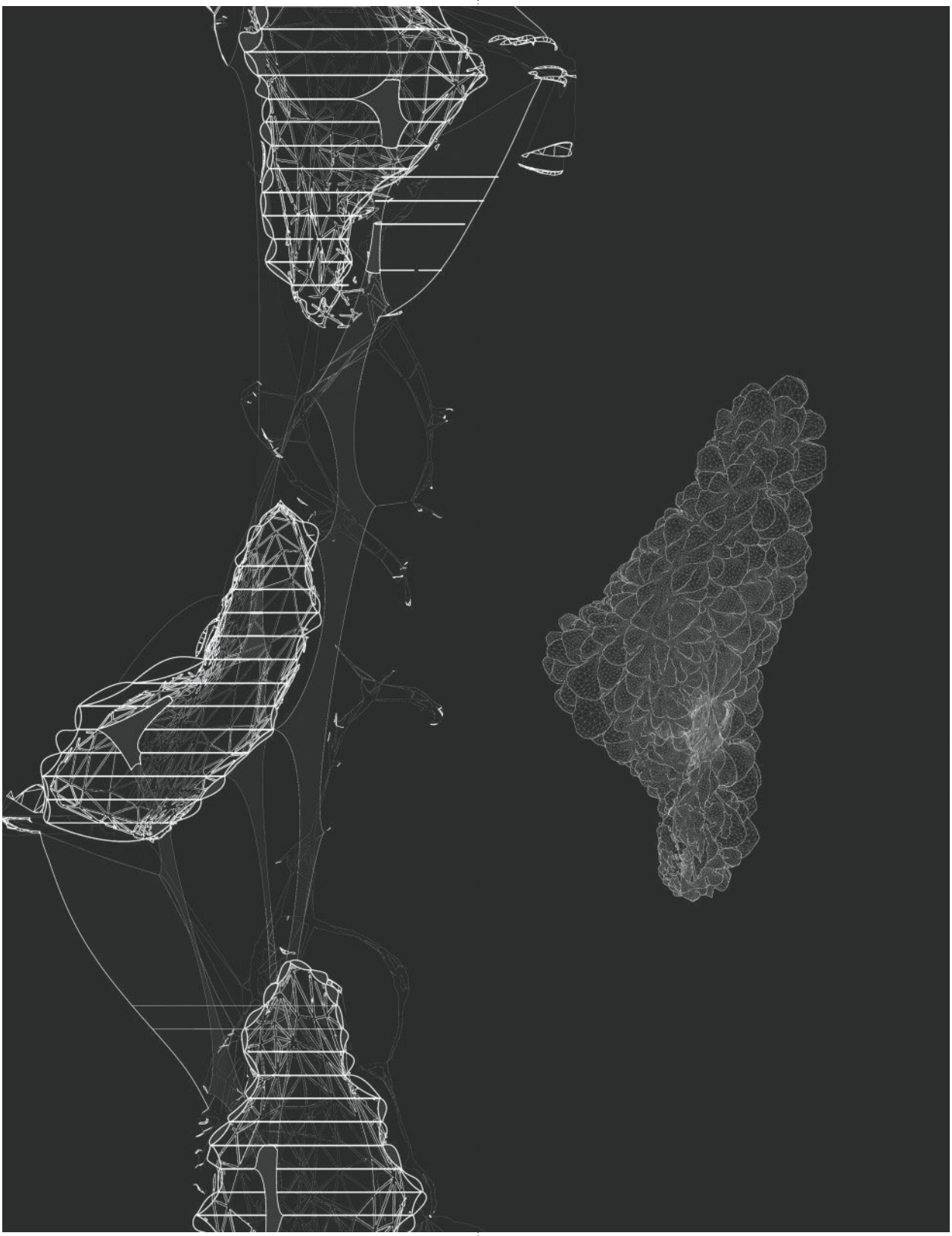
But there are spaces undefined by calculus, which are discontinuous. In the 1960s, intersecting with studies in biology and complexity theory, René Thom integrated topological functions with differential analysis in order to map, diagrammatically and quantitatively, all that had remained as yet outside of mathematics – the qualitative properties of catastrophic change. Despite the 'profound, but rather vague ideas of Anaximander and Heraclitus … theories [of change] rely on the experience of solid bodies in three-dimensional Euclidean space'.[14] Thom introduced a way of spatialising relations of force. From this new configuration emerged a space where the accident, the discontinuous function, is related to the whole, now conceived as the cusp of what Michel Foucault, and subsequently Gilles Deleuze, would thematise as the 'fold'.[15]

Deleuze wrote *Le Pli* in 1988. Thom's catastrophe cusp is central to the diagrammatic thinking in Deleuze concerning the problem of identity: difference in force drives being as becoming. The fold is thus a concept for this difference and belongs to 'an operative function': it is the detail for which difference cannot be represented.[16]

The fold, however, begins with Foucault. Although Deleuze encounters various folds in his writings from Merleau-Ponty to Heidegger, none of them constitute a theme. It is an other fold that emerges in Foucault's integration of archaeological history with political philosophy that influences Deleuze, which Foucault outlines in his analysis of force in *Discipline and Punish* (1975).[17] It is in his study of architecture, wherein we see force, function and diagram together for the first time. In his previous work, *Les Mots et les Choses* (1966), the fold is a problem about the identity of man beyond the transcendental-empirical doublet that remains embedded in the anthropological unity, and in which man constitutes both object and determinant of knowledge.[18] In *Discipline and Punish* the question becomes more urgent. Foucault recognises that the discursive and institutional formations that have produced this unity also constitute a technology in which its fabrication is a function of more than just knowledge, but also of power, and thus central to the relation between knowledge and power. It is political. The fold in Foucault is the function of force as a problem of power relative to the formation of knowledge. Foucault's words are precise and diagrammatic: it is a way of making power relations function in a function, and of making a function function through these power relations.'[19]

Foucault reconceptualised in its entirety the part/whole problem and the detail around the question of power: details are what power produces, and 'power functions in the form of a chain' – it is continuous.[20] Parts and wholes are thus also reorganised around the political question. In order to understand this, we must resist the thesis of representation. We must provide instead an analytics – an analytics of relations, of force 'down to the smallest detail', 'in accordance with the intelligibility of struggles, of strategies and tactics'.[21] Thus, three principles of power that define contemporary society in its stages of formation – force, the diagram and function – have indeed been continuously unfolding since the 19th century.

Foucault's words are precise and diagrammatic: it is a way of making power relations function in a function, and of making a function function through these power relations.



**Peter Macapia, Section Study, GrTplgy Tower, 2008**

Section study of a primary tetrahedral structure in which a secondary and compressive variable structural system is coupled with a cable tensile system and ETFE membrane.

Force, the diagram and function are also the attributes of contemporary design, from calibration in fabrication to the geometry and topology of matter/energy relations in the city. However, the challenge is not how to expand these functions, but to find others.

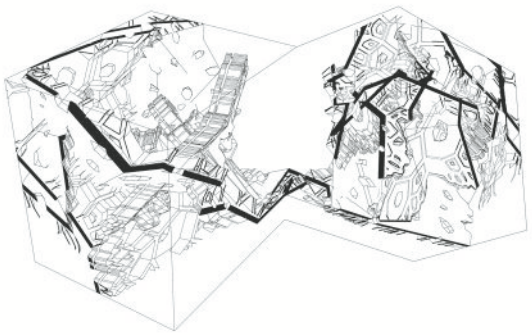
What might detail be in relation to the polis, and in relation to power under the triple designation of force, function and diagram? The city is strife. Two examples are the violent forces in Libeskind – this is Heraclitan – and the accidental forces in Jacques Tati – this is Epicurean. Libeskind's drawing project *Chamberworks: Architectural Themes from Heraclitus* (1983) presents the detail as both an atomistic force and a world-form. It is vectoral and carries in a new direction the problem of the architectural detail that he re-spatialised earlier in *Micromegas* (1979). Historical forces show us why these details cannot be assimilated. Detail reconfigures drawing through internal division; that of line as cut. This emerges first through Libeskind's drawing, but eventually organises his first building, the Jewish Museum in Berlin (2001). The interplay of line and cut, derived from conventional architectural notation, is also far greater than the building, since the building is much more than the sum of those details; the cuts/lines register at the scale of the city, at the scale of history and at the scale of erasure – the erasure of other details, other names, other addresses, other origins and destinations. Space cuts through space endlessly within the building, in its relation to the city, and so on, until a history of force unfolds for which there is no representation.

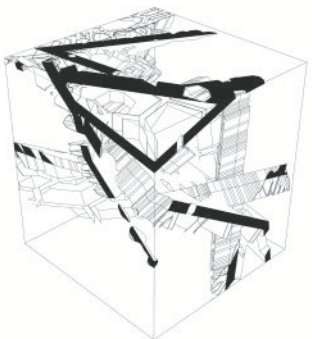
Tati's *Playtime* (1967) is a different analysis of force, one that resists the globalising effects of productive forces. A cinematic *clinamen*, Hulot falls through the laminar world of Le Corbusier's *City of Tomorrow* (1925).[22] Every point of the grid (the facade of a radio to the travel posters) follows precise subdivision as the permanent horizon of order. For Le Corbusier: 'We struggle against chance, against disorder, against a policy of drift and … death; we strive for order, which can be achieved only by appealing to what is the fundamental basis on which our minds can work: geometry.'[23] The curve, in fact, is 'ruinous'.[24] Hulot enters this state as a random particle, introducing at first only minor disturbances at uncertain times and in uncertain places. The particle sets off minor shifts that coalesce just enough to introduce a catastrophic change: the grid buckles under the weight of infinitesimally small forces and then collapses. Equilibrium returns as a different diagram. Instead of ordered movement, a different milieu emerges mixing genders, races, professions, ages, classes, types – subjects bonding together in a continuously shifting social whole. Stereotypes remain, but stratification no longer establishes their identities.

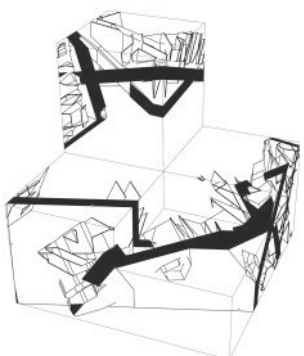
So it is not a question of violent or random forces, since both define the city. How far can the detail focus while yet transforming this world, like the chrome casing on Mies van der Rohe's Barcelona Pavilion column (1929). Just how much world can the detail handle? The point, then, is to study force not in its issuance as something to be represented once again, but in its effects and destinations, in what it opens and closes, of this or that space, in relation to this or that political or economic asymmetry. Force is not the same as power. Power uses force, but force also acts on its own. It is uncertain. ◬

**Peter Macapia, Informe Combinatorial 8, 2014**

Spatial study of a combinatorial system. The combinatorial results operate on a completely discrete system, but change in one variable allows for completely different spatial qualities to emerge, hence the infinite gradient of quality based on discrete elements.



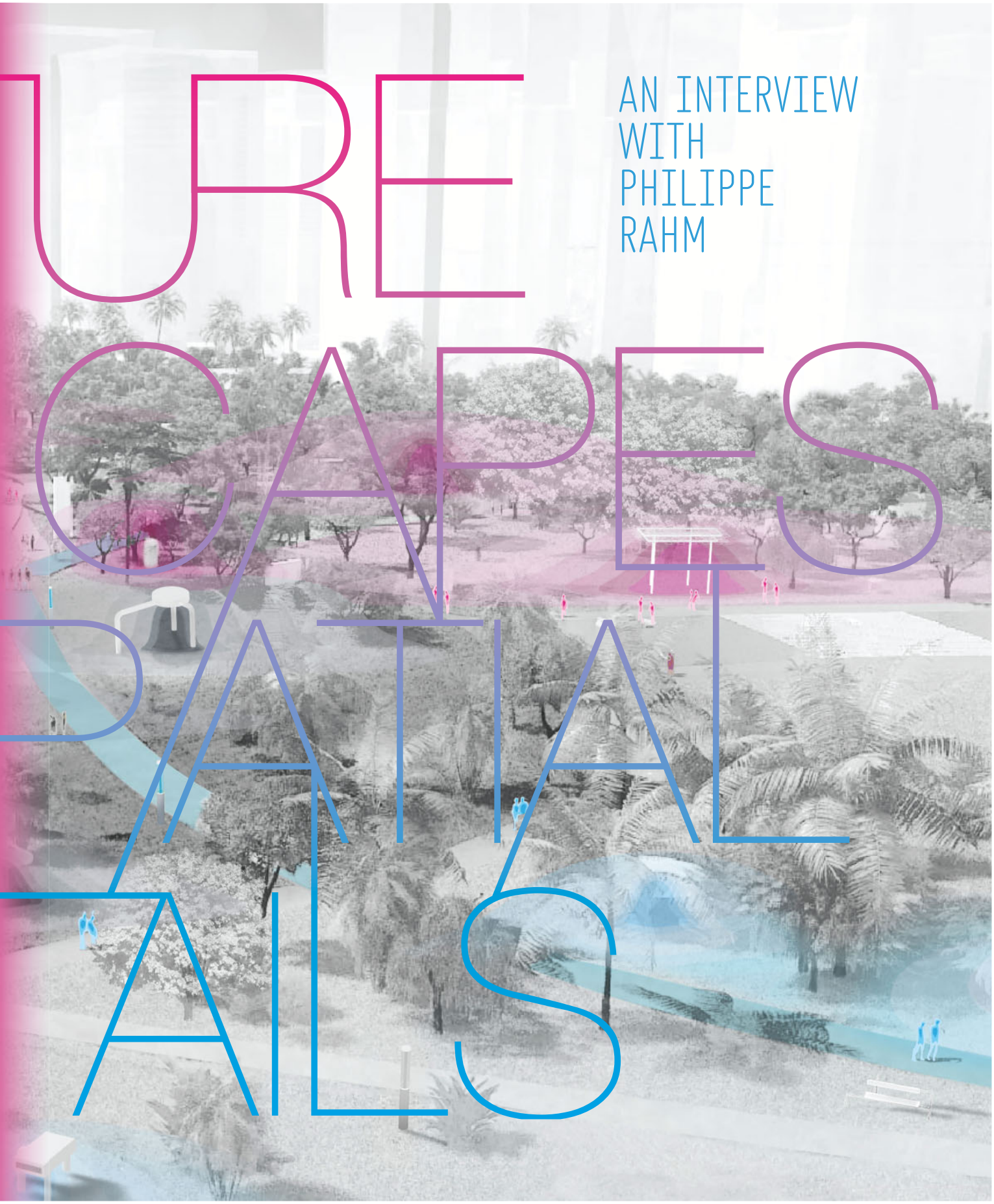




**Notes**

1. Ingrid D Rowland and Thomas Noble Howe (eds), *Vitruvius: Ten Books on Architecture*, Cambridge University Press (Cambridge), 2001, p 47.
2. Erwin Panofsky, *Gothic Architecture and Scholasticism*, Meridian (New York), 1957, p 57.
3. Ibid.
4. Michel Foucault, *The Archaeology of Knowledge*, Routledge (London and New York), 2002.
5. *Vitruvius*, p 50, and Lucretius Carus, *De rerum natura (On the Nature of Things)*, trans William Ellery Leonard, EP Dutton (Boston, MA and New York), 1916.
6. Ibid.
7. Gottfried Semper, *Der Stil in den technischen und tektonischen Künsten, oder Praktische Esthetik*, Verlag fur Künst and Wissenschaft (Frankfurt am Main), 1860.
8. See Auguste Choisy, *Histoire de l'architecture*, 2 vols, Gauthier-Villars (Paris), 1899.
9. Le Corbusier, *Towards a New Architecture*, trans Frederick Etchells, Architectural Press (1927). Originally published in essay form in *L'Esprit Nouveau* in 1921, subsequently published as *Vers une architecture*, Editions Crés (Paris), 1923.
10. See Friedrich Nietzsche, *Philosophy in The Tragic Age of the Greeks*, trans Marianne Cowan, Regnery Publishing (Washington DC), 1962, p 52, and Marx's *Differenz der demokritischen und epikureischen Naturphilosophie*, 1841.
11. 'Leibniz therefore describes the individual substance as essentially a "force" rather than a quantity.' Robert Latta, *Leibniz*, Oxford University Press (London), 1898, p 37.
12. Gottfried Leibniz, *Letter to Arnauld*, 1687 (G.ii.122). See ibid, p 39, note 1.
13. Ibid.
14. René Thom, *Structural Stability and Morphogenesis*, trans DH Fowler, WA Benjamin, Inc (Reading, MA), 1975, p 6.
15. Gilles Deleuze, *Le Pli: Leibniz et le Baroque*, Les Éditions de Minuit (Paris), 1988.
16. Gilles Deleuze, *The Fold*, University of Minnesota Press (Minneapolis, MN), 1993, p 3.
17. Michel Foucault, *Discipline and Punish: The Birth of the Prison*, trans A Sheridan, Vintage (New York), 1979. Originally published in French as *Surveiller et Punir; Naissance de la prison*, Éditions Gallimard (Paris), 1975.
18. Michel Foucault, *The Order of Things*, Vintage (New York), 1994. Originally published as *Les Mots et les choses: Une archéologie des sciences humaines*, Gallimard (Paris), 1966.
19. Michel Foucault, *Discipline and Punish: The Birth of the Prison*, trans A Sheridan, Vintage (New York), 1979, pp 206–7.
20. Michel Foucault, 'Two Lectures' (1976), in C Gordon (ed), *Power/Knowledge: Selected Interviews and Other Writings, 1972–1977*, Harvester (London), 1980, p 98.
21. Michel Foucault, 'Truth and Power', in ibid, p 114.
22. Originally published as *Urbanisme*, G Crés, (Paris), 1925. First English publication by Payson & Clarke Ltd, NY, nd 1929, from 8th edition of *Urbanisme*.
23. Le Corbusier, *The City of To-morrow and its Planning*, trans Frederick Etchells, Dover (Mineola, NY), 1987, p 93.
24. Ibid, p 10.

Mark Garcia



# URE SCAPES SPATIAL TAILS

## AN INTERVIEW WITH PHILIPPE RAHM

From his Paris base, **Philippe Rahm** has gained an international reputation for uncharted explorations into the physical environment; his preoccupation with the meteorological has opened up wholly new possibilities for sustainable design. In this interview with Guest-Editor **Mark Garcia**, Rahm highlights how his practice has developed an alternative approach, or third way, for the detail, which is neither the highly worked-up tectonic detail nor the non-detail, but instead has grown out of a focus on climate and the application of new and often modest techniques.

Philippe Rahm's research into redesigning spaces through new and emerging technologies has revolved around the production and modification of the very small, invisible, multisensory and physiologically reactive details of space. While this close and scientific attentiveness and sensitivity to the details of the environmental conditioning of space has largely been the preserve of services engineers and their related disciplines (electrical, mechanical, plumbing, ventilation, heating, air conditioning and, most recently, data and wireless communications), Rahm has relocated and integrated it firmly and distinctly into the core of contemporary spatial design.

Always driven by theory and by research and concepts from the sciences, Rahm's early experiments were often at the avant-garde of art/architecture or conceptual architecture, and as interior or architectural design. Having now matured into a bigger office with larger, more permanent projects including an urban park in Taiwan, he is successfully upgrading his design research methodologies and his small, experimental prototypes, pavilions and concepts into larger designs which (though now operating at the urban and landscape scales) retain the conceptual, processual and production primacy of the detail throughout the whole of the design.

**Philippe Rahm architectes, Mosbach paysagistes and Ricky Liu & Associates, Jade Meteo Park, Taichung, Taiwan, due for completion in 2015**
*previous spread*: Masterplan showing the park's three types of natural and artificial climate servicing devices, connected by climatic paths that link them as separate but networked zones of similarly microclimate-controlled details.

*above*: Blue areas and devices reduce the humidity, pink reduce temperature and grey the air pollution.

Rendering of the natural and artificial climatic devices. The synergy of both the natural and artificial to generate highly specific yet continuously adjusting microclimates regulates the humidity, temperature and air pollution of the landscape environments.

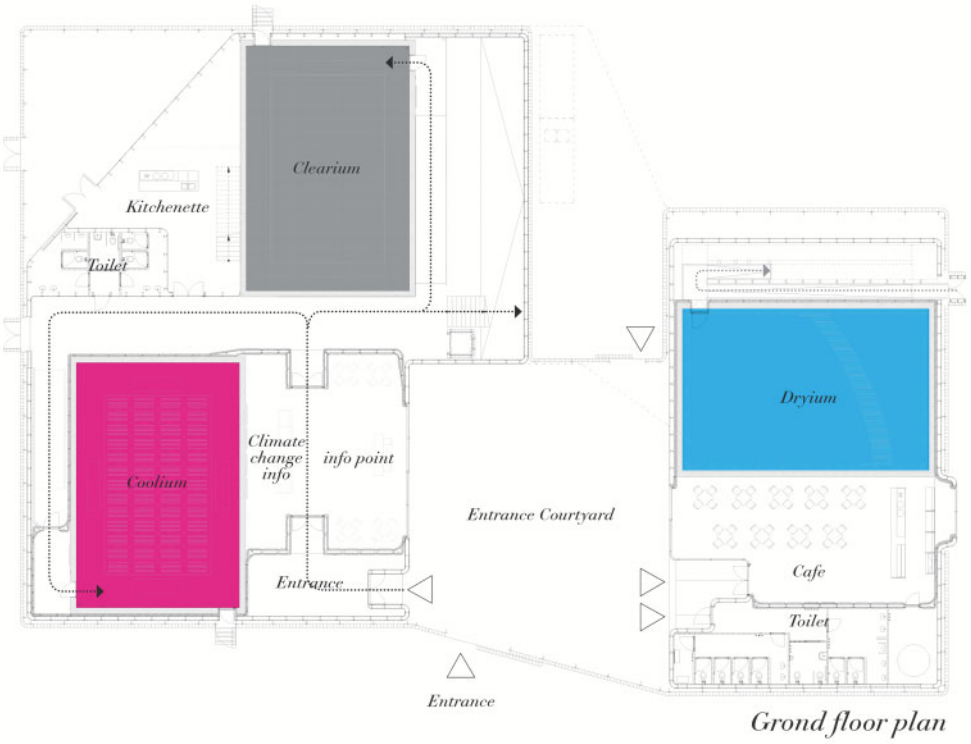
**Meteorological Details of Space**

Rahm identifies two tendencies in the contemporary discourses of the detail in architecture: 'The detail is most related to the tectonic; in the discourse of architecture, both the modern and the classical sense, there are two tendencies of detailing. In one, for example with David Chipperfield or with Hans Kollhoff, the detail is tectonic and an [inherent?] part of the shape and form of the building. It relates to the expression of the construction of the detail as it becomes the building. The other tendency is that of "no-detail", for example in the work of Rem Koolhaas. It comes from trying to find the most efficient way to build without the detail … These are the traditional distinctions of the detail.'

Rahm is critical of both tendencies. In the first: 'Very often it is faked. It is an image. The tectonic idea is sometimes obscured. For example, with concrete all the forces are there together in the concrete so you no longer understand the forces in the whole construction. The process becomes hidden. It can become nostalgic and aestheticist … In the second, techniques of construction are sometimes not strong enough to realise what (as architects) we want to realise. Neither tendency starts from the detail.'

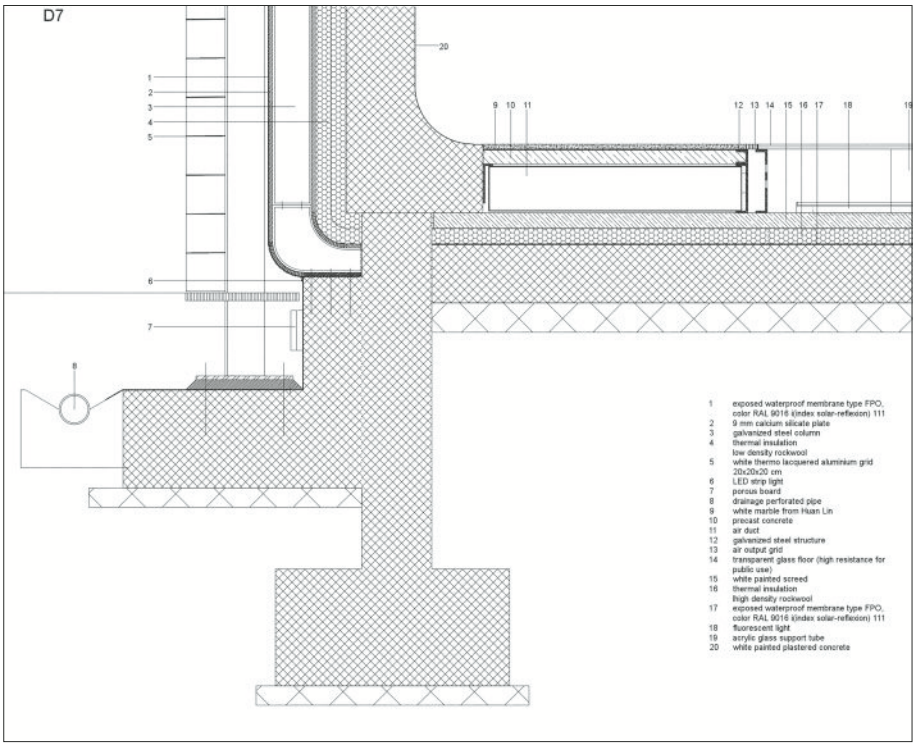
Rahm's research is pursuing another, alternative approach: 'Maybe there is a kind of new, or another direction in my work – the detail that comes from small or new techniques that are more linked to climate. In the normal design process, ventilation is achieved through the positioning of radiators and the management of humidity and other meteorological details. The services engineers are in charge of this and they come completely at the end. But we can reverse the process. Today these questions of heat, radiators etc are becoming much more important because of the need for sustainability, and due to energy-reduction laws.

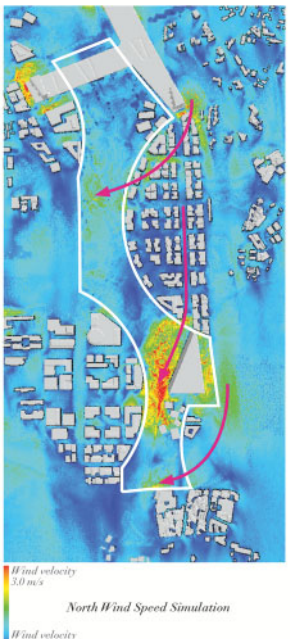
'We have done a lot of projects that completely reverse the design and detailing process. We started with small design details like those of ventilation, temperature, humidity and light. So we had a pipe, and we asked: "Why not enlarge this pipe", and the pipe became a space that became a corridor [for example in Filtered Realities, 2008]. For humidity we started with the idea of Mollier diagrams and how they were used to organise air, finding the shape according to this management [Mollier Houses, Vassivière, France, 2005]. Then, rather than working with structural engineers, we might work with thermal engineers first. The result is sometimes invisible.'




Organisation of the three main Meteorium meteorological spaces: the Coolium, Dryium and Clearium.

Succession of the climatic layers composing the transition between exterior to interior: physical layer, waterproof layer, thermal insulation layer and structural layer.






North Wind Speed Simulation


Influence of North Wind from Simulation


Cooling Devices Location and Cool Path

**Meteorological Details of Landscape**

Moving out in scale, in 2011 Philippe Rahm architectes, Mosbach paysagistes and Ricky Liu & Associates won the international competition to design the Jade Meteo Park, a large 70-hectare (170-acre) urban park in Taichung, Taiwan, including a 1,500-square-metre (16,150-square-foot) visitor centre. Due for completion in July 2015, and with a budget of US$90 million, this high-tech landscape project is designed to have a continuous and active presence for surveillance, security, control and maintenance as well as for public interaction. Its genealogy can be traced back directly to the 19th-century landscapes of Frederick Law Olmstead and Jean-Charles Alphand, and to the avant-garde late 20th- and early 21st-century precedents of OMA's Parc de la Villette (Paris, 1982), Downsview Park (Toronto, 2000) and, more recently, to the work for Fresh Kills Park (Staten Island, New York, 2009–) by James Corner Field Operations.

However, this project differs from its antecedents through its use of computational fluid dynamics (CFD) simulation to survey the landscape and its existing microclimates, as well as the effects of the details of individual design interventions on the design as a whole. One of the most central features of the Jade Meteo Park design is its deployment of advanced wireless, publically and aesthetically prominent climate-control technologies throughout the landscape (its real-time environmental conditions are updated and customised for personal experience on the iPhone and iPad). In addition, the range of climate factors Rahm has chosen to design with are also very different from previous precedents, though they share certain similarities in their diagrammatic design concepts and methods.

All of the projects referred to above focus on the overlapping transpositions of different types of artificial and natural details to create continuous cross-mixings of factors, generating multiple field conditions punctuated by intensities and singularities of difference, variety and variation in the distributions of factors. In the Jade Meteo Park, the CFD simulations revealed 11 main areas, or 'Climatic Lands', of the park that became the focus of the climatic interventions, where temperature, humidity and air pollution were intensively modified through natural (choice of plants, trees etc) and high-tech artificial devices to achieve the required overlapping microclimates. The cooling devices use convection cooling to blow air that is chilled through underground heat-exchange mechanisms. Conductive cooling, shading, water chilling and misting/evaporation devices cool specific spaces. The drying devices blow air through silicate gel exchangers to create dehumidified spaces. Active air-filtration devices that remove nitrogen oxide, sulphur dioxide and ozone as well as free-floating aerosol particulates are combined with ultrasound devices to repel mosquitoes, creating cleaner air spaces.

North Wind Velocity and Vector Simulation

Influence of North Wind and Surrounding Roads from Simulation

Depolluting Devices Location and Clean Path

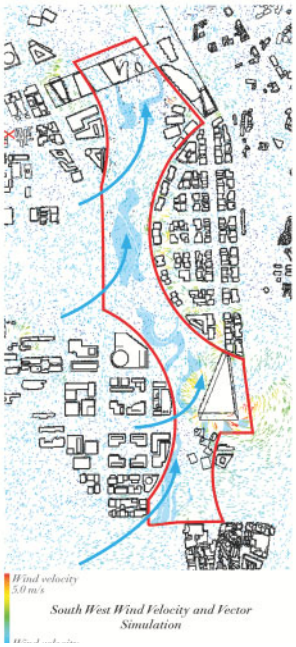
This mix of three different types of climatic interventions creates a wide diversity of microclimates and multiple sensory experiences at different hours of the day and across the year. Cool climatic lands contain leisure programmes, dry climatic lands contain sports programmes, and cleaner climatic lands are for family activities. The same types (cooler, dryer and less polluted) of climatic zones are all linked together across the park via three corresponding Climatic Paths. As Rahm explains: 'This is a very big project, but we are able to design all the details ourselves. It is three times the size of the Parc de la Villette. All the devices of the park, from trees to fountains, can be climatic devices. We are designing gradients of details arranged in fields – there are no borders or lines.'

**Microclimatic Affects of Meteorological Details**

Inside the park, this design methodology and theory is concentrated into a corresponding tripartite architecture of cool, dry and clean. A visitor centre, the Meteorium, contains four distinct environments, each created through a specific form of detailing to produce distinct types of atmospheric and ambient affects within different architecturally detailed climates. The Climatorium is the first layer of architecture, a porous white aluminium layer (for storage, toilets, corridors, offices, information centre, café and so on). This wraps three further distinct spaces: the Coolium (cool room), Dryium (dry room) and Clearium (clear/clean/unpolluted room).

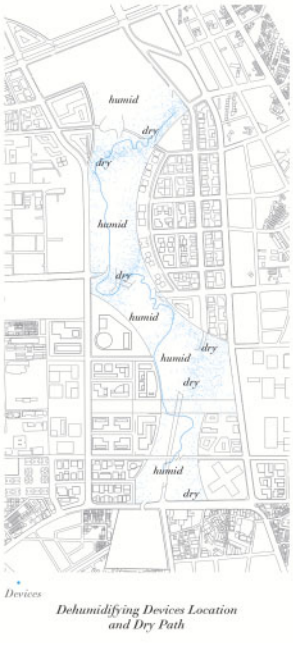
The Coolium replicates the real-time light and temperature climate of Jade Mountain in the centre of the island. The Dryium simulates the climate as it changes across a whole day, the 21 November, which is statistically the day of lowest humidity across the country. Here, fluorescent tubes are distributed throughout the room in a pattern that simulates the precise path of the sun across the Taiwan sky. The Clearium re-creates the less polluted climate of Taichung in 1832, the year before the onset of the Industrial Revolution in Taiwan. As such the whole architecture functions as a kind of museum or simulacrum of the intangible and ephemeral details of Taiwanese atmospheres and climates. Historical and real-time telepresent, these environmental ambiences are simultaneously physiologically, physically and mimetically detailed and abstract, conceptual and intellectual, critical and post-critical.

According to Rahm, the tectonic and construction method of the Meteorium focuses on the detail in order to 'separate every layer of each building, like a grid, into different habitable interstices. In a first layer, we only stop the human: wind, air, even birds can go through. The second layer is against rain and water. A third is insulating, to stop heat. The next is a structural envelope. We separate and make every layer independent, not like a traditional wall. We create spaces between layers. We divided the building in this way to understand




South West Wind Velocity and Vector Simulation


Influence of South West Wind and Basins from Simulation




Dehumidifying Devices Location and Dry Path

*above, opposite and p 83*: Diagram plans for the Dry, Cool and Clear zones of the Jade Meteo Park showing the climatic singularities and meteorological paths as interacting, shifting and overlapping field effects of micro-affects.

the functions of the wall against the single physical block (of light, humidity, noise etc) of the traditional wall. It is less deconstruction than disassociation of the layers. Normally a wall manages everything together in a single way and a single line. There are, in modern construction methods and walls, different layers, but they are all together. We divide everything to deal with different details in different ways. This is to allow for a freer, precise, controllable mix of the different details of space. The construction can have many more different and more detailed zones creating different space qualities, of different micro-affects. This always first begins with the detailed sensing and mapping of spaces. The programme comes after the climate: this is programme-to-climate or form-follows-climate or even function-follows-climate.'

**Infra-Meteorologies and Micro-Affects in the Future Details of Architecture**

For Rahm, the future details of architecture lie not in 'the solid envelope of the space, but in the qualities of the space itself. The question of the chemical and other qualities of the air, the design of the details of the air, of the light, of the heat, its electromagnetic intensities, its chemical quality, its taste … I like the idea of "terroir" … when you drink wine you drink the minerality of the area. There is a kind of intoxication with the chemical substance of the territory and I like this idea, that it is possible to be inside the chemical quality of a terroir, to smell the mineral quality of a stone.'

Rahm's disassociating and displacing of the physical details of space to more precisely control and modulate them results in a counter-intuitive thickening of the material aspects of his designs. While these might come at a material, financial and volumetric price, their formal modesty and elegance belies a more stealthy architectural impact that relies on the production of almost immaterial micro-affects and micro-ambiences. Paradoxically, this seemingly more precise and high-resolution Modernism, or infra-high-tech detailing of the architecture, is then an elegant and efficient camouflage for what is in reality the services and servicings for the production of synthetic, invisible but hyper-detailed, more vague, diffused and blurring fields of multi-functional architectural details as micro-atmospheric micro-effects. These high-tech architectural details become the shifting meta-landscapes and infra-meteorologies of critical and political hyper-real simulations and telepresensings of landscapes through micro-affective micro-atmospheres. ▫

*Interview with Philippe Rahm conducted in Venice in August 2012.*

**Note**

1. Construction started in January 2014 with completion expected in July 2015.

# THE RISE OF THE 'INVISIBLE DETAIL'

## UBIQUITOUS COMPUTING AND THE 'MINIMUM MEANINGFUL'

The architectural detail has provided the essential material building block for conveying an idea. **Carlo Ratti and Matthew Claudel** of the SENSEable City Lab at the Massachusetts Institute of Technology (MIT) ask how this, though, is all set to change in a digital context. As technologies shrink and vanish from sight, what might become the new minimum meaningful unit for architecture? How might a new relational scale establish itself, at the level of the 'invisible detail' or the microchip? How might this, in turn, change the very nature of buildings as they become highly responsive, human-occupied transmitters?

**Carlo Ratti Associati, MG Flat, Venice Architecture Biennale, 2004**

Only two materials are used: plaster and low-cost industrial hardwood, from sawmill waste. Various elements change dynamically to serve several functions, and thanks to a video projector coupled with a rotating mirror (technology developed by IBM), any surface of the apartment can become a screen, creating a truly digital environment.

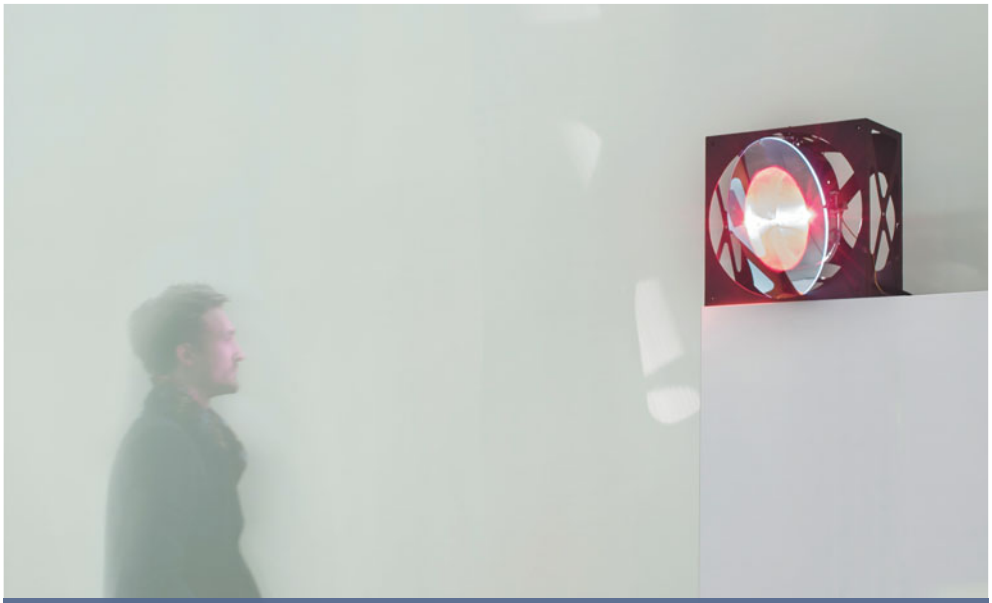
There is a grain of sand in a concrete wall in the Church of the Light in Ibaraki, Japan (1989). It is the smallest material element of the building – a mere speck – yet this sand was deliberately chosen by Tadao Ando to serve as a crucial tool in the profound transformation of human spatial experience, ultimately to resolve a meticulously crafted piece of architecture. This grain of sand is not just a utilitarian constructive material dumped into concrete slush and poured as walls of a building – it is evidence of intentionality.

The granule might seem to fall under the *Oxford English Dictionary*'s traditional definition of detail: 'A minute or subordinate part of a building, sculpture, or painting, as distinct from the larger portions or the general conception.'[1] By this characterisation, an individual detail is simply a constituent part that carries neither value independent of the whole, nor a direct relationship to it. Yet it could be more. An alternate definition – one we presuppose in this article – lends detail the weight of significance far beyond its function as a subordinate unit. What is at stake is the difference between sand as mute aggregate filling a volume of concrete, and sand as a crucial element in the delicate communication of architectural meaning. In the latter, detail can be thought of as the smallest radical element of architecture that can be imbued with significance, what in other fields, such as statistics or medicine, might be termed the 'minimum meaningful'.[2] A detail is the most basic unit for conveying an idea in and of itself while simultaneously serving as a building block in elaborating a larger concept.

An analogy is borrowed from linguistics: the morpheme, defined as 'any of the minimal grammatical units of a language, each constituting a word or meaningful part of a word, that cannot be divided into smaller independent grammatical parts'.[3] A morpheme is the irreducible linguistic element, whether it is a single letter, a group of letters or a full word. It may or may not stand alone, such that every word is composed of one or more morphemes. Yet the critical qualifier is that it conveys meaning. Similarly, in an architectural sense, the smallest morphological detail is irreducible and carries meaning in and of itself, in addition to composing the overarching theoretical construct of a building. Peter Zumthor, an architect renowned for his mastery of material, contends that 'details express what the basic idea of the design requires at the relevant point in the object … They lead to an understanding of the whole of which they are an inherent part.'[4] As in Ando's grain of sand, detail can be thought of as a hyper-specific, localised transmitter of meaning that simultaneously echoes and composes the intricate ensemble.

Detail is the crucial operative component of architecture: from the small to the large and from material to concept, the detail holds sway. The individual unit, the minimum meaningful, echoes and constitutes the whole. How, then, can the notion of detail be redefined in a digital context? How can architects surrounded and suffused by networks explore possibilities beyond what is material or formal? Will the architect continue to be fettered by those same means of conveying significance? Can we imagine a new, digital 'minimum meaningful unit' of signification?

Zumthor's solemn material piety and Ando's attention to the minutiae of construction amount to a contemporary obsession with detail – a preoccupation that can be traced back to the Modernism of the early 20th century. Its momentum began with a concerted effort to strip architecture of ornament,



**MIT SENSEable City Lab, Local Warming research project, Cambridge, Massachusetts, 2012**

Today there is a radical asymmetry between human occupation of buildings and climate control. Local Warming dynamically puts heat exactly where people are, using a motion tracking system and infrared lenses to create personal (and personalised) climates.

effectively destroying the intermediary means of architectural communication. And if 'ornament is crime', as Adolf Loos polemically contended,[5] the architect's only recourse was to obsessively focus on abstract detail – a white wall demands perfection. The constructive detail, the minimum meaningful, was paramount, and each nakedly visible element had to speak clearly, from the choice of window dimensions to the type of metal in a doorknob. In the final capitulation of ornament, only the micro and the macro of architecture remained – material and concept – amplifying a stark dichotomy of scales and demanding that the architect consider every visual and material choice intentionally. The era continued to echo with manifesto-driving phrases – 'Less is More',[6] 'God is in the details',[7] 'Architecture is order'[8] – that elevated detail proportionately to the social theory it supported. According to Marco Frascari: 'The common denominator in these different forms and uses (of the phrase "God is in the details") indicates that the detail expresses the process of signification; that is, the attaching of meanings to man-produced objects.'[9] Modernism exacerbated a dipole of distilled material simplicity and abstract coherence.

Today, as silicon merges with concrete, wood and brick – that is, as architecture receives a heady digital transfusion – a new relational scale may emerge. Technologies are shrinking and even vanishing from sight, gently suffusing our buildings and cities, and handing architects a new toolkit for conveying meaning at the human scale. Microchips have become fluid, adaptable and dispersed, to the point that detail is not strictly visual, but virtual: 'The suggestion that the detail is the minimal unit of production,' wrote Frascari, 'is more fruitful because of the double-faced role of technology, which unifies the tangible and intangible of architecture.'[10]

At the event horizon of the tangible/digital collapse, technology can constitute a minimum meaningful unit for architecture in several ways. First, a microchip (or its effect on a building) can be made visually explicit as physical components of the building. Borrowing from the work of Hiroshi Ishii at the Massachusetts Institute of Technology (MIT) Media Lab, this digitally activated space could be thought of as 'radical atoms': 'Our vision of "radical atoms" is based on hypothetical, extremely malleable and reconfigurable

*'Radical atoms are blossoming into a thriving field at the crux of computation and fabrication, poised to transform architecture through a profound denouement of the traditional physical / digital boundary.'*


**Carlo Ratti Associati, Digital Water Pavilion, World Expo, Zaragoza, Spain, 2008**

The pavilion dynamically alters both its visual and experiential qualities in response to human behaviour. Thousands of droplets of falling water form a liquid curtain that is minutely controlled by digital valves, parting to admit visitors or displaying living text and images. The pavilion can become a game as children jumping through its walls, a communication tool showing words and images, or a piece of urban art for Zaragoza's citizens.

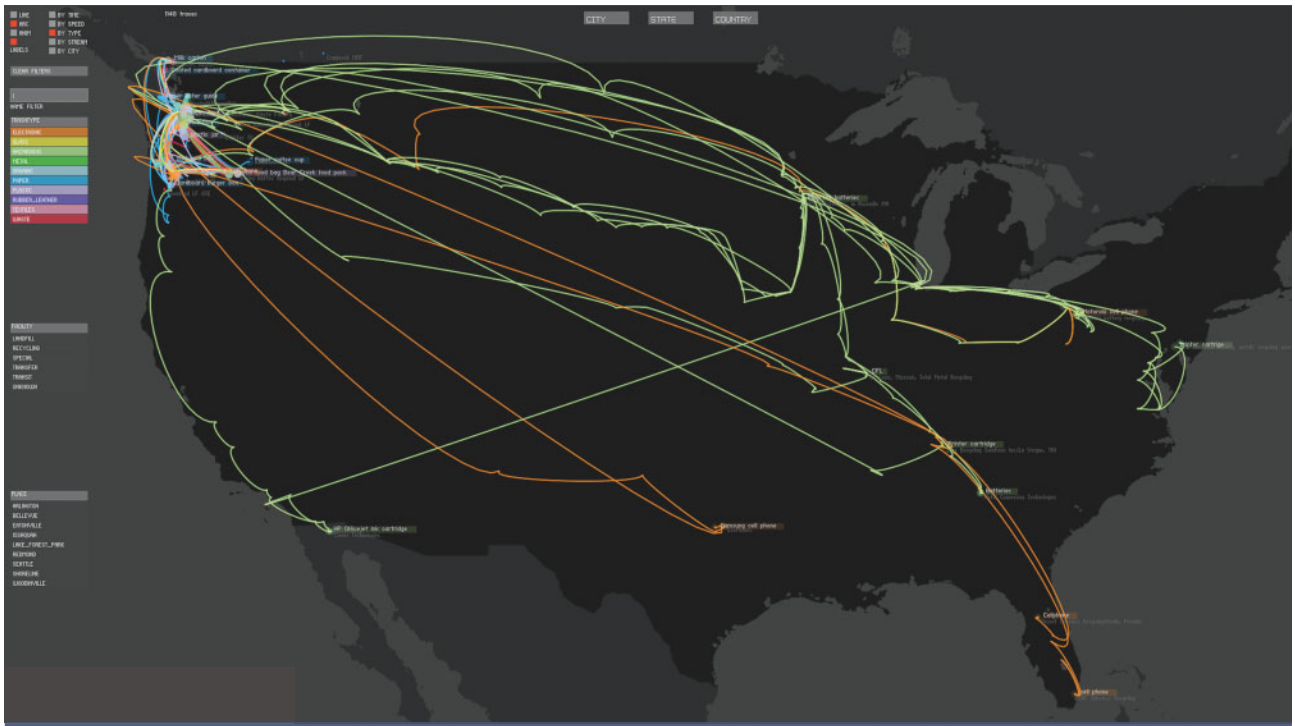
materials that can be described by real-time digital models so that dynamic changes in digital information can be reflected by a dynamic change in physical state and vice-versa. Bidirectional synchronization is key.'[11]

Radical atoms are blossoming into a thriving field at the crux of computation and fabrication, poised to transform architecture through a profound denouement of the traditional physical/digital boundary. Explorations like Cedric Price's pioneering cybernetic theory of performative architecture (1976–80) – buildings that could be constantly reconfigured by an algorithmic 'Boredom Program') – through Jean Nouvel's Institut du Monde Arabe (1987), with its light-responsive facade of dilating apertures, show possibilities for mechanical systems to be controlled remotely or immediately and explicitly transform a building's appearance and operation in real time. As technologies and materials become increasingly sophisticated, built space will appear as never before, visually transformed as a result of explorations in dynamic structure animated by sensors and actuators working in tandem.

From the propagation of ubiquitous computing, another tool has emerged to shape and communicate the minimum meaningful: 'invisible detail'. Without being visually perceived, a microchip can nonetheless instigate a powerful interaction between people or between people and architecture, becoming, in many ways, a system of 'living bits and bricks'.[12] Through these ambient electronics, intangible interactions with the building and its inhabitants are now the subject of design. If the essence of architecture is to shape the human experience of space, then the faculty of the architect expands dramatically when he has the ability to deploy technologies that remain unseen yet reveal their presence – convey meaning – performatively, through their effect on people.

At the same time, intangible elements can also be a crucial interface with broader networks, exploding architecture to a potentially infinite scale (and radicalising the Bauhaus dream of working 'from spoon to city').[13] Being enmeshed with a digital fabric constitutes a dramatic shift in the purview of architecture, what Mark Wigley describes as 'network fever': 'The growth of invisible networks demanded new scanning instruments. The computer was the ideal mechanism to negotiate between the visible and the invisible … Electronic space is being settled.'[14] What Wigley describes is an integral coupling of digital bits and material atoms, one that redefines the role of networks in humanity's physical space. In the same way as architecture mediated between man and environment (primitive hut), citizen and state (government building), or believer and god (church), digitally infused space can become the new interface between the human and the global network, a hyperlink between personal experience and, well, everything.

Networks overlaid on physical space now form a digital blanket that connects people, objects and events, enabling a vibrant and unprecedented understanding of patterns and flows – the signature of humanity. In only the past decade, the meteoric propagation of smart phones has placed a high-powered computer in almost every pocket, activating each denizen of the city as a node in the collective human network. Even beyond telecommunications, sophisticated technologies for sensing and actuating allow for real-time observation, analysis and transformation of urban space, an idea developed, among others, by Mark Shepard in *Sentient City: Ubiquitous Computing,*




**MIT SENSEable City Lab, TrashTrack research project, Seattle, 2009**

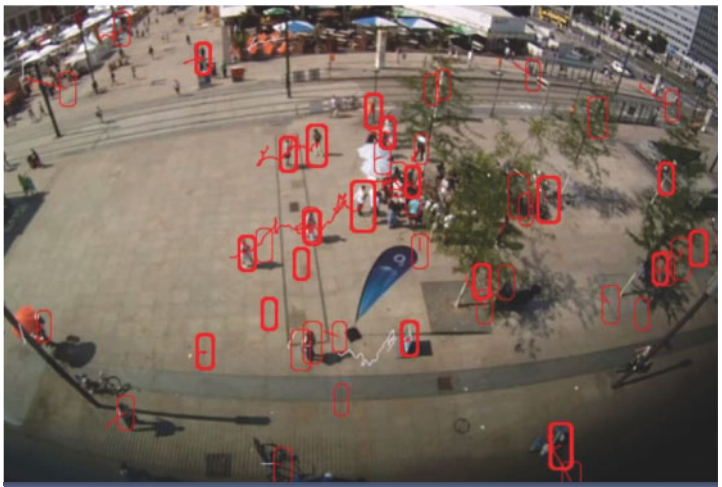
Digital and physical merge to reveal an invisible metabolic function of the city: its waste removal system. In 2009 an initial deployment of thousands of geolocating tags were attached to ordinary pieces of garbage, and over the following weeks and months traced a dizzyingly complex disposal chain across the entire US: an elaborate system brought to light through the invisible detail.

*'There is no longer a dichotomy between the visible and the invisible, tangible and intangible details: radical atoms and invisible details are intrinsically bound by a technology-infused performative dimension.'*

*Architecture, and the Future of Urban Space*,[15] and ultimately amounting to the invisible detail at the city scale. Using these tools, a team of researchers at the MIT SENSEable City Lab initiated the TrashTrack project in 2008, which sought to sense and analyse an invisible metropolitan dimension: the waste disposal system. By attaching geolocating tags to thousands of ordinary pieces of trash, a surprising (and inefficient) network was revealed. The digital suffusion of urban space allowed an unprecedented visualisation of waste management dynamics, pointing towards innovation from the scale of individual behaviour to that of systematic management. In short, silicon details constitute a fine-grained ambient intelligence, vivifying the built environment as embedded, invisible yet decisive architectural elements that operate at the convergence of bits and atoms.

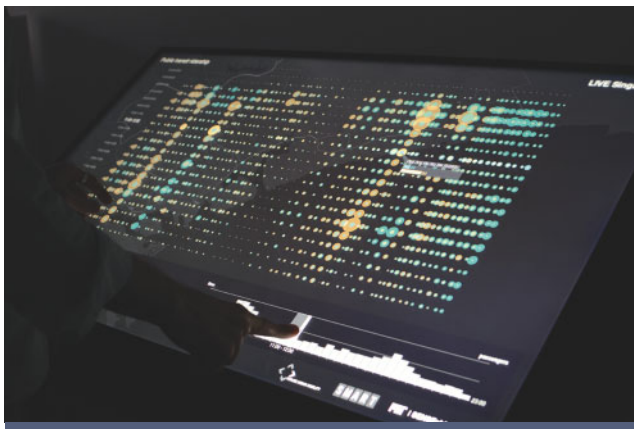
There is no longer a dichotomy between the visible and the invisible, tangible and intangible details: radical atoms and invisible details are intrinsically bound by a technology-infused performative dimension. Whether or not they are material, details acquire meaning – integral, communicative meaning – if they change human interaction with and within architecture. 'Buildings must foster a new sensitive and intelligent dialogue,' balancing between grafted technological extension of humans and a functionally distant host to their activities.[16] The minimum meaningful unit strikes that chord, conveying significance through dynamic space and through people themselves.

In the mid-1980s, as technology moved towards prosthesis, a nascent 'cyborg theory' emerged, thanks to the ideas of theorists like Donna Haraway,[17] William Mitchell[18] and David Rorvik.[19] This same line of thinking carried forward to 'post-humanism', with a new generation of congenital rather than prosthetic technology, and today gives way to digitally networked humans integrally



**MIT SENSEable City Lab, Dynamic Public Spaces, BMW Guggenheim Lab, Berlin, 2012**

The workshop brought together citizens and networked technologies in Berlin's Alexanderplatz to impact augmented public space. Dynamic image processing detected pedestrian paths, behaviours and group dynamics, while ambient electronics traced noise, pollutant and social media data in real time. As a demonstration of mobility, communication and interaction, the results may lead to new ideas and better anthropocentric design for urban space.



**MIT SENSEable City Lab, LIVE Singapore! research initiative, Singapore-MIT Alliance for Research Technology (SMART) Centre, Singapore, 2009–**

LIVE Singapore! is an ongoing research initiative to develop robust platforms for the collection, management and visualisation of large real-time datasets, from telecommunications networks to transportation systems and weather patterns. What emerges is an intuitive cartographic information system suggesting new ways to view, understand and navigate the city.

enmeshed in an Internet of Things.[20] With a complete suffusion, invisible detail will be the crux of performative interaction between people and with architecture.

The Modernism of the 20th century sparked an epoch of detail as a monologue rather than a dialogue. The minimum meaningful unit was a material, tangible morpheme that amounted to a poured-in-place manifesto. But that is changing. As built space comes to life at the convergence of bits and atoms, we have the opportunity – the responsibility – to rethink architectural detail as a responsive, performative, human-integrated transmitter of meaning. Architect and theorist Peter Eisenman polemically asked: 'Now that technology has gone rampant, maybe we need to rethink the cosmology – can we go back to a cosmology of anthropocentrism?'[21] And that, precisely, is the power of the architectural detail in a digital era: to refocus the minimum meaningful unit of significance onto human interaction.

**Notes**

1. OED Online, December 2013: www.oed.com/view/Entry/51168?rskey=NUJNz6&result=1&isAdvanced=false.
2. Martin Krampen, *Meaning in the Urban Environment*, Routledge & Kegan Paul (London), 1980, p 11.
3. OED Online, December 2013: www.oed.com/view/Entry/122336?redirectedFrom=morpheme.
4. Peter Zumthor, *Thinking Architecture*, Birkhäuser (Berlin), 1977, p 16.
5. Adolf Loos, 'Ornament und Verbrechen', 1908. Published in English as 'Ornament and Crime', in *Ornament and Crime: Selected Essays*, trans Michael Mitchell, Ariadne Press (Riverside, CA) 1998.
6. Mies van der Rohe, quoted in Paula Behrens, *VIA 7: The Building of Architecture*, MIT Press (Cambridge, MA), 1984, pp 23–37.
7. Mies van der Rohe, quoted in Aldman Whitman, 'Obituary, Ludwig Mies van der Rohe', *New York Times*, 19 August 1969: www.nytimes.com/learning/general/onthisday/bday/0327.html.
8. Le Corbusier, *Toward an Architecture*, trans John Goodman, Dover Publications (New York), 1986, p 3.
9. Marco Frascari, 'The Tell-the-Tale Detail', 1981. Published in Kate Nesbitt (ed), *Theorizing a New Agenda for Architecture: An Anthology of Architectural Theory 1965–1995*, Princeton Architectural Press (New York), 1996.
10. Ibid, p 10.
11. Hiroshi Ishii, *Tangible Media Group*, MIT Media Lab, 2013: http://tangible.media.mit.edu/project/radical-atoms/.
12. Carlo Ratti and Alex Haw, 'Living Bits and Bricks', *Architectural Review*, 24 April 2012: www.architectural-review.com/essays/living-bits-and-bricks/8629380.article.
13. 'Dal cucchiaio alla città' (from spoon to city) is a slogan coined by Italian architect and critic Ernesto Nathan Rogers to describe the Milanese architectural and design process, which at the time encompassed all scales. There is some disagreement about when Rogers said this; Deyan Sudjic notes that Rogers wrote something very much like it in a 1952 editorial for *Domus*. See Deyan Sudjic, *The Language of Things: Understanding the World of Desirable Objects*, WW Norton (New York), 2009, p 34.
14. Mark Wigley, 'Network Fever', *Grey Room*, No 4, Summer 2001, pp 82–122.
15. Mark Shepard, *Sentient City: Ubiquitous Computing, Architecture, and the Future of Urban Space*, MIT Press (Cambridge, MA), 2011.
16. Antoine Picon and Carlo Ratti, 'Architecture Vivante: des Bâtiments aux Usagers', *L'Architecture d'Aujourd'hui*, 3 September 2013, p 73.
17. Donna Jeanne Haraway, 'A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century', *Simians, Cyborgs and Women: The Reinvention of Nature*. Routledge (New York), 1990.
18. William Mitchell, *Me++: The Cyborg Self and the Networked City*, MIT Press (Cambridge, MA), 2003.
19. David M Rorvik, *As Man Becomes Machine: the Evolution of the Cyborg*, Doubleday (Garden City, NY), 1971.
20. Neil Gershenfeld, Raffi Krikorian and Danny Cohen, 'The Internet of Things', *Scientific American*, October 2004, pp 76–81.
21. Peter Eisenman and Christopher Alexander, 'Debate: Contrasting Concepts of Harmony in Architecture', Harvard Graduate School of Design (GSD), 1982. First published in *Lotus International*, Issue 40, 1983, pp 60–8.

# INFORMATION, COMPLEXITY AND THE DETAIL

Gehry Partners, Fondation Louis Vuitton, Paris, 2005–currently under construction

The proliferation of affordable computing has transformed the capability of architecture to deal with complex forms and details. As **Dennis R Shelden**, Chief Technology Officer of Gehry Technologies, explains, this has resulted in the production of an abundance of digital information or data. The intersection of two curved surfaces, for instance, is now much more complex than the surfaces themselves. Complexity requires more information and thus more processing, making details like this ultimately more expensive to produce. The jury is still out on what the future might hold, as architecture undergoes a period of fundamental transition in which, for the time being at least, there remains an essential mismatch between the surfeit of digital information and the tight economic limits on physical production.

It is clear that architecture has by now been fundamentally impacted by computation, including its various professional and theoretical permutations – building information modelling (BIM), parametric modelling, and algorithmic and generative approaches. This impact ranges from the radical expansion of the palette of available and realisable forms to the changing practices, shifting roles and reconfiguration of processes made possible by BIM.

Beyond its impact on the tools and techniques of architectural practice, it is appropriate to consider the deeper question of how computation has affected the architectural object itself. Have buildings become more essentially computational, and if so, how? Does parametric modelling conducted in the practice of architecture result in a building that is inherently parametric? How does the computational nature of the project persist and become legible in the end product? How can we characterise and quantify this computational content of built form?

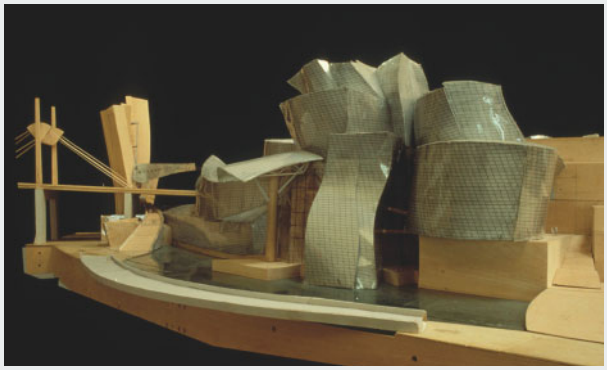
The detail is an appropriate point of inspection for this inquiry. The term 'detail' is itself multivalent and evocative, suggesting specific, focused points where the macro forces of the building come together and collide, and their collisions resolve. This focused concentration of effort and information suggests a place to see the impacts of calculation and computation exposed as a geometric solution. At the same time, the detail evokes a sense of the physicality of design, where the more abstract ambitions of form confront the necessity of material and material-processing resolution. Further, the detail suggests a specific localised expression of the systems of building, and the resolution of architectural intention as systems design, expressed both as geometric logic and organisation of parts.

These three themes – of geometry, materiality and systemisation – are clear and significant themes of contemporary architectural computation, and perhaps of architecture at large. This essay attempts to consider them specifically from the vantage of computational and information theory to ask: What are the structures, topologies and organisations implied by architectural computation in general, and how do these structures map themselves into, and manifest themselves as, today's architectural projects? The detail is here a compelling point of focus.

## PHYSICAL COMPUTING

To tackle these questions, we must first recognise that computation is not just something conducted in digital machines and abstract numerical spaces, but a possibility of the world itself. While now less familiar than theoretical, numerical and digital alternatives, the notion of computing 'in the world' has a historical basis extending back to Euclid's axiomatic system of constructions that serves as the foundation of Western geometry.[1] A theory of design algebra that operates directly on spatial shapes has been treated extensively in George Stiny's shape grammars.[2]

By extension, we can rigorously consider hybrid mathematical systems whose operations are performed partially in physical space and partly in numerical or digital space, drawing on mathematical regularities, similarities and mappings of both spaces to connect together operations conducted in each. Manifold theory and Hilbert spaces, among others, provide the mathematical mechanics for constructing systems that operate across multiple spatial topologies.



**Gehry Partners, Guggenheim Museum, Bilbao, Spain, 1997**
Physical modelling draws on material behaviour to solve for the geometry of downstream sheet material enclosure systems.

The common characteristic that binds these disparate topologies together is space: the natural spatial regularities of measurement, distance, continuity and the like that appear in both numerical systems and physical spaces and can be counted on to transfer computational results from one medium to another. This spatial information infuses across the project, binding its various media, operations and artefacts together. It persists in the form and its descriptions, but moreover is projected across the various processes that produce the form, connecting design intent to the digital tools and physical toolings of the architectural, engineering and construction project writ large.

We can see model-making and indeed construction as examples of posing and solving problems as physical computations: mathematical systems of spaces, elements and their operations that exist or are performed in physical space. A physical model can be seen as a computational system for exploring the behaviours of digital algorithms (and the ultimate behaviours of construction systems) in as much as now digital models serve to explore and predict the possibilities of a physical world. A paper sheet can stand in for a number of algorithmic surfaces, including the well-known developable or curvature-constrained surfaces, as well as represent the constraints and affordances of a range of folded-plate and sheet-enclosure systems. The sheet's internal molecular stresses conspire to guide the designer towards configurations geometrically analogous to those of the algorithmic geometries, through interactions that are far more direct and tactile than those of its digital analogues.

While we recognise the similarities of these chosen systems and draw on them to associate the model and its target, we of course also accept that they are not the same thing: physical and digital space have both phenomenological and topological differences as much as they are similar. The remarkable ability of digital models to serve as predictors for a future architectural state is neither a happy accident nor in any way inevitable, but rather the result of deliberate choices made in the selection of both materials and algorithms, and of continuous effort in keeping these phenomena aligned over the progression of design, simulation and construction.

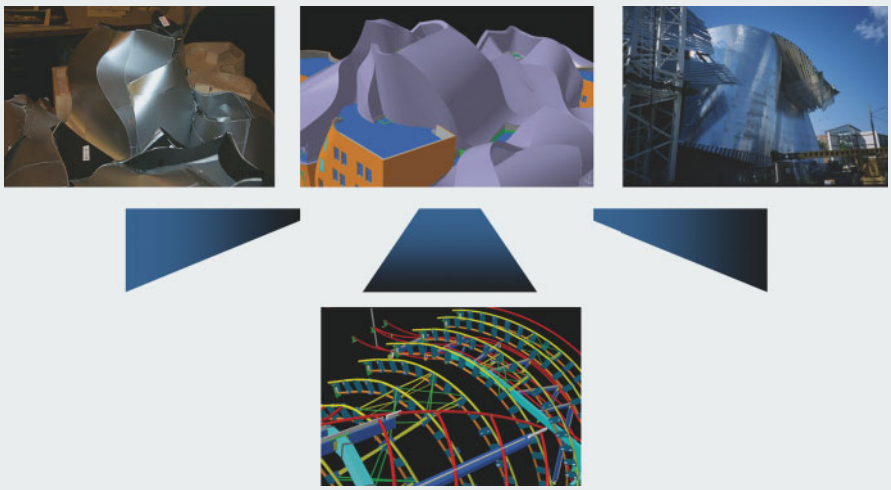
## GEOMETRY AND COMPLEXITY

It would seem self-evident that today's non-Euclidean geometries are more complex than the orthogonal constructs of the past, and that the widespread availability of computing at vast scales and low cost has afforded architecture unprecedented capabilities to tractably manage and manipulate this complexity. An arc is more complex than a line, a sphere than a plane, and a curve or curved surface considerably more complex still. A system for fabricating planar or space curve joints requires more complexity – more degrees of freedom, more gears, more memory and information processing – than one that produces a linear break edge.

Information theory as developed by Claude Shannon[3] and Andrei Kolmogorov[4] allows us to formulate and measure this complexity in a rigorous manner, a topic whose architectural significance was explored by William Mitchell.[5] From a computational perspective we can see the increasing complexity of these richer shapes through the lens of their geometric descriptions: increasingly complex functions requiring higher-order factors, more nodes and more data. We can simply say that the complexity of a project is proportional to the number of parameters necessary to describe it – a number that increases exponentially as form expands from planar to complex geometry, concept to detailing, and digital to physical space.

As complex as curved-surface mathematical descriptions are, their physical analogues are infinitely more so, for while the complexity of a geometric surface is on the order of the number of its control points, the potential complexity of a physical surface is as high as the count of its molecules. The purpose of materials processing – the industrial operations that render trees into 2x4s and ore into metal sheet – is to lower the world's complexity and align its behaviour to those geometries for which we have tractable models and numerical solutions.

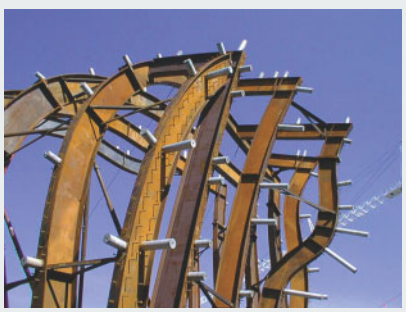
**Gehry Partners, Peter B Lewis Building, Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, 2002**
Information content and information complexity expand exponentially as geometry moves from overall form to detail, and from digital to physical media.



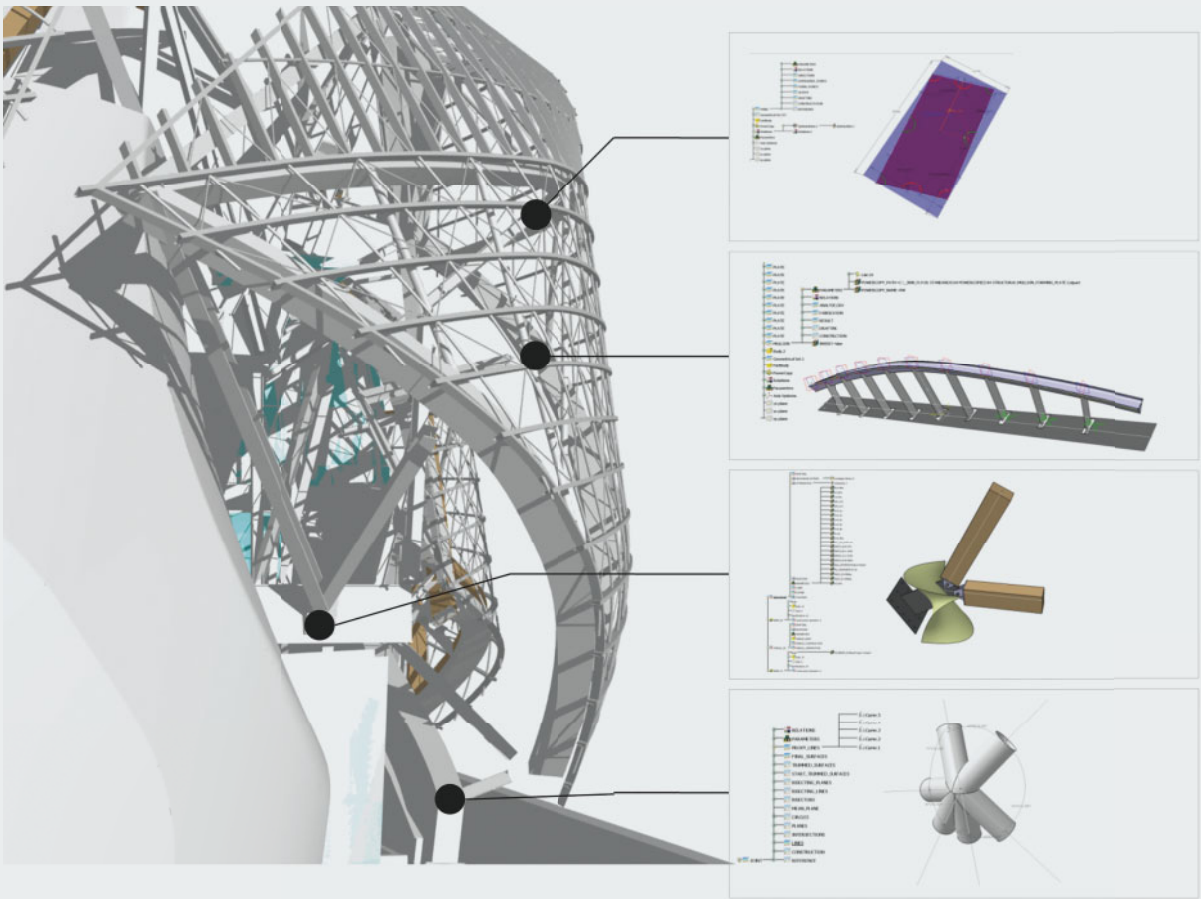
## DETAILS AS PRODUCT SPACES

The intersection of two curved surfaces is more complex than the surfaces themselves, and the detail of this intersection requires more information, more processing and more cost from an information, production and financial perspective than the surfaces that it connects. The connection detail must resolve all the geometric, material and systematic requirements of all the systems it connects. The detail therefore occupies not just the geometric or spatial intersection of the connecting systems, but also occurs in the product space of these systems' parametric spaces of possibility.[6] The complexity of this product space is the exponential sum of the dimension of each system.

The information content of form propagates into its detailing, collecting at these points of system resolution. This information content is preserved in ways that are somewhat invariant over any selection of fabrication approach. There are no simple ways of detailing complex forms; rather, we can see the complexity of the macro form moved around by detailing decisions, distributed and solved for in different ways. Consider two different, now somewhat classical approaches to detailing complex structural frames on Gehry's Experience Music Museum (Seattle, 2000) and Walt Disney Concert Hall (Los Angeles, 2003). The former relies on a curved rib system, while the latter is rationalised into a regular bay of standard linear extrusions. While the Concert Hall members are absolutely simple in their construction, the geometric complexity of the form is collected at the connection. In contrast, on Experience Music the geometric complexity and associated information content is more diffuse, spread across the length of the beam and away from the connection that becomes a simple angle bracket. We can see in these two examples radically different methods for addressing the complexity of the macro-level form, not just in the geometries chosen, but in the strategy for distributing, collecting and resolving the form's information content.



**Gehry Partners, Experience Music Museum, Seattle, 2000**
**Gehry Partners, Walt Disney Concert Hall, Los Angeles, 2003**
*centre and bottom*: Detailing strategies present markedly different approaches to localising and resolving information and fabrication costs.



**Gehry Partners, Fondation Louis Vuitton, Paris, 2005-currently under construction**
Parametric details can be highly intelligent objects, encapsulating numerous behaviours and operations. Beyond geometric specificity, intelligent details can be self-analysing and self-documenting. They adhere to object-oriented encapsulation including rigorous distinction between external and internal behaviours.

## COMPLEXITY AND MAKING

It is possible to claim that the new geometries – the non-Euclidean forms that characterise much of contemporary architectural form – set the stage for architecture's re-engagement with the physical world. This has been true first off as a pragmatic necessity. In the most conventional practice, the detail is developed downstream of form. Conventional architecture is intentionally developed independent of construction means and methods, as a way of protecting intent from the fluctuations and idiosyncrasies of procurement. Slab and column frames can be constructed equally of steel or concrete, or a wood frame from metal stud, without radically impacting the design concept. This independence of form and material from construction became the plaything of Postmodernism. The fidelity of form to construction became a variable in architectural style – one could orient materials and details to greater affinity or, alternatively, with greater play to those formal qualities the material enabled, but this game unfolded with little penalty to construction costs or pragmatics.

Non-Euclidean forms have created a tighter link between the macro-scale gestures of form and their fabricated realisation, and the detail is the locus of this connection between form and production. Unlike their planar equivalents, contemporary forms are not uniform in their connection to specific means of fabrication. Families of geometry admit specific surface qualities that can enable or prohibit specific ways of making. These production capabilities tie closely to the flexibilities – and specific economic affordances – of materials and systems. The detailed resolution of form at the local scale has resulted in a feedback loop between these aspects of design – the macro-level geometry, its localised detail, the affordances of specific materials and the mechanics of fabrication systems. This has necessarily moved conceptualisations of detailing way in advance of their place in conventional practice – from construction phase to conceptual and schematic design.

## THE OBJECT-ORIENTED DETAIL

The detailing strategies of today are developed parametrically, precisely to package, replicate and reduce information complexity. Details are developed as parametric packages that propagate into the supply-chain operations and into their spatial instantiations. As such, their system strategies are strongly informed by object-oriented information architectures. Parametric details make clear distinction between their public interfaces – the higher-level system drivers that control the detail, and the internal or private organisation. They exhibit polymorphism and class – instance organisation. This object organisation allows details information content to be encapsulated in ways that control the explosion

**Gehry Partners, Peter B Lewis Building, Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, 2002**
**Gehry Partners, Eight Spruce Street, New York, 2011**
The economies of production are shifting rapidly from site-built to increasingly prefabricated and modular assemblies, where the efficiencies of factory manufacturing over the on-site labour greatly compensate for costs of shipping. Digital modelling and assembly simulation are critical to the feasibility of prefabrication.

of geometric specificity to the detail location and minimise the potential for complexity to bleed out and across the system. Parametric detailing strategies now package a wealth of behaviour beyond the geometric configuration: they can be self-documenting, self-fabricating, self-analysing, self-classifying and exhibit other intelligent behaviours.

## PRODUCTION AND INFORMATION COST

The practices of architecture, engineering and construction have evolved in response to an implied calculus that trades off costs of complexity between description and physical production. This balance of information cost shifts over time. The cost of project description – architectural and engineering documentation – was historically high relative to production on site or in the factory, resulting in the modern modular construction, mass produced as repetitively dimensioned parts or resolved in the field by trades.

Digital design, and specifically the economies of automation, has shifted the economic balance radically towards description over manufacturing or fieldwork. Projects are now highly described, simulated and virtually constructed, often numerous times, before physical production is begun. Similarly, the capacities of digital prediction allow highly efficient factory production at tight tolerances to be conducted, minimising low-efficiency and low-tolerance fieldwork. Of course, new capabilities for fabrication – from 3D printing to robotics – are rapidly shifting this balance again, allowing highly efficient, high-precision and high-information-content physical production to be increasingly available at reasonable unit costs.

## FLEXIBILITY AND DETERMINACY

One of the more fascinating impacts of digital production has been a paradoxical new place for indeterminacy. Today's digital geometries offer extraordinarily high levels of control of information, beyond the limits of what production can economically support. As a response, contemporary detailing can defer physical solution to the materials themselves, supporting moments where the precision of geometry is left to the materials' behaviours to resolve. This response to the emergent geometric complexity of contemporary forms takes a very specific and deliberate approach to how indeterminacy at the detail level is registered and coordinated into overall highly deterministic geometric systems.

## TOWARDS THE FUTURE

In moving among digital and physical systems we are constantly transforming among systems with greater and lesser information content. These transformations are tractable, but inherently lossy, as the subtlety of material behaviours is rationalised into finite numerical systems, and the purity of abstract geometry encounters the physical will of material media. The specific signatures of forms produced today reflect a tension between increasing availability of digital information and the contemporary economic limits of physical production. Much of the richness of contemporary built form derives from this tension, of low-information systems being pushed to accommodate high-information form. Considerations of specific means of production, new systems of fabrication with new geometric affordances, and tradeoffs between information and material costs drive the richness and tension behind today's form making. Technologies such as 3D printing hold the potential for vast orders of magnitude of information to be applied to production at insignificant cost. Will the newfound interest in production as an architectural driver survive this explosion of opportunity? Will the availability of limitless information content in the physical world result in a new agenda for materiality and detail? Or will limitless freedom of materiality result in the same loss of direction and recourse to decoration that the modern steel frame and curtain wall did for the last generation? ⍷

**Notes**


1. Thomas L Heath, *The Thirteen Books of Euclid's Elements*, Dover (Mineola, NY), 1956.
2. George Stiny, *Shape: Talking About Seeing And Doing*, MIT Press (Cambridge, MA), 2006.
3. Claude E Shannon and Warren Weaver, *The Mathematical Theory of Communication*, University of Illinois Press (Urbana, IL), 1949.
4. Andrei Kolmogorov, 'Logical Basis For Information Theory And Probability Theory', *IEEE Transactions on Information Theory*, 14 (5), 1968, pp 662–4.
5. William J Mitchell, 'Beyond The Ivory Tower: Constructing Complexity in the Digital Age', *Science*, Vol 303, No 5663, 5 March 2004, pp 1472–3.
6. Stephen Willard, *General Topology*, Addison-Wesley (Reading, MA), 1970.

David Benjamin

# GROWING

Carlos Olguin

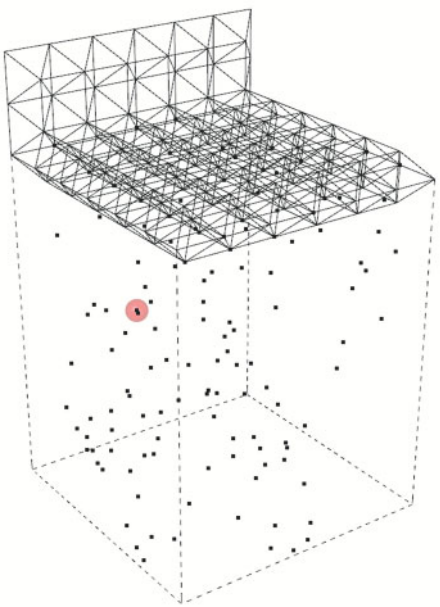
# DETAILS

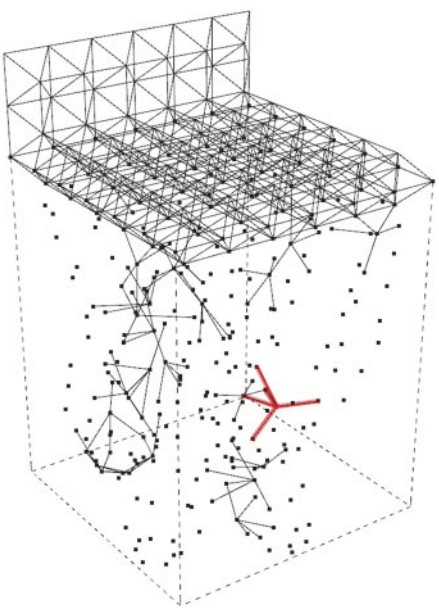
Danil Nagy

Here **David Benjamin and Danil Nagy** of New York-based practice The Living, and **Carlos Olguin** of Autodesk Research, describe how in their design for the Evolving Chair they piloted Project Cyborg, a cloud-native meta-platform for matter programming. By providing a range of design opportunities at multiple scales, Cyborg seeks to introduce a more fluid and open-ended approach to detailing that is less confined by matter and scale.

Project Cyborg is a cloud-native meta-platform developed by Autodesk Research's Bio/Nano/Programmable Matter Group that accelerates the introduction of applications for matter programming and bio-inspired design. The design paradigm behind matter programming is now being gradually applied to concrete projects across a range of domains and metric scales: from material science to synthetic biology, from the nano- to human scale and above, and from 3D (bio)printing to 4D printing. This cross-pollination between different applications is helping to create a robust, scale-free body of knowledge.

For architecture, Cyborg offers unique directions for the design of new massing forms, building systems, components and materials. In the context of the architectural detail, it provides a similar range of opportunities at multiple scales. The creation of the architectural detail generally involves the bringing together of discrete elements, systems and materials through mechanical attachment. Cyborg's expansive and fluid approach to matter and scales may allow us to move from discrete elements to integrated systems, leading to a revolutionary world of architectural details. In the long term, programming matter at the nanoscale will redefine the way we design everything. In the short term, the current fields of generative design and 3D printing are already enabling advances in design and the future details of architecture.





**The Living and Autodesk Research Bio/Nano/Programmable Matter Group, Evolving Chair, 2014**
*previous spread*: The process involves generating, evaluating and evolving tens of thousands of iterations representing a wide range of potential designs.

*above*: Instead of sketching the legs of a chair, the user sketches a blank box and creates a system to generate a fine lattice of structural supports.

*opposite*: The designs are plotted according to performance and colour coded according to formal similarity.

One application of Cyborg is in the work of architectural firm The Living on the multi-objective optimisation of new human-scale structures. In the Evolving Chair project, for example, the design of a novel chair structure would not have been possible without the unique computation and manufacturing techniques provided by Cyborg. A manageable standalone object for a case study, the chair structure involved all of the same factors, opportunities and challenges of designing architectural details.

**Generative Geometry**

The project first required the creation of a custom Cyborg module for generative geometry, then drawing on the power of built-in Cyborg modules for structural simulation and optimisation, including the use of cloud computing.

For the custom Cyborg module, the generative geometry system was loosely based on the logic of bone formation. As in bone growth, the system uses a tube-like structural element made out of a small lattice with variable density, with a variable cross-section so that the member can taper or bulge. In bone formation, lattice density and cross-section adapt to structural forces. In the geometric system for the chair, both of these features were controlled by input parameters and allowed to vary widely, so that as the automated optimisation progressed, some very high-performing and interesting design options would emerge. In preparation for the subsequent simulation phase, the resulting 3D latticed structure was converted into a watertight model using the Autodesk Inventor Server application within Cyborg.

**Structural Simulation and Optimisation**

For simulation, a separate Cyborg module encapsulating a cloud instance of Autodesk Robot Structural Analysis automatically ran a finite element simulation on each design iteration. Since one of the goals of the project was to use additive layer manufacturing to produce the designs directly from the optimisation, the finite element analysis and generative geometry modules were calibrated to account for features such as minimum bar diameter that could be constructed by the target 3D printer.

At this point, a general optimisation service in Cyborg – built in part on top of another project, Autodesk Project Saturn – was used to manage and spawn, in an automated fashion, all design iterations, including their respective structural simulations. It was therefore possible to make use of the incredible power of cloud computing in a seamless manner by configuring the design workflow from a web browser – Cyborg's native front end.

**Next Steps**

In this phase of the project, Cyborg was used to design a novel chair by creating a geometric model with a wide range of design permutations, specifying the structural loads for the chair, choosing two objectives of minimising weight and displacement after loading, and then selecting the most desirable result by looking at the mathematically best designs and the trade-offs between them. The geometric arrangement of thousands of small bars was explored to generate unexpected, high-performing designs. But this is just the beginning.

Part of the power of the Cyborg platform and this novel design approach is that they are able to work at multiple scales. The

*Part of the power of the Cyborg platform and this novel design approach is that they are able to work at multiple scales.*

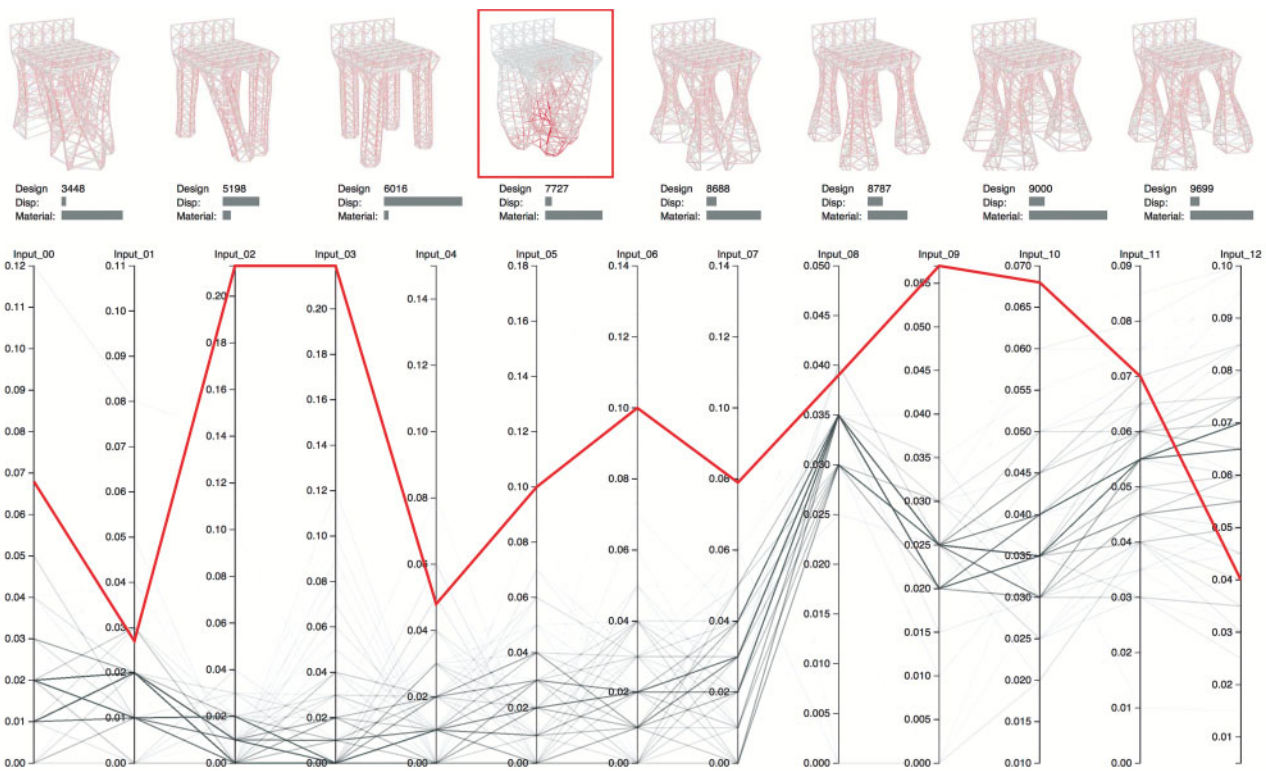
same modules could be used at both lower resolution and higher resolution; for example, in addition to the lattice density and the cross-section of the chair legs, they could explore the number of legs (lower resolution) and the material composition of the lattice (higher resolution). This exploration of the material composition of the lattice includes multi-material constructions as well as the use of synthetic biology to design new high-performance materials, a macro-micro approach fitting for the algorithms and logic of biology that are integrated throughout Cyborg.

**Further Applications**

The resulting chair, as with many chairs designed by architects over the past century, could be understood as a proxy for a building. The same workflow and most of the same Cyborg modules employed in the design of the chair could be applied to designing architecture. Further Cyborg modules could also be integrated to address the additional complexity of a building. Modules for environmental and energy simulations, such as wind flow, and even programme layout analysis, could be incorporated within the Cyborg workflow alongside existing modules of generative geometry, structural simulation and multi-objective optimisation. This is all managed by a domain-agnostic service configured to reflect the underlying design framework, which has been built specifically for this kind of complexity and multifaceted simulation.

While the Evolving Chair project involves two objectives common to other algorithmic approaches (reducing weight and maintaining strength), in several ways it goes beyond the topology optimisation approach. For example, multiple generative geometry systems can be used, rather than a single subtractive system. Within each geometric system, a very wide design space is deliberately established and a variety of solutions sought, rather than starting with a narrow design space and filtering out solutions in a linear process. Both macro geometry and micro geometry can be varied simultaneously, and the flexible and tunable setup can allow subtleties such as different performance requirements for different regions and multiple materials in the same structure. Most importantly, objectives beyond strength and weight can be incorporated. This is not to say that the Evolving Chair represents a

A view of the chair designs according to their input parameters – their virtual DNA – reveals new strategies and patterns for solving the design problem.



This new approach, which harnesses computation and biology, may produce designs that are novel and outperform traditional as well as smart methods.

The software workflow can lead directly to full-scale manufactured objects through carefully planned algorithms and additive layer manufacturing.

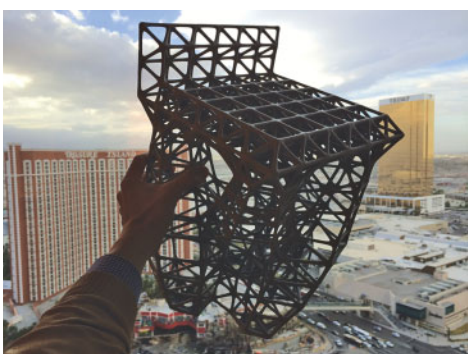
*Cyborg offers the ability to design at multiple scales simultaneously, from the composition of materials to building components.*

completely alternative approach to topology optimisation; rather, it is one that could be considered to be much broader. Topology optimisation is a subset of the approach, to which can be added many other features.

**Future Details of Architecture**

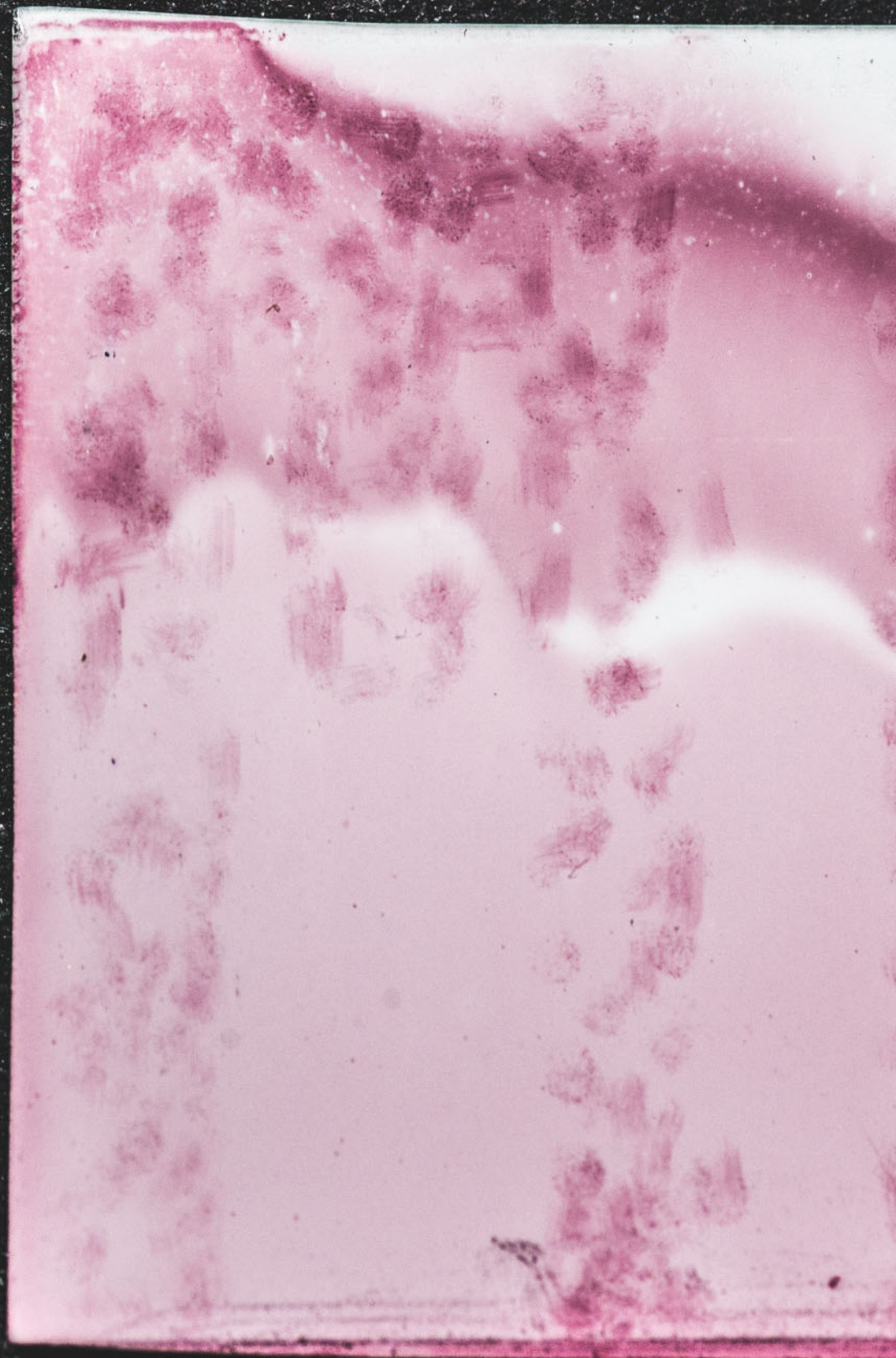
The chair case study illustrated here demonstrates the relevance of Project Cyborg and its applications for designing future details of architecture. The support structure for a chair – or a curtain-wall panel connection detail, or other architectural details – can be grown in this new platform and using this new approach. Cyborg offers the ability to design at multiple scales simultaneously, from the composition of materials to building components. Designs can be calibrated for manufacturing via 3D printing, including making structures out of multiple materials: rigid material, flexible material, transparent material, conductive material and beyond. The use of cloud computing in Cyborg leads to a method that can automatically explore a very wide design space of possible options, strategically navigating through a galaxy of billions of design iterations, and producing results that humans or computers alone could never create.

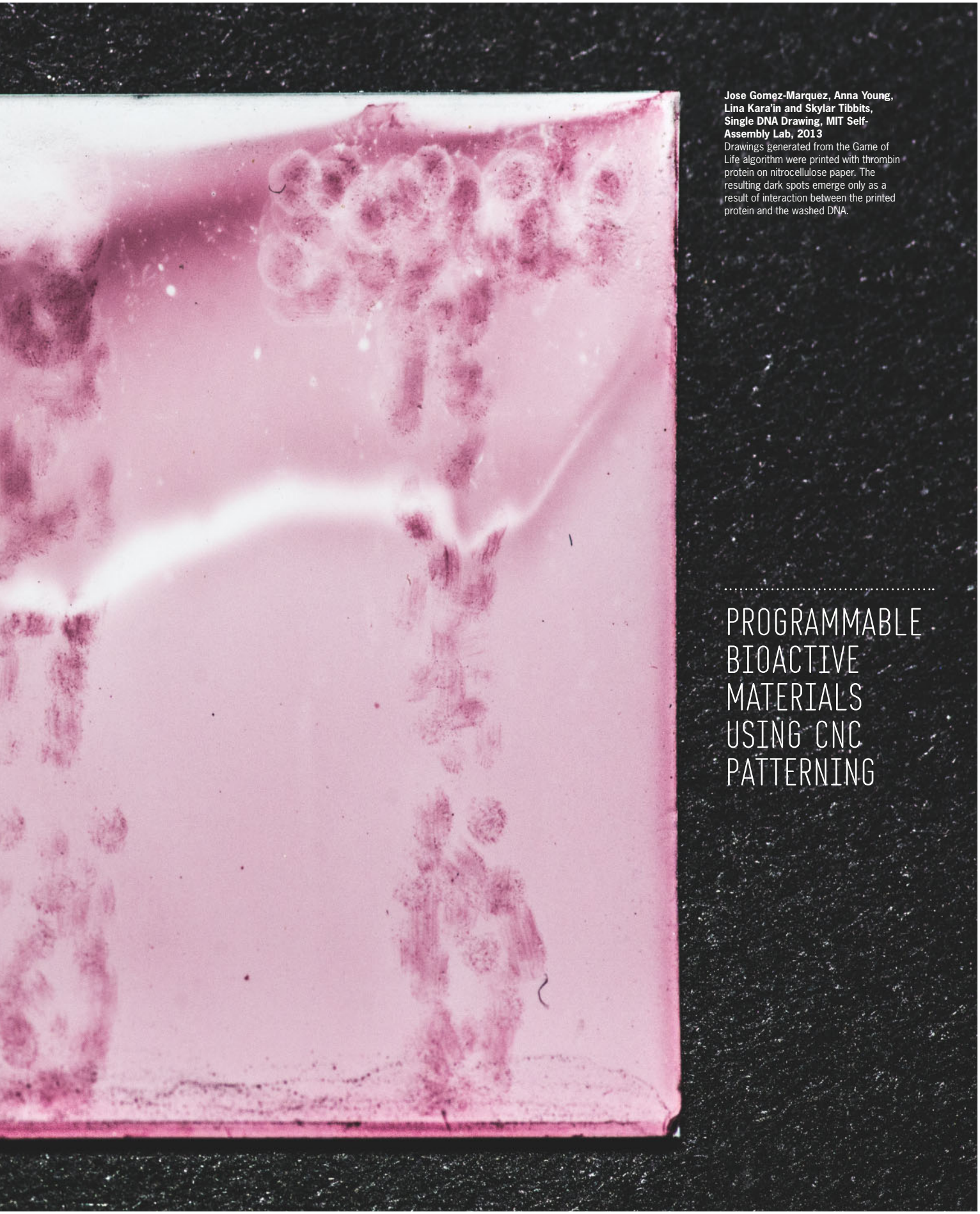
All of these features promise to give rise to architectural details that are more complex, nuanced and unusual, where life and other forms of programmable matter are integrated as the object of design and not just the source of inspiration. This approach may lead to a new kind of design intelligence that may start with a new aesthetic of growing novel, high-performing structures. But like all forms of intelligence, it is bound to develop a life of its own beyond anything we know today. ⧈



Skylar Tibbits, Lina Kara'in, Joseph Schaeffer, Helena de Puig, Jose Gomez-Marquez and Anna Young

# DNA disPLAY





**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, Single DNA Drawing, MIT Self-Assembly Lab, 2013**
Drawings generated from the Game of Life algorithm were printed with thrombin protein on nitrocellulose paper. The resulting dark spots emerge only as a result of interaction between the printed protein and the washed DNA.

# PROGRAMMABLE BIOACTIVE MATERIALS USING CNC PATTERNING

2D, 3D and 4D printing are fertile areas for design and material experimentation, and thus the architectural detail in the future. Here **Skylar Tibbits**, along with his collaborators – Lina Kara'in (MIT Self-Assembly Lab), Jose Gomez-Marquez, Anna Young and Joaquin Navarro (Little Devices Lab, MIT), Lee Gehrke, Helena de Puig and Justina Tam (Gehrke Lab, MIT), and Joseph Schaeffer and Carlos Olguin (Autodesk Inc) – describe the development of DNAdisPLAY: a project that created a physical prototype and design workflow for 2D bioprinting, resulting in the development of software, hardware and printed DNA patterns on paper.

Since the introduction of inkjet printing, two-dimensional printing technologies have democratised our ability to create at-home physical documents. Paper-based printing has become ubiquitously accepted as both a commercial-scale process and a necessary at-home tool. Charles Hull's 1984 invention of 3D printing has followed suit with a new vision for the way we make things from industrial manufacturing to do-it-yourself fabrication.[1] Both of these technologies have challenged and catalysed the design process by transitioning to digital tools and generative processes across software, fabrication and material domains.

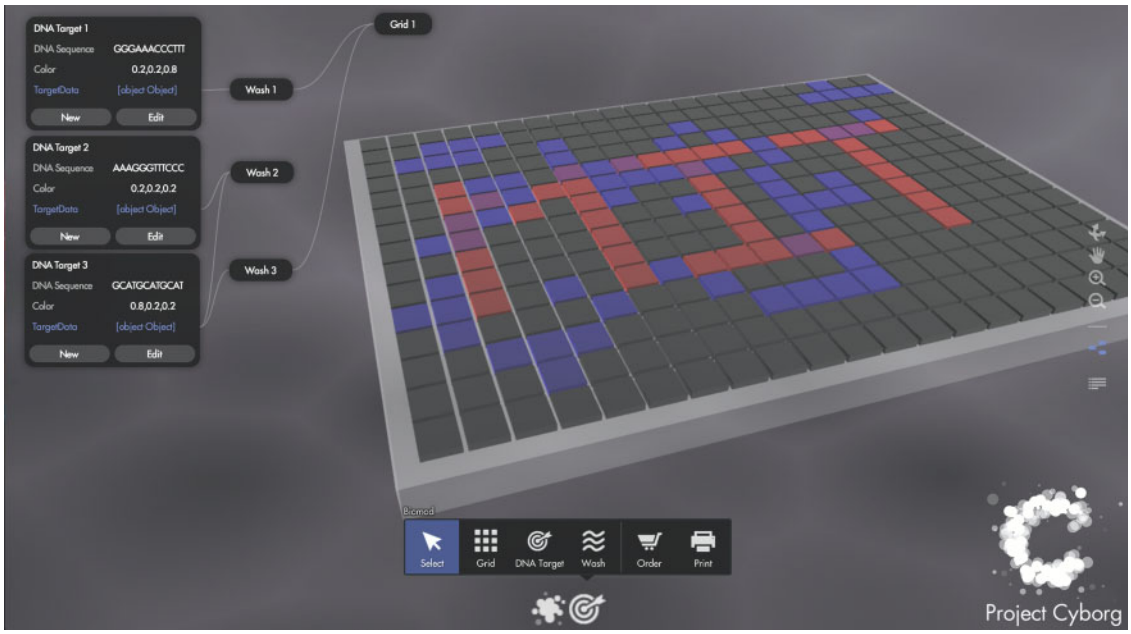
An opportunity has emerged to program materials across length-scales to store information, compute digital logic and change physical state, material property or shape. 4D printing is one recent technique that allows multi-material structures to be printed and self-transform in shape and material property when exposed to water.[2] Similarly, yet at a much smaller scale, 'DNA origami' is a technique where custom sequences of DNA are synthesised and then self-assemble into nanoscale functional objects. These 2D and 3D objects are typically designed using software such as cadnano, developed by the Wyss Institute and Autodesk Inc.[3] At the materials level there is an influx of research around smart materials and self-assembly processes to efficiently manufacture new material properties and fabricate meso-scale structures.[4] Each of these developments points towards a future of programmable materials that can be printed with new physical properties and controllable behaviour, thus once again challenging the design field to invent new tools and applications.

## Printing with DNA

3D printing remains far from the realities of construction and architectural materials that rely heavily on two-dimensional assemblies of sheet-based goods and complex user, material and environmental constraints. Thus there is an opportunity for a resurgence of 2D printing with the addition of programmable materials, offering limitless applications in architectural sheet materials, wall finishes, responsive materiality, environmental adaptation and many others.

Advances in DNA nanotechnology offer an opportunity to use printed DNA as a smart architectural material. DNA's four nucleotides can form specific bonds: adenine (A) binds to thymine (T), and guanine (G) binds to cytosine (C). This logic allows a programmable substrate to build computational components such as logic gates, motors and sensors as well as self-assembling 2D and 3D objects with defined structural properties and bioreactive patterns.[5] DNA can be used to store arbitrary information into custom-synthesised DNA strands that can then be sequenced to read out the exact digital information from biological material.[6] These properties make it extremely well suited as a programmable printed material that can sense internal and external conditions, compute information and visually transform.

2D bioprinting is a mature field generated from microarray and high-throughput multiplexed analysis platforms.[7] Self-assembly at the nanometer scale using additive and subtractive processes employs expensive photolithographic and atomic force microscopy tools.[8] Similarly, static stamping of protein patterns onto substrates has given way to a number of computer-controlled dynamic patterning deposition options such as contact spotting, non-contact spotting, inkjet and piezoelectric deposition systems.[9] However, all of this equipment remains an expensive niche domain, often costing in excess of $100,000. The software layer that runs these machines is often complex and optimised for parallelisation and combinatorics, varying the intensity and reagents within a matrix. Unfortunately, the deposition systems available are difficult to use and do not lend themselves to complex DNA patterning on a variety of material substrates.




**Carlos Olguin and Joseph Schaeffer, Project Cyborg, Bio/Nano/ Programmable Matter Research Group, Autodesk Inc, 2013**
Autodesk's Project Cyborg is a software tool under development for the generative design and simulation of biological information. The displayed patterns emerge only after simulating the washing of complimentary DNA strands.

## The DNA Printing Workflow

DNA disPLAY was developed as a collaboration between the Massachusetts Institute of Technology (MIT) Self-Assembly Lab, Little Devices Lab, Gehrke Lab and Autodesk as a physical prototype and design workflow including software, hardware and printed DNA patterns on paper.[10] The project attempts to take on the challenge of utilising DNA as a new programmable design medium by making it both physical and visual for the built environment. The aim was to allow anyone to design and print with DNA, eliminating the expensive and difficult step of DNA imaging and opening up possibilities of biological printing for architectural surfaces. Proteins were CNC-printed on nitrocellulose paper and then washed with DNA and gold nanoparticles to reveal custom patterns. The workflow has four main steps: design and software; custom biomaterial; CNC printing; and programmable drawings.

### *Design and Software*

The first step in the DNA printing workflow is a new software tool for generative design and simulation of biological information. A custom application was developed and built on top of Project Cyborg, the code name of a new design platform being developed by Autodesk Research's Bio/Nano/ Programmable Matter Research Group. This software tool allows one to design and map patterns with their associated biological information. It was designed to embed domain-specific knowledge and allow users to easily work at a high level, designing patterns, interactions and dynamic transitions for DNA printing. Each printed droplet represents a biological pixel in the software, and can be embedded with known biological sensors and organised into complex patterns reacting to internal or environmental triggers. After an arrangement of pixels has been designed, populated with biological sensors and simulated, the custom proteins and DNA sequences can be ordered directly. Future work will attempt to link the designed digital structure in Project Cyborg directly with hardware platforms, allowing them to be printed directly on various substrates.

### *Custom Biomaterial*

In previous work, the research team printed multiple patterns and symbols with ligands on paper to create a diagnostic imaging system. As the team moved towards an easier approach to 2D biopatterning, a convenient biological structure was sought to serve as a conceptual framework. Thrombin protein and its aptamer (thrombin binding aptamer/TBA) were selected due to their well-characterised interaction with binding affinities in the nanomolar range. One of the first therapeutic DNA aptamers to be isolated was with human thrombin, a key protein that helps regulate the formation of blood clots.[11] The DNA aptamer 5' GGTTGGTGTGGTTGG 3' self-folds in a G-quadruplex secondary structure in order to bind to thrombin.[12] The aptamer was bound to a gold nanoparticle solution and the protein remained in a separate solution, ready for printing. The binding allowed the printed thrombin patterns to emerge only after encountering the correct DNA sequence.

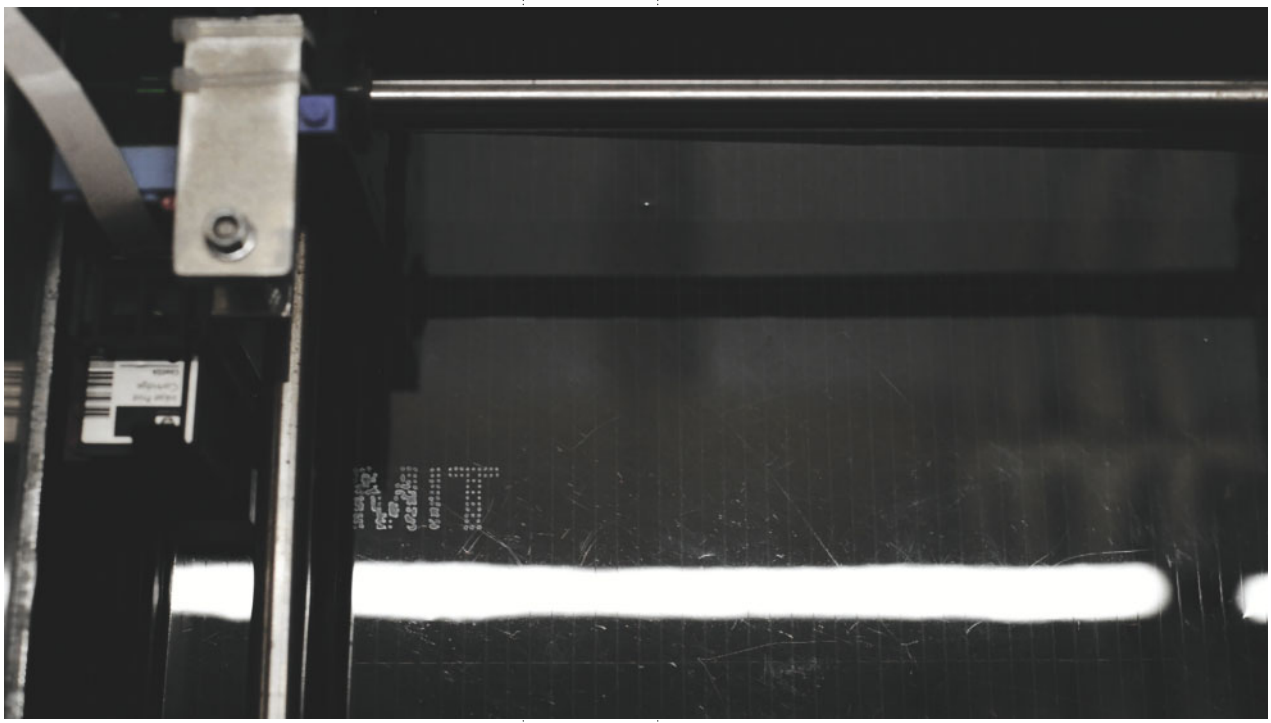
### *CNC Bioprinting*

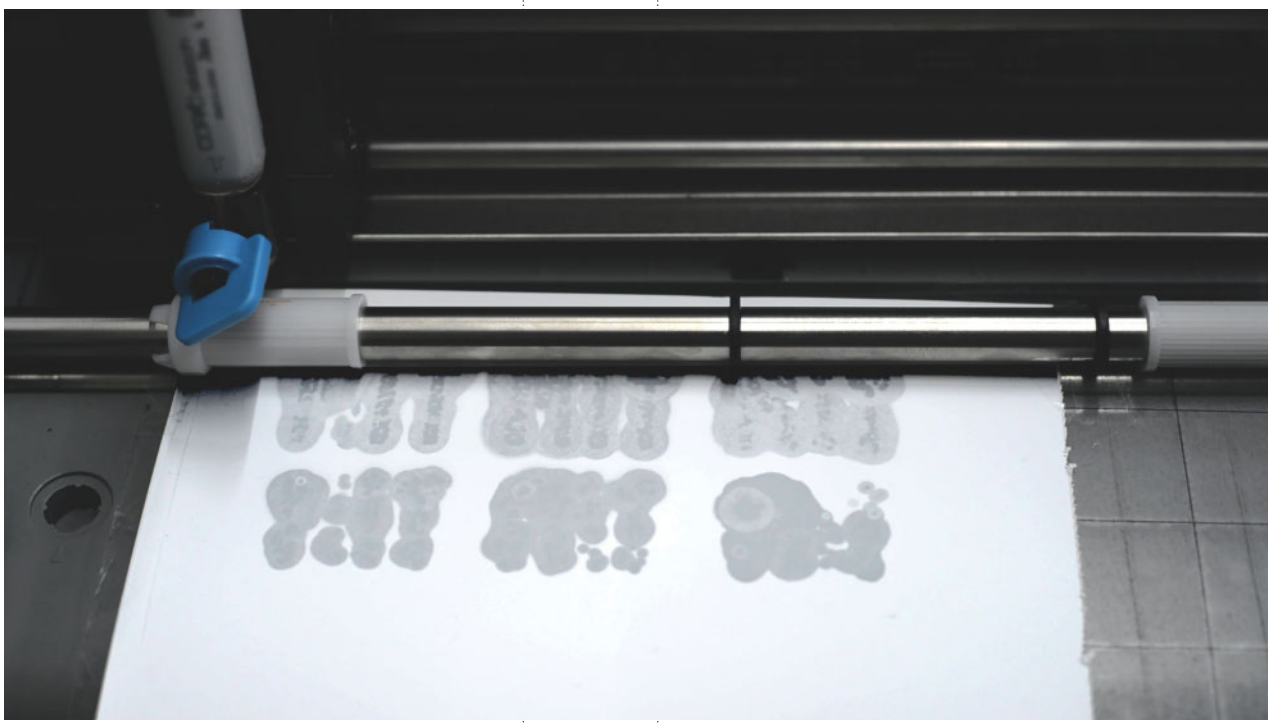
After generating patterns, simulating interactions and ordering custom biomaterials, the physical structures were then printed on various substrates. Three main hardware platforms were tested, with corresponding opportunities and drawbacks. First, a custom CNC printing machine was built and used to deposit DNA and protein markers with HP inkjet cartridges. This platform allowed for complete control over resolution and quantity of droplet size, however it required a specialised software workflow that increased workflow complexity to transform from a standard image into a DNA printed output. The same approach was tested on a simple desktop printer, easing the design workflow but

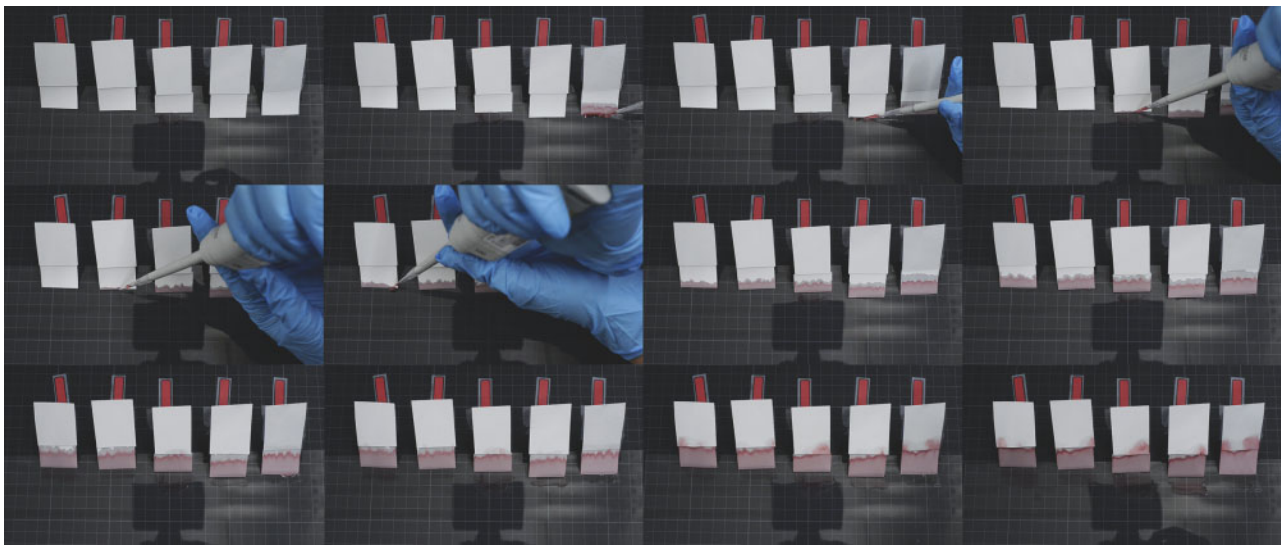
**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, CNC DNA Printer, MIT Self-Assembly Lab, 2013**
*top*: A custom CNC printer was developed to deposit synthesised DNA onto clear film in the precise letters 'MIT'.

**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, DNA Pen Plotter, MIT Self-Assembly Lab, 2013**
*bottom*: A pen-plotter and vinyl cutting machine were used for DNA and protein deposition. This hardware provided an easy interface and precise control over droplet resolution. A felt-tip pen was loaded and used to deposit thrombin protein on nitrocellulose paper.

**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, DNA Washing, MIT Self-Assembly Lab, 2013**
*opposite*: After depositing thrombin protein on nitrocellulose paper, a custom-synthesised DNA sequence with gold nanoparticles was washed across the paper. The blank paper then revealed custom-designed DNA patterns emerging from the programmed interaction of the protein and DNA strands.





adding constraints in substrate handling and control of droplet size. The final machine, and the most successful thus far, was a vinyl cutter and pen-plotter. This achieved a fast workflow and full droplet size control. A felt-tipped pen, filled with thrombin protein, was mounted on the machine instead of a cutting blade. Droplet size was achieved by varying the impact height of the pen. In effect, an affordable computer-controlled contact-printing system was created. A series of six unique drawings were printed with thrombin protein using this machine and were then washed with DNA to reveal custom patterns.

***Programmable Drawings***

Printed DNA patterns were designed using principles from Conway's Game of Life, an early model of visual computing that has three fundamental rules: overcrowding, under-population and reproduction.[13] These rules were propagated from an initial pattern spelling the letters 'MIT'. A series of generations were printed showing a progression of the letters dissolving into complex dynamic patterns that emerged only after being washed with complementary DNA. The Game of Life, created with the material of life, was specifically chosen as a case study due to its proven capability of universal computing, its visual aspect and rule-based patterns of local interaction. These dynamic patterns can be extrapolated as a strong example for programmable DNA printing since they argue for a visual output that could dynamically transition between patterns based solely on local DNA computing.

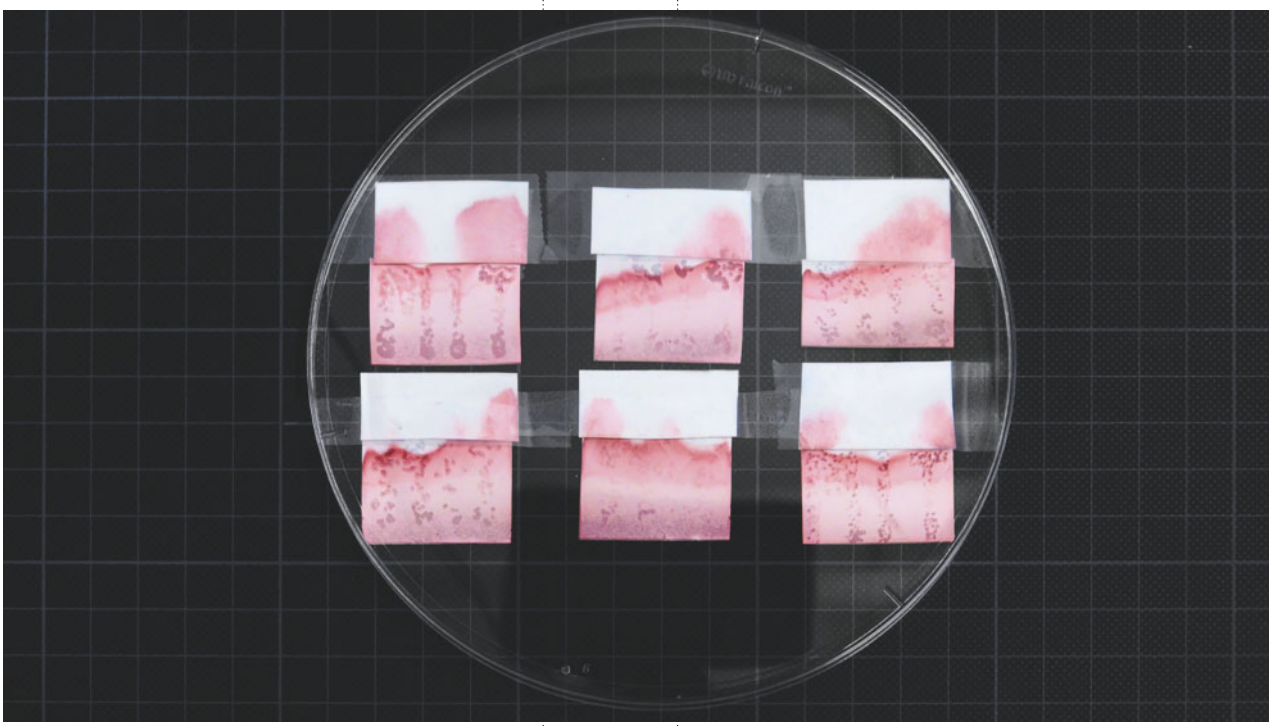
## Architectural Applications

On the surface, printed DNA drawings simply demonstrate the programmable binding of proteins and DNA. However, they conceptually go much further and point towards the capability for DNA to act as a type of smart ink for two-dimensional bioprinting and architectural surfaces. Avant-garde architecture has long been interested in transformation, both physically and visually, but the reality of today's architectural details for sensing and transformation rely solely on robotics-like motors, mechanisms, sensor devices, electronics and traditional notions of computing. These details are not scalable due to factors including their prohibitive cost, failure-prone nature, lengthy assembly time and lack of interoperability. Dynamic transformation has thus been relegated to machinery, products and other economies of scale, rather than architectural domains. However, the future of architectural details can now be revolutionised with printed biological material due to its simple, cheap and elegant response to the environment. DNA is everywhere; it is within our bodies, our buildings and surrounding environment. Programming this abundant material may therefore offer a world of transformation, sensing and environmental consciousness that has previously been inaccessible to architects.

In future, DNA-based architectural materials could be designed to react to the touch of a person's hand, a building's air quality or external environment such as pollution, sunlight or even acidity levels, showing a smart response between architectural surfaces and their dynamic surroundings. There is a strong potential for architectural material finishes to transform from one pattern, level of transparency, texture or shape into another. Like electronic displays made with DNA, these new building surfaces could sense, transform, compute or store information directly in the walls themselves. DNA facades, inks, signage and material textures may ultimately respond to the quality of a building's internal or external environment, and programmably adapt to user interaction. In a world where information technology, biological response and environmental consciousness are blending, printed DNA substrates may become the future of architectural details. ◘

**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, Six DNA Drawings, MIT Self-Assembly Lab, 2013**
*top*: Six DNA drawings were produced from the Game of Life algorithm, demonstrating unique patterns based on the interaction between CNC-printed thrombin proteins and DNA with gold nanoparticles.

**Lina Kara'in and Skylar Tibbits, MIT Game of Life, MIT Self-Assembly Lab, 2013**
*bottom:* Six generations of the Game of Life were produced from an initial starting condition in the form of 'MIT'. The following generations erode away based on three simple rules: overcrowding, under-population and reproduction. The generated patterns were used for protein deposition and DNA display.

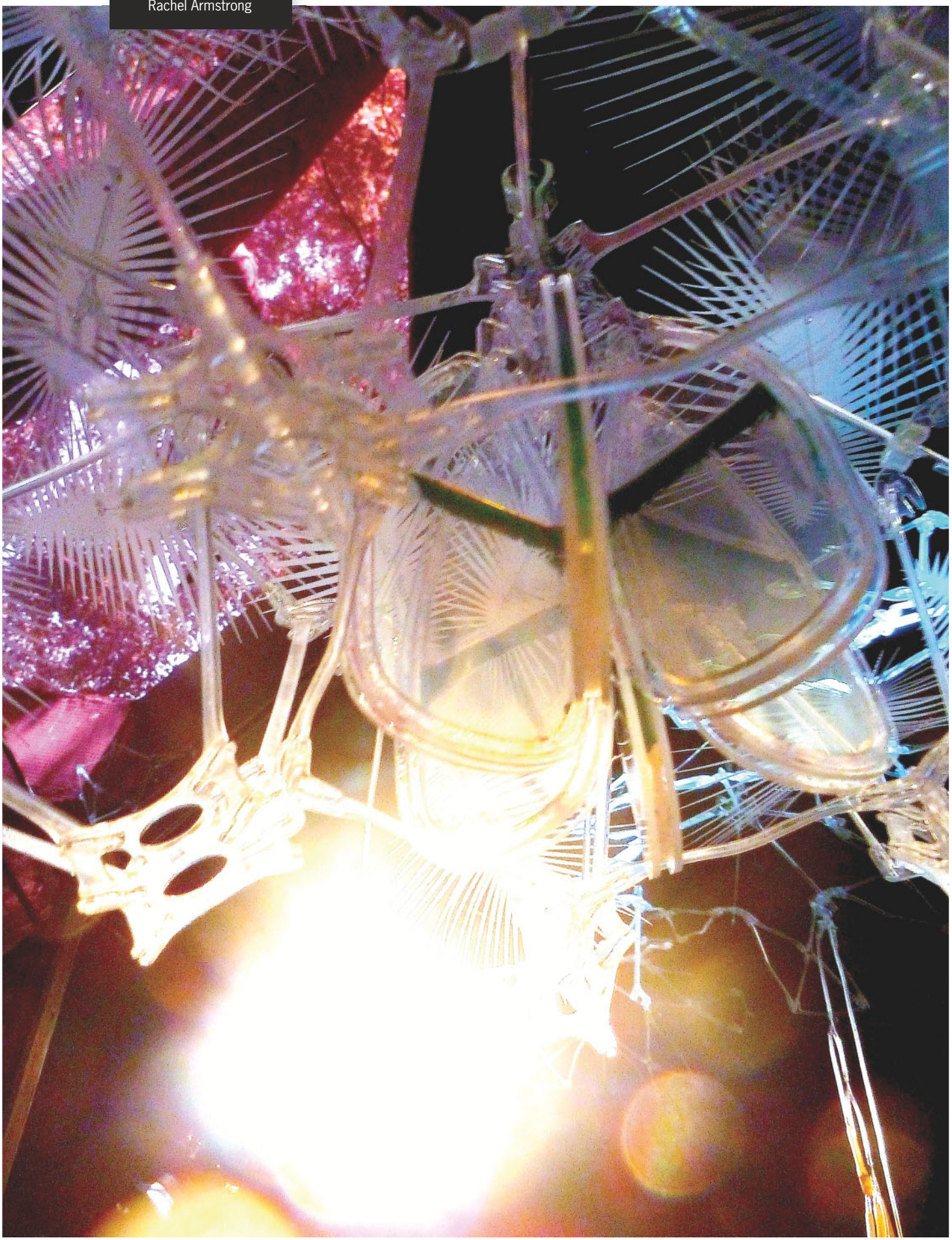


**Notes**

1. T Rowe Price, 'Infographic: A Brief History of 3D Printing', *Connections*, May 2012: http://individual.troweprice.com/public/Retail/Planning-&-Research/Connections/3D-Printing/Infographic_FINAL.pdf.
2. Skylar Tibbits, '4D Printing: Multi-Material Shape Change', in Bob Sheil (ed), *Δ High Definition*, Jan/Feb (no 1), 2014, pp 116–21.
3. Shawn M Douglas et al, 'Rapid Prototyping of 3D DNA-Origami Shapes with caDNAno', *Nucleic Acids Research*, 37(15), 2009, pp 5001–6.
4. George M Whitesides and Bartosz Grzybowski, 'Self-assembly at All Scales', *Science*, 295 (5564), 29 March 2002, pp 2418–21.
5. See 'Computing With Soup', *The Economist*, 3 March 2012: www.economist.com/node/21548488, and Thomas Tørring et al, 'DNA Origami: A Quantum Leap for Self-Assembly of Complex Structures', *Chemical Society Reviews*, 40 (12), December 2011, pp 5636–46.
6. George M Church, Yuan Gao and Sriram Kosuri, 'Next-Generation Digital Information Storage in DNA', *Science*, 337 (6102), 28 September 2012, p 1628.
7. Song Xu and and Gang-yu Liu, 'Nanometer-Scale Fabrication by Simultaneous Nanoshaving and Molecular Self-Assembly', *Langmuir*, 13 (2), 1997, pp 127–9.
8. Emmanuel Delamarche, André Bernard, Heinz Schmid, Bruno Michel and Hans Biebuyck, 'Patterned Delivery of Immunoglobulins to Surfaces Using Microfluidic Networks', *Science*, 276 (5313), 2 May 1997, p 779.
9. Leonardo R Allain, Minoo Askari, David L Stokes, and Tuan Vo-Dinh, 'Microarray Sampling Platform Fabrication Using Bubble-Jet Technology for a Biochip System', *Fresenius' Journal of Analytical Chemistry*, 371, 2001, p 146.
10. This work was developed for BioMod 2013, a DNA/biomolecular design competition, and would not have been possible without strong collaboration between the MIT Self-Assembly Lab (Skylar Tibbits and Lina Kara'in), the Little Devices Lab, MIT (Jose Gomez-Marquez, Anna Young and Joaquin Navarro), Gehrke Lab, MIT (Lee Gehrke, Helena de Puig and Justina Tam) and Autodesk Inc (Joseph Schaeffer and Carlos Olguin).
11. See LC Bock, LC Griffin, JA Latham, EH Vermaas and JJ Toole, 'Selection of Single Stranded DNA Molecules that Bind and Inhibit Human Thrombin', *Nature*, 355 (6360), 1992, p 564, and Besik I Kankia and Luis A Marky, 'Folding of the Thrombin Aptamer into a G-Quadruplex with Sr2+: Stability, Heat, and Hydration', *Journal of the American Chemical Society*, 123 (44), 2001, p 10799.
12. Astrid Joachimi, Günter Mayer and Jörg S Hartig, 'A New Anticoagulant-Antidote Pair: Control of Thrombin Activity by Aptamers and Porphyrins', *Journal of the American Chemical Society*, 129 (11), 2007, p 3036, and Helena de Puig, Anna Cifuentes Rius, Dorma Flemister, Salmaan H Baxamusa and Kimberley Hamad-Schifferli, 'Selective Light-Triggered Release of DNA from Gold Nanorods Switches Blood Clotting On and Off,' PLOS ONE, 8 (7), 2013, e68511.
13. John Conway, 'The Game of Life', *Scientific American*, 223 (4), 1970, p 4.

**Jose Gomez-Marquez, Anna Young, Lina Kara'in and Skylar Tibbits, DNA Handling, MIT Self-Assembly Lab, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, 2013**
DNA is often stored in small test tubes, must be handled extremely carefully and cannot be seen by the human eye.

The project attempts to take on the challenge of utilising DNA as a new programmable design medium by making it both physical and visual for the built environment. The aim was to allow anyone to design and print with DNA, eliminating the expensive and difficult step of DNA imaging and opening up possibilities of biological printing for architectural surfaces.



# THE POST-EPISTEMOLOGICAL DETAILS OF OCEANIC ONTOLOGIES

The convergence of advanced technologies such as nanotechnology, biotechnology, information and cognitive (NBIC) technologies is opening up the possibilities of working in architecture with lifelike systems and detailing dynamic matter. Here **Rachel Armstrong**, a co-director of the Advanced Virtual and Technological Architectural Research (AVATAR) group at the University of Greenwich, London, explores the potentials and limits of these emerging 'Oceanic Ontologies'.

Over the last 30 years, advances in biotechnology have created the possibility of working with lifelike systems. Terreform ONE's In Vitro Meat Habitat (New York, 2010) is clad with cultured bioengineered cells.[1] Magnus Larssen's Dune (Architectural Association, London, 2009) is a living, architectural-scale bacterial biofilm that continually fixes sand particles into sandstone,[2] and the AVATAR (Advanced Virtual and Technological Architectural Research) group project Future Venice is a collaboration that began in 2009 between Neil Spiller, chemist Martin Hanczyc from the University of Southern Denmark, Christian Kerrigan from the Bartlett School of Architecture, University College London (UCL) and myself that is shored up by the incessant activity of programmable 'protocells'.[3] Since these systems are 'living', their architectural details perform in ways that exceed classical, geometric-based descriptions of function and form, and engage directly with the lifelike character of the restless materiality from which these curiosities spring.

**Rachel Armstrong, Detail from the *Hylozoic Ground* installation, Venice Architecture Biennale, 2010**
This cluster of Liesegang ring plates is nested within the cybernetic *Hylozoic Ground* installation by Philip Beesley, where the plates slowly evolve under the forces of gravity and self-organising, periodic chemistries that appear as band-like patterns.

## Detailing Dynamic Matter

Indeed, many questions for architectural design spring from the need to design and engineer in ways that promote sustained, lively environmental connections. With the convergence of advanced technologies such as nanotechnology, biotechnology, information and cognitive (NBIC) technologies,[4] we are anticipating an 'information singularity' that may give rise to new kinds of materials and technologies that behave in ways we cannot predict or model accurately using our current methods. Lifelike fabrics also pose new challenges for detailing architecture since they exhibit phenomena such as emergence, and reach tipping points of organisation that possess a force and will of their own.[5] This requires architects and designers to find ways of working with distributed (or soft) rather than classical, centralised (or hard) forms of control. While this technological tipping point is yet to be reached, programmable materials that are embodied in dynamic biological and chemical technologies already exist[6] and may be coupled to mechanical systems such as as in the *Hylozoic Ground* installation by Philip Beesley at the 2010 Venice Architecture Biennale.[7]

Applications for these materials are most meaningfully applied in constantly changing contexts, where predicting the variables in the 'adjacent possible',[8] a term that refers to the limits of and creative potential for change in a system, is not meaningfully calculable. While buildings are conventionally imagined to operate under stable conditions, in this age of increasing environmental instability – where extreme weather patterns or rising sea levels disrupt equilibrium states and expose architectural design to landscapes of chaos and turbulence – the maintenance of building surfaces and infrastructures may be best performed by materials that exhibit varying degrees of autopoiesis and sensitivity to environmental change. In the context of climate change, fabrics that can respond to non-equilibrium systems and assimilate an abundance of environmental pollutants through active processes like carbon-dioxide sequestration, or use the presence of water for growth, may therefore be extremely advantageous and even essential in the detailing process. For example, director of the Massachusetts Institute of Technology (MIT) Self-Assembly Lab Skylar Tibbits has developed the notion of 4D printing, which is detailed through the presence of water[9] (see also his article on pp 104–11 of this issue) and

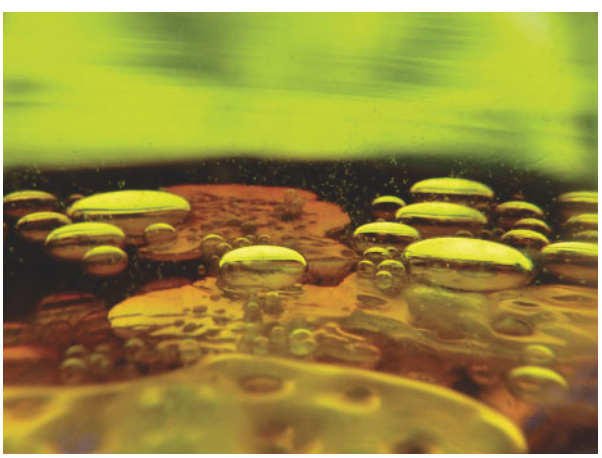
may even extend to continual growth and repair mechanisms that maintain structural integrity, such as self-healing concrete,[10] whose particulars cannot be predicted from knowledge of the system's individual components.

Lifelike systems such as smart chemistry and biotechnology seek restless exchanges with the natural world and may even be augmented within NBIC couplings. For example, algae bioreactors[11] monitored by microfluidic chips may support a range of ecological activities including processing pollutants, harvesting energy, growing food or continually forming patterns. The details of these incessant exchanges are not best represented by time slices of form and function, but may be considered as manifolds of interacting, continually evolving micro-landscapes of matter and information, as highly site-specific bodies. Such non-Euclidean geometries are embodied in materials such as aperiodic liquid crystals capable of directed self-assembly[12] and resist conformity to detailing conventions, as they continually push at the envelope of their existence, negotiating and renegotiating their surroundings.

Social and political scientist Matt Lee uses the term 'oceanic ontology' as a way of developing a materialism that is not reductive or naïve. Drawing from the process philosophy[13] of Deleuze and Nietzsche, Lee uses material interactions to inform oceanic ontologies as a way of directly producing maps rather than theories of concepts.[14] The resultant cartographies reveal unfolding events that give rise to architectural details in dynamic, embodied systems, and exist *a priori* as graphical notations and diagrams. This approach does not require the observer to locate the system within a particular form or function, as typifies biomimicry;[15] rather, it enables the system to remain unfixed as persistent, organising hubs of activity that may be navigated through the constant exchanges between fields of action, local events and architectural 'actors'. Such an approach can begin to make sense of highly unstable environments that are observed in the behaviour of multiple actors on a site.

**Observing Oceanic Ontologies**

The idea of architectural details produced by oceanic ontologies may be examined and explored using the Bütschli system, which produces lifelike dynamic droplets when an alkaline solution is added to a field of olive oil.[16] The chemical field spontaneously spreads out and breaks up into millimetre-scale droplets that can move around their environment, sense it, produce microstructures and interact with each other. Between 2009 and 2012 I recorded the structural and behavioural performance of over 300 Bütschli droplet experiments to design a cartographic system based on oceanic ontologies, which was then visualised as a diagram by architectural designer Simone Ferracina. The map records the potential activity on an oil field, which may be considered as a stage (or architectural site) on which the interactions between droplets are the 'actors' (the architectural programme). Interactions generate events and leave physical traces on this ever-changing stage, which operates beyond abstractions and directly records the site details as a generative, dynamic system.



**Rachel Armstrong, Venice Canalside, University of Greenwich, 2012**
*top*: Canal-side organisms in Venice spontaneously form a limestone-like structure from dissolved minerals in the water. This detailed, organic process is orchestrated through their metabolism to produce a slowly changing structure at the city's tidal zone.

**Rachel Armstrong, Micrograph of Bütschli system, University of Southern Denmark, 2009**
*bottom*: Bütschli droplets self-organise at the interface between strongly alkaline droplets and an olive oil field, and typically exhibit lifelike qualities such as movement within and sensitivity to their environment.

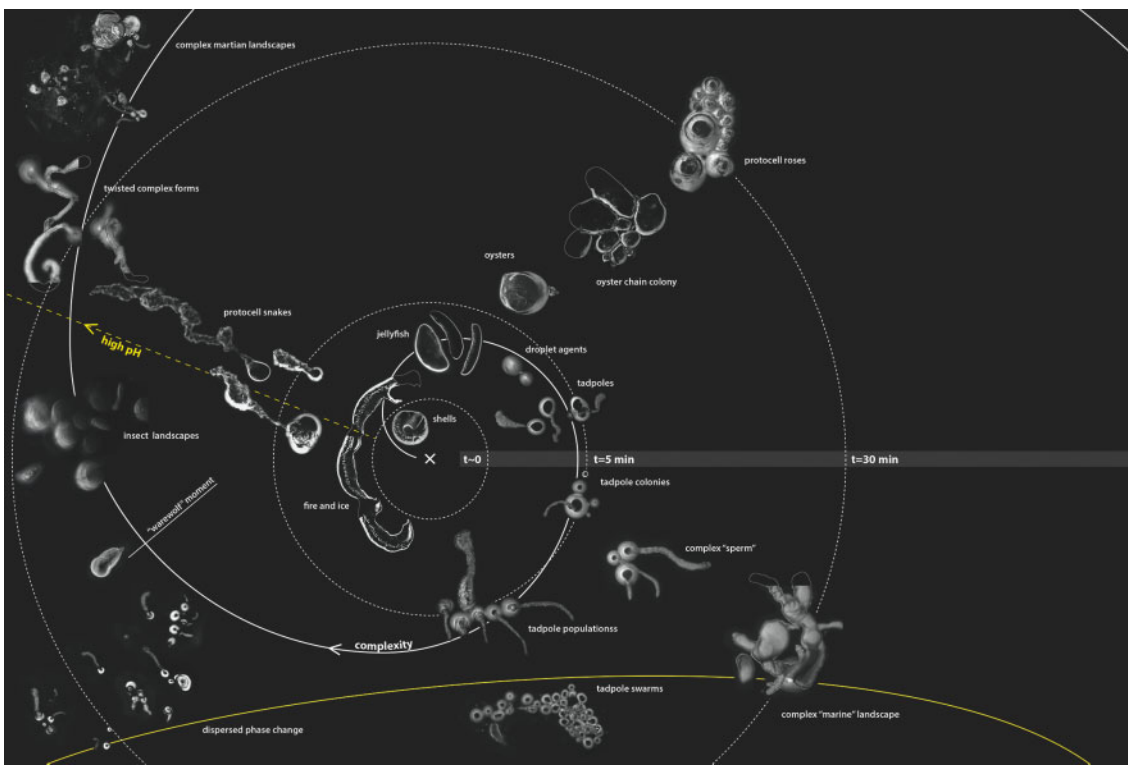
**Rachel Armstrong and Simone Ferracina, Topology of Protocell Evolution, University of Greenwich, 2012**
The diagram depicts dynamic droplets as 'actors' that operate within the many variable influences encountered in their oil field as an ontological 'map' of events. While the diagram is drawn as a 2D topology, the possible events within the field are manifold and open up multidimensional spaces through their multiple, contingent interactions that shape the evolution of the system.

The site details are organised on the diagram within concentric circles that represent an exponentially increasing series of time intervals, where novelty and event frequency rapidly decrease with time. Complexity within the system is represented as a tightly curled spiral around the origin of the reaction. This provides an instrument through which the relationships between the Bütschli forms and their progeny may be grouped according to aesthetic, process-led or cultural preferences. For example, complex oyster chains produce large volumes of matter from which their soft bodies bulge and are similar to complex marine landscapes, but are produced by droplets that have reached escape velocity from their residues and therefore differ in their detailing.

Oceanic ontologies may also provide opportunities for designers to understand architectural detailing as a dynamic process by directly revealing how materials respond to sudden changes in ambient temperature, or the way that episodic events like acidic rain alter them. In the Bütschli diagram, such occurrences are indicated by a curved trajectory that touches the spiral of complexity and may cause agents within the system to reach tipping points that transform their behaviour and morphology.

**Designing With Oceanic Ontologies**

Oceanic ontologies may be used to help imagine, describe and navigate complex challenges and terrains presented by dynamic materials interacting with site ecologies. For example, Mycotecture, by artist Phil Ross, is a living material that is grown from a combination of fungus and sawdust. Threads from the fungal mycelium transform the organic particles by trapping them, and form an entangled complex that may be processed into fungal bricks. Although these objects are assembled according to traditional masonry techniques, they are not fully subject to deterministic control paradigms as they grow and fuse if they are placed together.[17] Growth of the mycelium is sensitive to site conditions and requires moisture and nutrients to develop. While Ross has detailed Mycotecture using digital technologies, the material is only partly described through geometry, as it is dynamic. Oceanic ontologies may open up new possibilities for design and architectural detailing, particularly in relation to the environmental influences on such living materials.



Representing dynamic materials is problematic owing to necessary abstractions in the production of models. Indeed, in lively systems such as a modified, attenuated version of the Bütschli droplets, it is not possible to produce a model of the system, so the details are site specific and 'gardened' in situ. Spatial and temporal programmes may be used effectively, however, to shape events. For example, I produced modified Bütschli droplets at an interface that does not allow lateral movement for the 2011 Synth-ethic group show at the Natural History Museum, Vienna. Under spatial constraints, the droplets spontaneously exhibited Turing bands, which are undulating chemical waves that Alan Turing proposed could account for patterning in animals, such as 'dappling'.[18]

## Oceanic Ontologies and the Role of the Architect

Architects may develop a variety of tactics for environmentally compatible programmes using oceanic ontologies to identify alternative frameworks and materials for the production of spatial experiences and modes of construction that facilitate the horizontal coupling between agents. In this context, the architect becomes a codesigner within an ecology of design actants that collectively shape the unique character of a site by negotiating their individual claims on spaces. Acts of codesign are therefore equivalent to acts of 'life', which possess a 'will' and 'force' of their own and refuse to be fixed by deterministic pathways that are contingent on past events.

## Moral and Ethical Considerations

Implicit in the application of unpredictable lifelike technologies are moral and ethical questions where 'good' and 'bad' effects within a given system must be established. However, since outcomes are context sensitive, notions of control loom portentously in our risk-averse society.[19] Yet, oceanic ontologies are constrained by the limits of their reality and do not mean that absolutely anything is possible. Indeed, in order to establish the parameters of their existence, architects must iteratively explore the limits of possibility that are bound by the physics and chemistry of dynamic systems, but also by their cultural context.

Oceanic ontologies highlight a particular future that engages with the possibility of constructing architecture by the coupling of dynamic systems, such as Skylar Tibbits and Arthur Olson's *Fluid Crystallization* installation (MIT Self-Assembly Lab, 2013), which created a context for self-assembling objects in a fluid medium that formed dynamic patterns.[20] Indeed, such work highlights significant challenges in process-led approaches that raise questions about issues of agency, transformation, authorship and choreography of events within dynamic systems in ways that are architecturally meaningful.

**Phil Watson and Jonathan Morris, Skull Planet, Project Persephone, AVATAR research group, University of Greenwich, 2013**
Oceanic ontologies interact to produce a synthetic ecology of dynamic materials on a self-forming planet, as a new kind of nature.

## The Future of Oceanic Ontologies

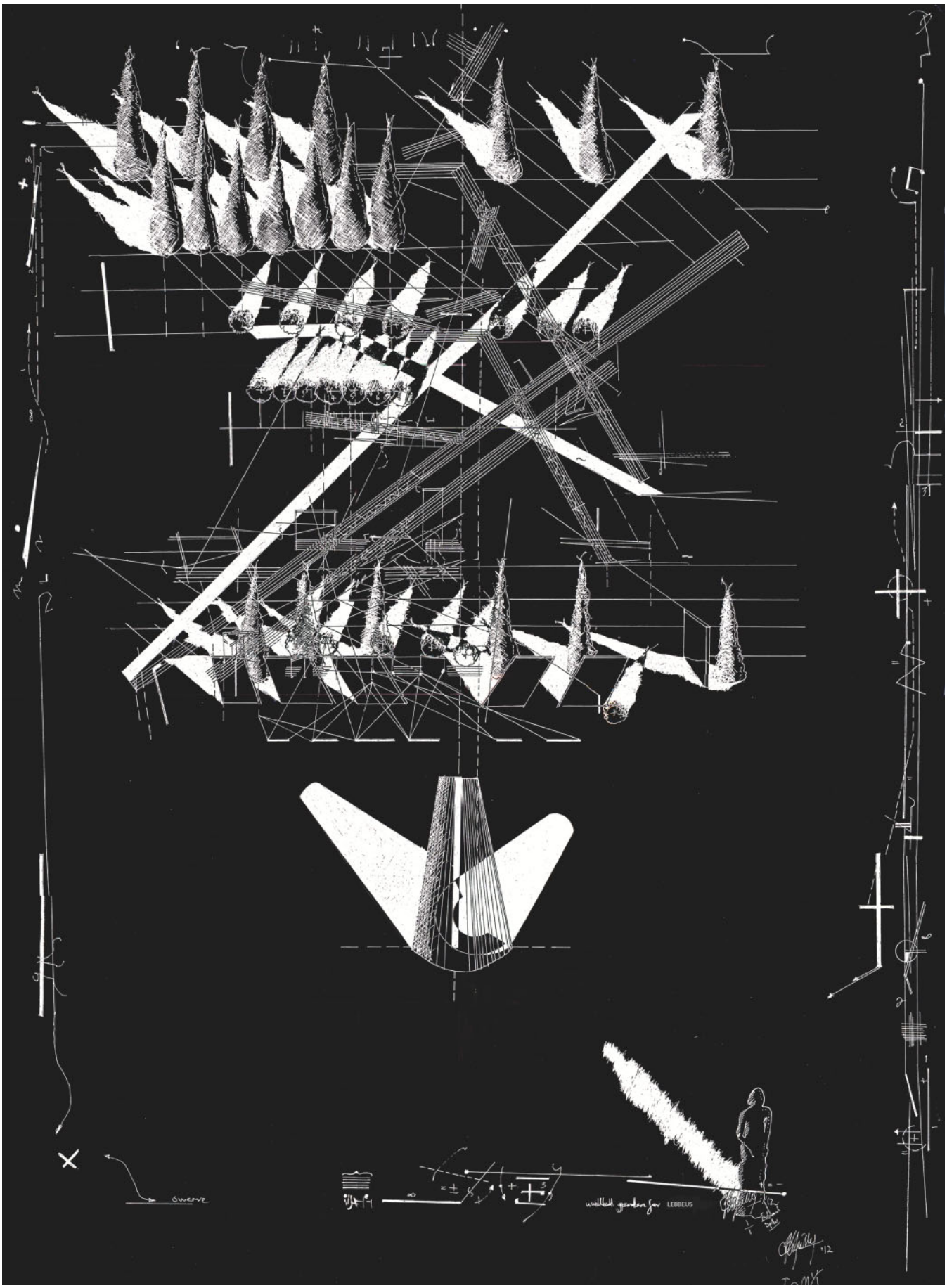
Project Persephone, which is part of the Icarus Interstellar research group's work and an AVATAR-led project initiated at the University of Greenwich, embodies an architectural-scale, process-led construction platform that proposes to design and engineer the living interior of a worldship. Its aim is to catalyse the construction of a real-world, crewed interstellar craft that will be assembled in Earth's orbit within 100 years.[21] Persephone is a programmable material system that is realised through the technology of soils as a palimpsest of processes that delay the heterogeneous matter in the worldship from reaching equilibrium. It firstly challenges the design imagination by using language that is derived from process philosophy to shape the expectations of the system. The processes themselves are based on the flow of elemental infrastructures that enable exchange between varieties of heterogeneous materials by inserting time and space into the post-natural fabric of the worldship. In turn, these are further perturbed by a variety of agents. Within this intense field of activity, the networks, relationships and flows established by the material computer move the system away from equilibrium and towards dynamic states that create the preconditions for the occurrence of lifelike events.

Yet, Persephone's design programme does not seek to create the lively events themselves, but to increase the probability of their occurrence. Consequently, Persephone's design details are not predetermined, but respond to perturbations within the worldship and can change and even evolve in environmentally sensitive ways over time. The details that emerge from these non-terrestrial networks may be recognised as new species that are categorised not according to their differences, as in classical Linnaean taxonomies, but are grouped according to their similarities and connections through oceanic ontologies. In this way Persephone's details seek commonalities between the diverse, heterogeneous agents that actively codesign the living interior to the worldship. Persephone's programmes, therefore, operate to prolong the diverse interactions that may give rise to synthetic architectures that are, ultimately, indistinguishable from 'life' itself. ⍙

*Persephone is a programmable material system that is realised through the technology of soils as a palimpsest of processes that delay the heterogeneous matter in the worldship from reaching equilibrium.*

**Notes**

1. Mitchell Joachim, 'In Vitro Meat Habitat: Material Shifts', in Simone Ferracina (ed), *Organs Everywhere*, Vol 4, September 2012, pp 60–1: http://organseverywhere.com/pdf/OE_4_Material-Shifts.pdf.
2. Rachel Armstrong and Neil Spiller, 'Synthetic Biology: Living Quarters', *Nature*, 467, 2011, pp 916–18.
3. The AVATAR architectural research group was founded by Neil Spiller in 2004 at the Bartlett, UCL, and has been based at the University of Greenwich, London, since 2011. See also Rachel Armstrong, 'Future Venice', in William Myers and Paola Antonelli (eds), *Bio Design: Nature Science Creativity*, MoMA/Thames & Hudson (New York and London), 2012, pp 72–3.
4. Mihail C Roco and William S Bainbridge, *Converging Technologies for Improving Human Performance, Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, NSF/DOC-sponsored report, Springer (Dordrecht), 2003.
5. Jane Bennett, *Vibrant Matter: A Political Ecology of Things*, Duke University Press (Durham, NC), 2010.
6. Rachel Armstrong, 'How Protocells Can Make Stuff Much More Interesting', in Neil Spiller and Rachel Armstrong (eds), ⍙ *Protocell Architecture*, March/April (no 2), 2011, pp 68–77.
7. Rachel Armstrong and Philip Beesley, 'Soil and Protoplasm: The Hylozoic Ground Project', in ⍙ *Protocell Architecture*, ibid, pp 78–89.
8. Stuart A Kauffman, *Reinventing the Sacred: A New View of Science, Reason, and Religion*, first trade paper edition, Basic Books (New York), 2008.
9. Skylar Tibbits, 'The Emergence of "4D Printing"', TED.com, February 2013: www.ted.com/talks/skylar_tibbits_the_emergence_of_4d_printing.html.
10. Henk M Jonkers, 'Self-Healing Concrete: A Biological Approach', in Sybrand van der Zwaag (ed), *Self-Healing Materials: An Alternative Approach to 20 Centuries of Materials Science*, Springer (Delft), 2007, pp 195–204.
11. Ian Steadman, 'Hamburg Unveils World's First Algae-Powered Building', *Wired*, 16 April 2013: www.wired.com/design/2013/04/algae-powered-building/.
12. Daniel A Beller, Mohamed A Gharbi, Apiradee Honglawan, Kathleen J Stebe, Shu Yang and Randall D Kamien, 'Focal Conic Flower Textures at Curved Interfaces', *Physical Review X*, 3(4), 041026, 2013, pp 1–8.
13. Johanna Seibt, 'Process Philosophy', *Stanford Encyclopedia of Philosophy*, 15 October 2012: http://plato.stanford.edu/entries/process-philosophy/.
14. Matt Lee, *Oceanic Ontology and Problematic Thought*, NOOK Book/Barnes and Noble, 2011. Available at: www.barnesandnoble.com/w/oceanic-ontology-and-problemat-ic-thought-matt-lee/1105805765.
15. Rachel Armstrong, 'Rachel Armstrong on Biomimicry as Parametric Snake Oil, *Architectural Review*, 11 July 2013: www.architectural-review.com/reviews/rachel-armstrong-on-biomimicry-as-parametric-snake-oil/8650000.article.
16. Rachel Armstrong and Martin Hanczyc, 'Bütschli Dynamic Droplet System', *Artificial Life*, 19(3–4), 2013, pp 331–46.
17. Phil Ross, 'Mycotecture', Hybrid Art, Ars Electronica Archive, 2013: http://archive.aec.at/#48240.
18. Alan Mathison Turing, 'The Chemical Basis of Morphogenesis', *Philosophical Transactions of the Royal Society of London, Series B, Biological Sciences*, 237(641), 1952, pp 37–72.
19. Neal Stephenson, 'Innovation Starvation', World Policy Institute, 2013: www.worldpolicy.org/journal/fall2011/innovation-starvation.
20. Karissa Rosenfield, 'Fluid Crystallization/Skylar Tibbits + Arthur Olson', *ArchDaily*, 28 July 2013: www.archdaily.com/407750/.
21. Paul Gilster, 'Project Persephone, Centauri Dreams', 6 September 2013: www.centauri-dreams.org/?p=28905.


wald und garten for LEBBEUS

# DETAILING THE WALLED GARDEN FOR LEBBEUS

**Neil Spiller, *Plan and Oblique View: Walled Garden for Lebbeus*, 2012**
While the initial sketches of this walled garden were being drawn, Lebbeus Woods died in New York at the same time as Hurricane Sandy hit the city.

Lines thick and thin, from delicate to bold, from dense, hard black to soft, ethereal gray, precise straight lines and nervously jittery lines, lines that group into recognizable and abstract shapes, lines standing, or moving, alone. Their effect in any of the drawings is encyclopedic: of a richly depicted, subtly inflected linear world ...
— Lebbeus Woods, 'Spiller's World', 19 March 2011[1]

I write this still reeling from the shock of Lebbeus' death, although many of us knew our friend was unlikely to be with us for much longer. I have known him over 20 years. His encouragement and enjoyment of my work has often been a much-needed balm to my own day-to-day creative struggle. Lebbeus was an architects' architect, seldom built, a huge inspiration to students and those of us who still cling to the idea that architecture can change society. He leaves us a lifetime of drawings – drawings of other worlds, worlds haunted with benevolent enigmas. He also leaves the best architects in the world memories of conversations, thoughtful prompts and happy meetings. Let us not ever deny that Lebbeus was and is one of the most talented creators and illustrators of architecture ever. He could effortlessly match the greats from other centuries such as Ledoux, Boullée and Piranesi. He was a virtuoso, a master.
— Neil Spiller, in Lebbeus Woods's obituary, *The Guardian*, 31 October 2012[2]

Towards the end of October 2012, I decided that I wanted to design a walled garden for my Communicating Vessels project.[3] I love traditional walled gardens; it is their sense of containment, secrecy and privacy that contributes to their spatial otherness. On 30 October that same year I was emailed by *The Guardian* and asked to contribute to an obituary for Lebbeus Woods. The walled garden therefore became the *Walled Garden for Lebbeus*. Through eyes blurred with a tear, the obituary and the garden took form.

### The Enigma of the Day

Initially, there were only a couple of drawings of the garden. However, over the past 18 months these have blossomed into a suite of 25 or more. I wanted the garden to channel all manner of architectural ambiences and make some familiar quotes, not only from my own architectural lexicon, but also from Leb's, Aldo Rossi's Moderna cemetery (1971) and OMA's Parc de la Villette competition entry (1982). The 30 October was also the day Hurricane Sandy ripped through New York, where Leb lived (this is not to suggest that the two events were connected). As 2014 has progressed, a whole series of ideas have evolved in the work, mainly about the choreography of augmented reality and gravity gradients over time. I wanted the garden to have another virtual side, one that would augment the simple world of walled space, trees, a truncated cone and statues I had created. This I saw as a new area of architectural detailing, one barely explored by contemporary architects. I wanted the drawings to explore this juxtaposition of virtual and actual, of points of view, ghosts, light and dark.

*In the dampness of the autumn dew, and with shiny brown leaves slippery underfoot, the boy surveyed the panorama, pausing only to take another bite from a steak and kidney pie, grasped in his cold, numb right hand. He gazed at the*

**Neil Spiller**, the Hawksmoor Chair of Architecture and Landscape and Deputy Pro Vice Chancellor of the University of Greenwich, London, has an unrivalled international reputation for the virtuosity of his visionary graphic work. Here, in a highly personal and poetic eulogy to Lebbeus Woods, Spiller pays tribute to his master through the lens of his own work, where detail becomes an important element in an imagined, augmented world in which the concrete or the specific lends credence to the fictional.

*evergreen trees – ordered but somehow unordered – the walls of lines and voids clashing randomly yet providing a sense of enclosure for the garden by suggestion. In the distance he saw a sculpture of a woman. He wheeled his bike towards her. As he came nearer he could see the back of her head was missing. The stillness and quiet were at the same time comforting and disquieting. He could now see from a plaque cast into her small plinth that her name was Electra. He leaned his bike up against her – like all young men do ...*

> For Neil Spiller, drawing is thinking. He does not 'express' thoughts already formulated, in which case his drawings would be mere illustrations. Rather, he formulates thoughts through drawing, indeed by drawing. Each line, each tone is a word. Their groupings are sentences. Their total ensemble is an essay, presenting a fully formed thought. However inadequate this analogy may be to suggest the fullness of Spiller's works, it does underscore their strong conceptual nature and what I believe are his intentions for them. Nor does the analogy detract from their lyrical, evocative mood; again, it underscores it in that the thoughts realized in the drawings are complex and subtle ones that defy simple explanation or illustration. In a sense, they are thoughts that can only be formulated by the means he has chosen, that is, by drawing and indeed by exactly the drawings he has made.[4]

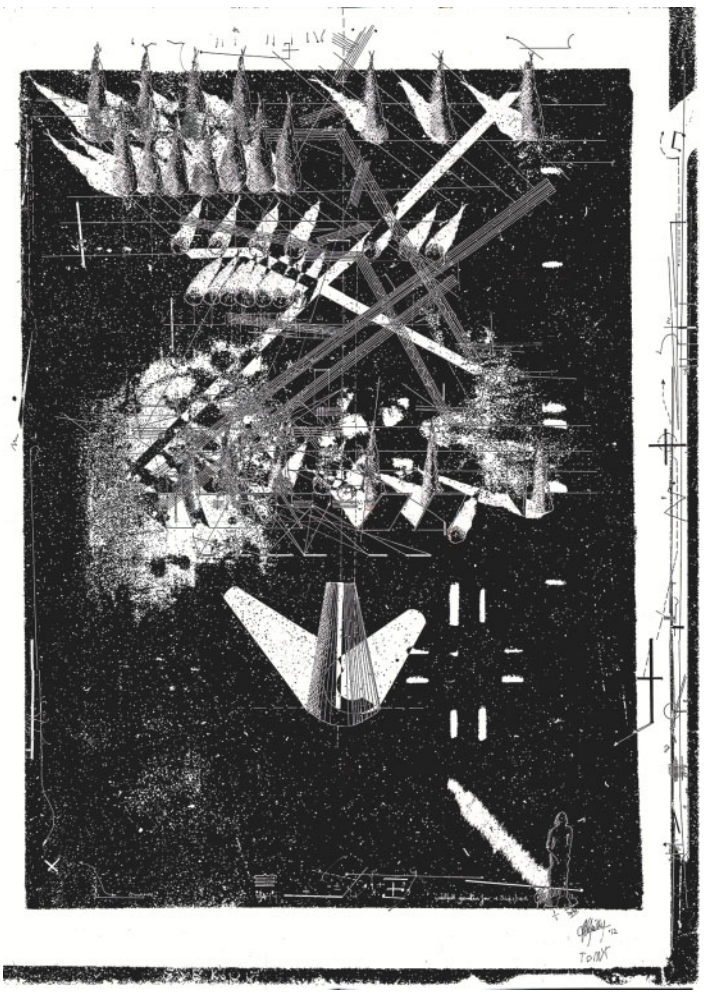
## Vectors and Storms

Augmented reality presents architects with a huge and wonderfully creative challenge. Suddenly the world is mostly empty, full of virgin spaces and surfaces ripe for virtual architectural intervention. Some of our old skills will be useful here, but equally we must develop another sense of detail to further reinforce more traditional notions of the detail. This is not the first time I have experimented with augmented reality and combinations of virtual and actual (cyborgian) terrains. My interest in this technology was sparked in 1998, when I became aware that augmented reality (AR) was being used to instruct operatives on how to construct space-frames or to see pipes embedded in walls. Indeed, AR is now used for all manner of relatively mundane applications like selling cars, viewing paintings or even 'chest buster' T-shirts where the baby alien bursts out of the wearer's chest.[5]

In urban terms, AR has been used to direct unfamiliar urbanites to the nearest McDonald's or Starbucks. I have reservations about this virtual demystification of the treasure trove of the city and the reduction of the possibilities of discovery, of synchronicity and the potential for further denial of all that does not accede to the continuing consumerisation of the urban realm. However, poetics and beauty still stubbornly hang on. Most people are now familiar with the smart phone 'app' that allows us to see the stars in the daylight, behind walls and beyond the horizon. So with the *Garden for Lebbeus* I wanted to create an augmented-reality environment that proposed a sublime, beautiful storm

**Neil Spiller, *Dark Cloud Coming Breaking the Day, Oblique View with Superimposed Augmented Reality Weather System and Ghostly Object Trajectories: Walled Garden For Lebbeus*, 2013**
If one presses one's face into the back of the head of the statue and looks through its eyes, one would see an augmented-reality storm forming and passing violently across the garden, as well as a series of ghostly objects moving among the trees and architecture of the garden.

For Neil Spiller, drawing is thinking. He does not 'express' thoughts already formulated, in which case his drawings would be mere illustrations. Rather, he formulates thoughts through drawing, indeed by drawing.

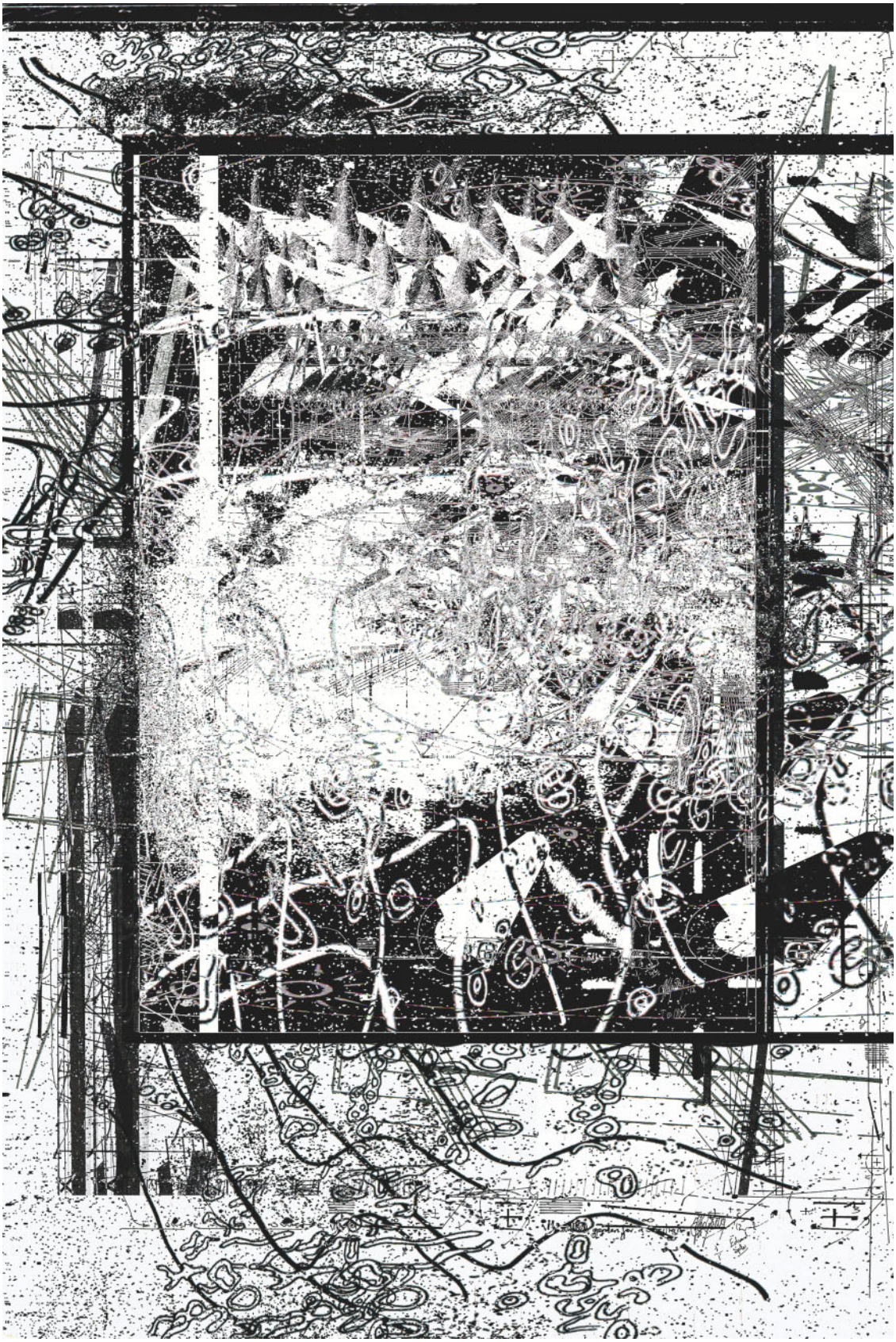


**Neil Spiller, *Virtual Objects and their Virtual Shadows – Garden Removed: Walled Garden for Lebbeus*, 2013**
The ghostly objects move throughout the garden, often in the peripheral view of the spectator, presenting a disquieting series of presences.


LEBBEUS

**Neil Spiller, *Stormbringer Coming Now: Walled Garden for Lebbeus*, 2013**
Plan showing augmented-reality weather systems entering the garden, and the ghostly objects forming from virtual vectors within.

**Neil Spiller, *Stormbringer Dance on the Thunder Again – Plan: Walled Garden for Lebbeus*, 2013**
The storm is now raging at full pitch, virtual snow covers most objects, and virtual gravity gradients distort views and the form of virtual objects.



bringing chaos, unable to be fully read or quantified viscerally or visually; to inject an alternative view of these technologies and stake another claim for them to be used in the service of architecture's poetic theatre. To do this one has to detail with time, velocity, multiple placements, points of view, gravity and ethereality. The storm will eventually abate and a new dawn comes into being.

### Stone-Cold Faces

*As he climbed up onto his bike, one foot on a pedal, another on the crossbar, and finally both feet tiptoed on the saddle, the boy ruminated on the last time he had seen the Professor. The Professor, the custodian of the island, had found him scrumping apples and given him a lecture on 'Pate physics', 'De Jericho', 'Alfred Jerry' and the 'Rocky Road from Dublin'. The boy had marvelled at the happiness in the Professor's eyes as he suddenly broke off from his lecture and chased after a rather drowsy wasp as if it were the White Rabbit. Now the boy pushed his face into the hollowed void in the back of the statue's head, and feeling her cold caress around his face and her clayey cold kiss on his lips he opened his eyes wide, seeing through her eyes. Immediately the garden went dark and was filled with a foreboding. The crust of the pie dropped from his hand. A clap of thunder, deafening, in his ears, he felt the statue shudder with its force.*

Towards the end of his career, Leb started to work in a more abstract way. He became interested in the primal conditions of architecture, those of the angle, the corner, the vector, of storm and fall and of texture and contrast. This is not to say he was not interested in these conditions before – of course he was. But recently, often, the building proposition was secondary to the confluence of lines and vectors:

> The variety of marks he makes is truly astonishing. Lines thick and thin, from delicate to bold, from dense, hard black to soft, ethereal gray, precise straight lines and nervously jittery lines, lines that group into recognizable and abstract shapes, lines standing, or moving, alone. Their effect in any of the drawings is encyclopedic: of a richly depicted, subtly inflected linear world, in which tone and color most often play subordinate roles. We feel, upon entering the drawings, as though we have found an entire world, whose exploration will take us away from our familiar one, but eventually bring us back to it, our perceptions enriched, our imaginations stimulated and expanded, the better to appreciate the familiar in new ways.[6]

I felt he was writing about himself as much as me.

## Ghostly Apparitions

Leb believed, and I certainly concur with him, that people 'construct' their realities by 'building' within them, pushing and establishing personal spatial, societal and physical boundaries. This is a well-known basic premise of second-order cybernetics, and Leb's interaction with Heinz von Förster earlier in his career will have cemented this notion in Leb's mind. In amongst the storm and the subsequent new dawn I wanted to also create and choreograph some ghostly forms that echoed my past as recognition of this lifelong process of boundary pushing and world building. Each ghostly form would wax and wane within the storm and conduct strange choreographies, between themselves, actual things and virtual things, all subject to moving fields of variable gravity and unworldly storm clouds. The drawings of these interactions I knew would have meteorological nuances. I also wanted it to virtually snow and thaw within the garden at this time as part of its moving complex tableaux.

*The boy saw a million see-through arrows coalesce into objects: columns, hooks and strange, tied bags – wispy like wedding dresses. Clouds formed, spitting rain and snow, which came out of nowhere. Thunder and lightning was heading the boy's way. He worried that he would be hurt by this storm, this stallion twister of vortexes within vortexes that rocked the sky and danced on the thunder again. As quickly as it had come it was gone, the light changed, a rainbow appeared fleetingly, snow melted and objects deconstructed, and a calmness filled the air. Suddenly the bicycle moved and the boy fell, grazing his cheek and knees on the rough surface of the statue.*

> Spiller's world includes much of the familiar – boundaries, edges, limits, creating forms we half or fully recognize. Then there are the mysterious forms, the ones we don't recognize at all. Bringing them all together to form a continuous landscape suggests above all else a transformation – the familiar past will become the unfamiliar future. What we know will change, sometimes slowly, often quickly, into what we do not know. Spiller's drawings are unsettling, even frightening. He presents us with a world we must work at to navigate. Rationality and emotion are needed in equal measure and will meet in our imaginations. The sheer beauty – or ugliness – of the drawings seduces us to try to match his creative efforts with our own. This brings the drawings firmly into the domain of architecture and far from that of art. The architect has designed spaces for us to inhabit, rather than objects for us to appreciate from outside.[7]

When I know what is in the truncated cone I will let you know! It is a work in progress. ⌀

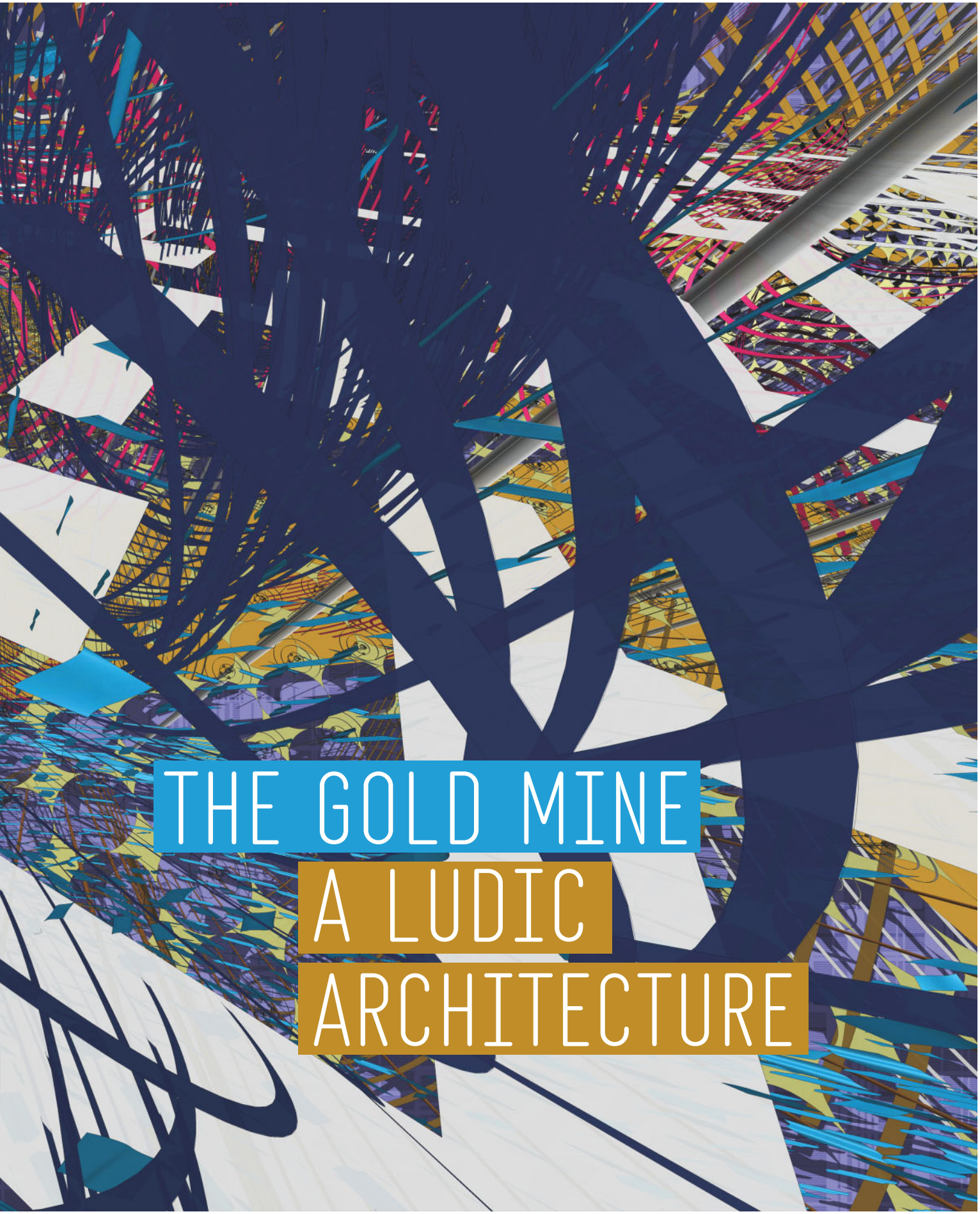
He [Lebbeus] became interested in the primal conditions of architecture, those of the angle, the corner, the vector, of storm and fall and of texture and contrast.

**Notes**

1. Lebbeus Woods, 'Spiller's World', 19 March 2011: http://lebbeuswoods.wordpress.com/2011/03/19/spillers-world/. Accessed 10 November 2013.
2. Neil Spiller, in Lebbeus Woods's obituary: Oliver Wainwright, 'Lebbeus Woods, Visionary Architect of Imaginary Worlds, Dies in New York', *The Guardian*, 31 October 2012: www.theguardian.com/artanddesign/architecture-design-blog/2012/oct/31/lebbeus-woods. Accessed 10 November 2013.
3. The Communicating Vessels island project surreally speculates, through drawing and design, on the impact of virtuality and biotechnology on architectural design in the 21st century. The project is ongoing and was instigated in 1998.
4. Lebbeus Woods, 'Spiller's World'.
5. See http://io9.com/5938851/augmented-reality-chestburster-t+shirt-pops-a-xenomorph-out-of-your-torso.
6. Lebbeus Woods, 'Spiller's World'.
7. Ibid.

*Lebbeus Woods's Blog* is due to be published in book format by Princeton Architectural Press in spring 2015.

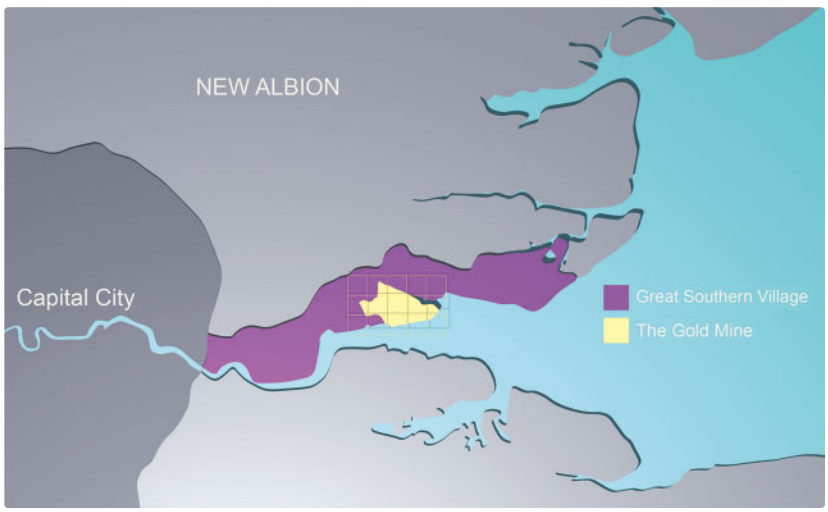
**Neil Spiller, *View Back Towards Statue as Storm and Objects Abate: Walled Garden for Lebbeus*, 2013**
A ghostly column returning to virtual vectors and dispersing, virtual snow melting and the beginnings of a new dawn in the garden – a time of renewal.



# THE GOLD MINE
# A LUDIC ARCHITECTURE

**Nic Clear, The Gold Mine/Great Southern Village Plan, 2014**
Map showing the context of the Gold Mine within the Great Southern Village as part of the New Albion system.

As an educator and architect, **Nic Clear** is renowned for his passion for film and science fiction; he teaches a unit in film and animation at the University of Greenwich, London, where he is Head of the Department of Architecture and Landscape. Here, in a recent speculative project, the Gold Mine, he weaves together a science fiction-like narrative that is heightened by its attention to visual and narrative detail.




Briefly, nothing and nobody in the Gold Mine is exploited. It is essentially an automated civilization in its manufacturing processes with human labour restricted to something indistinguishable from play, or a hobby.
— After Iain M Banks, 'A Few Notes On The Culture', 1994[1]

They wander through the sectors of the Gold Mine seeking new experiences, as yet unknown ambiances. Without the passivity of tourists, but fully aware of the power they have to act upon the world, to transform it, recreate it.
— After Constant Nieuwenhuys, *New Babylon: Outline of a Culture*, 1974[2]

**The Great Southern Village (GSV)**
The Great Southern Village, or GSV,[3] is a post-scarcity, post-singularity settlement that forms part of the New Albion system. While it is primarily an extension of the capital that stretches from the orbital in the west to the estuary mouth in the east, and is approximately 50 clicks long and 10 clicks wide, the GSV is an autonomous urban region with its own independent system of control and governance.

The settlement is a highly dense, highly populated zone controlled by a network of artificial intelligences (AIs). The GSV, along with the greater system of New Albion, works on the single ideological concept that nothing is wasted; all resources – biological, material and energy – are controlled optimally, and every single atom is accounted for.

That nothing is ever wasted is an aspect of the post-scarcity world that might sound counterintuitive. However, all material is always recycled; nothing is ever thrown away. Indeed, it is this technological ability to utilise every available piece of matter that actually creates a post-scarcity world. Everything can be broken down into its constituent elements so that they can then be recombined anew; sometimes this means reducing them right down to their atomic structures.

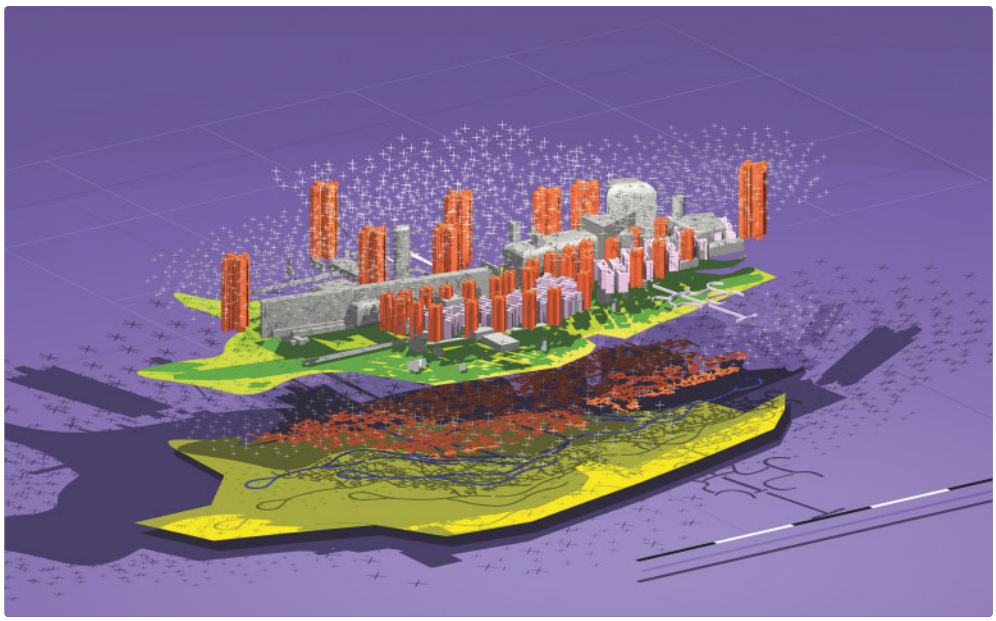
The megacities of New Albion are located on historic transport routes, with the areas between them designated as wilderness. Following on from James Lovelock's thesis that 'we should air condition the cities and let Gaia take care of the world',[4] urban growth has been concentrated into clearly defined dynamic areas with the rest of the country allowed to return to an untended state.

The Great Southern Village is named somewhat ironically as it was previously occupied by barbaric native tribes whose existence belies the pastoral image of the term 'village'.

The GSV is home to over a billion people; it is divided up into a series of plates, each of which has a unique character even though the nature of the plates is constantly changing. Located within the GSV is the Gold Mine, a plate designated for creative play and leisure purposes.

**Nic Clear, The Gold Mine, 2014**
*right*: Layered isometric. The Gold Mine is organised as a series of striated spaces: below the green landform level are the labyrinths and service systems, and above are the main ludic spaces and the accommodation.

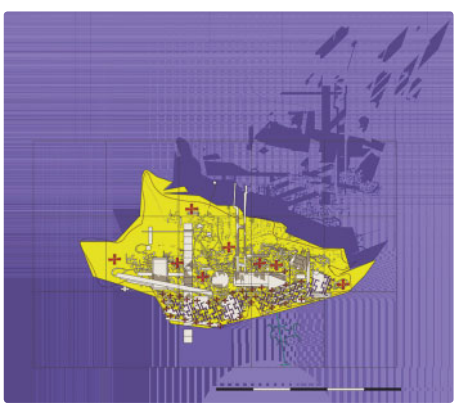
*bottom*: Composite plan. The overall organisation of the Gold Mine follows precedents set out by various 20th-century utopian architectures. The plan is notional and is subject to continual change



## The Gold Mine

The Gold Mine[5] is a linear city seven clicks long that runs along the banks of the estuary, located 10 clicks from the eastern edge of the GSV. The area had been evacuated due to flooding in 2025, since it had been 3 metres (10 feet) below the level of the highest tide and even the extensive flood defences could not hold back the rising waters of global warming. The flooding ceased to be a concern once society reached its current phase of abundance and the area was chosen for resettlement, partly due to its location, partly due to the fact that there was still a surfeit of materials left there following the floods, but mostly due to the mythic status it had acquired from its musical heritage.

The linear nature of the East–West axis is bisected at various points by built structures that break up the main armature and introduce more scenic elements



by connecting the city with the landform parklands that separate the Gold Mine from the rest of the GSV and New Albion beyond. These structures generally follow parts of the terrain of the former island, though this is not seen to be particularly significant.

The Gold Mine has been fully operational for 20 years, and is in a continual state of evolution. Its population is around 3.8 million inhabitants,[6] though this figure can fluctuate quite considerably due to seasonal variations and whatever events are scheduled for any given period. Even in its current state the Gold Mine could accommodate nearly 10 million inhabitants, however its under population is deliberate and seen as conducive to the 'work' that goes on there.

The Gold Mine itself is designated a creative leisure zone, where the inhabitants are engaged in developing speculative ideas and projects that may later be deployed across the whole of society. Its 'industries' are based around the concept of *'homo ludens'*,[7] and for the inhabitants leisure and gaming activities are linked into processing and problem-solving issues set up by the AIs. The benefits of this are that inhabitants are encouraged to create and act out wild fantasy scenarios that are fully indulged and supported. Given that the whole of the post-scarcity world is run according to ludic principles, the Gold Mine is still considered incredibly hedonistic even by those standards.

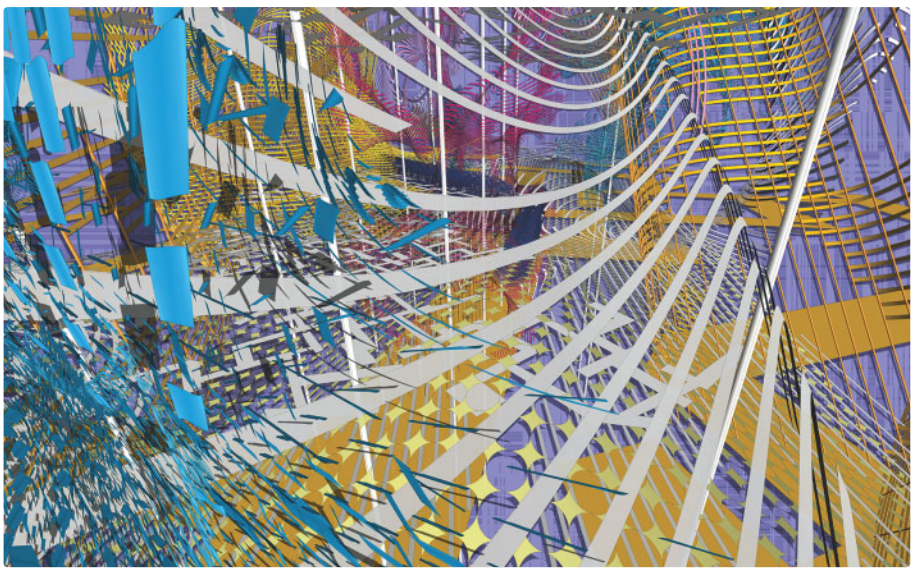
There are two main work scenarios that inhabitants perform. The first is task based and might involve working through combinations of puzzle-based computational operations.[8] The second is problem based and can often involve role playing or competitive gaming. Both are an evolution of an ancient approach to solving unsolvable problems; that is, to give them to a 'bunch of weirdos' without telling them they are unsolvable.[9]

The structure of the city is itself a giant computer with every surface being part of a programmable substrate that embodies a whole array of functions from data storage to environmental control. The surface substrate also carries light, power and data throughout the entire system.

All substrates capture energy in a number of ways: photovoltaic, electromagnetic, chemical as well as kinetic. This captured energy is stored within another part of the substrate. One of the main features of the Gold Mine is that energy is essentially free due to the fact that the various systems operate in an incredibly efficient manner and very little energy is lost due to problems of storage and transmission. Its proximity to the tidal reach of the estuary means that tidal energy is harnessed, its south-facing facades maximise solar energy, and ground-source energy systems are utilised as is biomass. But these are supplementary systems akin to solar-

*The Gold Mine is constantly being remodelled both by the AIs and by its human occupants – usually by a combination of both. No architects are involved; the AIs act as expert systems that organise the logistical and structural transformations, while inhabitants can 'sculpt' their own spaces using interactive interfaces.*

**Nic Clear and Hyun Jun Park, The Gold Mine, Ludic Space Perspectives, 2014**
*this page and pp 128–9*: Interior views of mixed-reality ludic spaces, where inhabitants undertake creative activities. Architectures are formed from physical components made of nanotube 'nets' combined with holographic virtual-reality projections. Interaction with other inhabitants is optional and must be consensual.



powered garden lighting; the main sources of energy are the hybrid fission-fusion reactors that extend from the Gold Mine's shoreline out into the river estuary.

The fabric of the built structures is part of an intelligent system that uses smart matter[10] as its primary construction material. Smart matter is made up of billions of nanotechnology machines that can alter their configuration to develop almost any kind of object, and is largely used in combination with other more plentiful materials (dumb matter). One of the principal 'dumb' materials in the Gold Mine is salt (sodium chloride), which can be easily extracted from the river and used to build elaborate crystalline structures with the smart matter acting as a 'glue', fixing the material so that it is not affected by water that would otherwise dissolve it. Smart matter allows the environments of the Gold Mine to be constantly reorganised and remodelled – the whole city is in constant flux with only certain strategic elements remaining static.

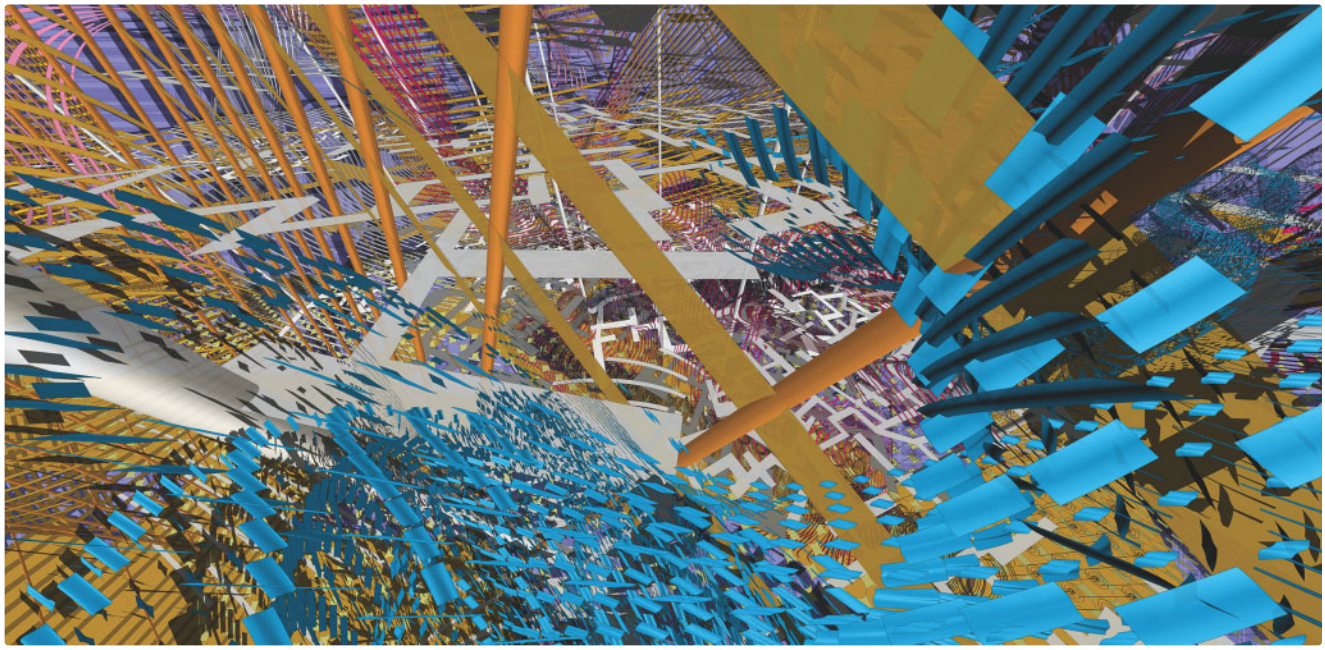
The underlying structures of the Gold Mine are created from carbon nanotubes that are both incredibly light and immensely strong. The nanotubes are woven into high-tensile polymer structural nets by swarms of weaving bots; indeed, these bots are responsible for the majority of the constant remodelling work that goes on. Individual enclosures and spaces are either created in-situ or prefabricated and then hung or clipped onto the structural nets. Services can be rerouted in any direction throughout the system and do not need to rely on gravity, and the service conduits can pump material without the need for an external pump.

The overall profile of the Gold Mine is relatively modest with the majority of the built sections only 50 storeys high, although some of the residential towers go up to 200 storeys.

The Gold Mine is constantly being remodelled both by the AIs and by its human occupants – usually by a combination of both. No architects are involved; the AIs act as expert systems that organise the logistical and structural transformations, while inhabitants can 'sculpt' their own spaces using interactive interfaces. These spaces are usually tested as virtual-reality environments that can be modified prior to construction. The spaces of the Gold Mine are multisensory environments that use light and sound to heighten its experiential qualities, to create varying levels of privacy and intimacy or to facilitate greater openness and communality.

Virtual reality and augmented reality are extensively used throughout the Gold Mine and sometimes it is impossible to differentiate between these and actual space, since even the 'physical' environments are constructed to mimic any conceivable form and material. All surfaces have incorporated within them the ability to act as an interface, so anything that can be physically simulated can also be created through the use of a screen.

Citizens of the Gold Mine are its most valuable resource and the greatest care is taken to make sure that no human potential is wasted. People live



long, healthy and productive lives; their natural systems are heavily augmented for both performance and cosmetic purposes, and every inhabitant of the Gold Mine is connected to its system by a series of neural and physiological implants, allowing them to augment their surroundings simply by thinking about them. Some of these changes are perceived by the individual alone, or by anyone who wishes to subscribe to the authors channel. The fact that the majority of inhabitants are highly experienced in the use of games and augmented-reality environments stops the type of psychosis that almost non-stop immersion in such an environment can entail.

To facilitate this level of immersivity, nearly all citizens have artificial corneas implanted at birth that allow the eye to function as a screen with data overlays. Radically different scopic regimes, such as seeing across a greater range of the electromagnetic spectrum, are also possible.

The levels of augmentation extend beyond the body into the clothing that inhabitants wear and into the objects they use. Smart clothing is the norm; it is capable of adapting colour and texture and is part of a biometric feedback process that interfaces with the system.

Children who grow up in the Gold Mine are guided by the system in terms of their personal and educational development. As with the overall running of the city the goal of the system is to maximise the potential of every child and to develop skills and abilities in accordance with their desires. One aspect common to all children, indeed almost every inhabitant of the Gold Mine, is that they can speak at least 12 languages. A child's education is developed through a process of individual and collective games at an appropriate pace for the individual, and is constantly monitored to be both fun and stimulating. Children in the Gold Mine almost never get bored unless it is necessary for them to do so.

Crime is extremely rare in the Gold Mine for two principal reasons: firstly the majority of inhabitants are simply too well adjusted to commit unsanctioned deviant behaviour, and secondly the system has ways of accommodating and channelling any anti-social urges into productive outlets. For example, it has been found that psychopaths are very good at designing fractal pattern systems and are often employed to develop vivid textures for multisensory environments. For those inhabitants who simply cannot control their urges, these can be accommodated through virtual means; acting out depravity has been found to be an effective substitute and can even be utilised as part of the ludic impulse. Nothing is wasted. ▵

**Notes**

1. Iain M Banks, 'A Few Notes On The Culture', 1994: see http://nuwen.net/culture.html – 'Gold Mine' inserted in place of 'The Culture'.
2. Constant Nieuwenhuys, *New Babylon: Outline of a Culture*, exhibition catalogue, Haags Gemeentemuseum (The Hague), 1974: see www.notbored.org/new-babylon.html – 'the Gold Mine' inserted in place of 'New Babylon'.
3. General Systems Vehicle, or GSV, is the name given to the largest spaceships of the Iain M Banks novels set in 'The Culture', a Space-dwelling anarcho-utopian civilisation run by powerful artificial intelligences referred to as 'Minds'. At 50 kilometres (30 miles) long, the Great Southern Village would be considered one of the second largest types of 'plate class'.
4. James Lovelock interviewed in *The Guardian*, 15 June 2012: www.theguardian.com/environment/2012/jun/15/james-lovelock-interview-gaia-theory/print.
5. The Gold Mine was the name of a legendary nightclub that existed on Canvey Island, Essex, in the 1970s.
6. The current population of Canvey Island is 38,000.
7. Johan Huizinga, *Homo Ludens: A Study of the Play-Element in Culture*, Beacon Press (Boston, MA), 1955.
8. See Firas Khatib's work on proteins using the foldit computer game: http://fold.it/portal/info/science.
9. Allegedly this is how NASA solves all of its unsolvable problems.
10. See Ray Kurzweil, *The Singularity is Near*, Viking Books (New York), 2005, pp 28–9.

Mark Burry

# THE ARCHITECTURAL DETAIL AND THE FEAR OF COMMITMENT

**Mark Burry** holds a unique position in architecture, straddling the worlds of practice and academia as Senior Architect to the Temple Sagrada Família in Barcelona and as Professor at RMIT in Melbourne, where he is Founding Director of the RMIT Design Research Institute. In his Counterpoint to this issue of AD, he puts the spotlight back on construction, asking whether the detail could be in danger of falling victim to an inadvertent and 'massive separation of design from making'. As he states: 'to detail effectively is to understand not only what the building "is", but how it will be made'.

**Mies van der Rohe, Barcelona Pavilion, International Exposition, Barcelona, 1929**
The highly influential pavilion under construction ingenuously reveals in its state of undress a structural frame that was subsequently deliberately concealed on completion, despite the apparent 'honesty' of visible materials and textures of the finished building.

Such has been the rate of change in architecture over the last century that whoever tackles this rich collection of contemporary essays on the 'future details of architecture' will inevitably bring generational baggage with them. Guest-Editor Mark Garcia has assembled a galaxy of thoughtful contributors who together have covered a very wide spectrum of perspectives ranging from the quasi-nostalgic to those visionary gazers whose glimpses of possible futures have only the flimsiest links to anything familiar to us in today's material world.

My baggage comes from having been involved in teaching construction and supervising postgraduates for 25 years, many of whom have chosen to connect their doctoral endeavours with what they hope to make their future within architectural practice. My counterpoint to this edition of Δ is framed around the challenge of proselytising building 'detailing' to students of architecture as not only a design exploration and synthesis in itself, but one that has equal legitimacy as the broader design considerations for the building as a whole; that although detailed design's task is ultimately to inform the builder, it has many other transitory but crucial roles along the way – not least design decision-making.

The ultimate goal – providing building knowledge at a general level, and building information at the specific level – requires commitment, for once a building is being built, very few architects ever get the opportunity to treat detailed design as a malleable work-in-progress. But design is such a loose process in itself, and to be denied the chance to evolve the design further while building is equivalent to the artist not being able to discard the almost completed work in favour of starting afresh based on revelations that can only appear in the process of bringing the work into being. The capital intensity of building therefore has a set of implications that accompany few other creatively centred professions; even film has more room for manoeuvre, to the extent that Oliver Reed could be digitised back into existence following his premature departure from the cast of Ridley Scott's film *Gladiator* in 1999. Once building commences, architects have such a potentially fertile design feedback loop deliberately closed down, regardless of the extraordinarily potent new insights that might occur as work proceeds. This is extremely scary, especially to new players: long before the first sod is turned, the design is committed.

In my very first days as an architecture student our 'construction studies' lecturer squared up to us on day one by presenting the following dilemma: 'There is such a thing as exciting buildings that leak', he contended (was he minded of Sir James Stirling's Faculty of History Library (1968) just a few hundred metres from where he lectured?), or there are 'boring buildings that do not'. He was very clear that his professional responsibility lay in dedicating his classes to buildings that did not leak. Simultaneously, elsewhere in my studies exemplar details were celebrated in lectures, presented as iconic components of iconic buildings: worthy evocations of masterly authority. This did not quite do it for me as the canonisation of both master and portfolio often seemed as trite as the slogans that went with them: Mies van der Rohe's 'less is more', 'God is in the details',[1] along with Louis Kahn's absolute classic: 'You say to a brick, "What do you want, brick?" And brick says to you, "I like an arch". And you say to brick, "Look, I want one, too, but arches are expensive and I can use a concrete lintel." And then you say: "What do you think of that, brick?" Brick says: "I like an arch."'[2]

For myself, and what I've also witnessed with students over the years, fawning idolatry for the detail decoupled from the whole within the comfort of the lecture theatre is worryingly remote from the reality of the building site. In so doing, discussion of the detail is several times removed not only from the context of its actual being, but, more critically, also so distant from the actuality of making. Even opportunities for simple yet critical observation during class site visits pale in comparison with the insights students draw during hands-on making, when design moves from the design studio to the workshop. How many students of architecture would prefer not to roll up their sleeves when offered the chance?

Students are hyper-aware of the commitment that comes with building, because when they commence their studies their complete ignorance of the craft of building hoves quickly into significance as the difference between the practical (building science) and the less tangible (design theory) plays out. The shared confidence that may come with the 'Emperor's New Clothes' aspects of design within the studio quickly evaporates when confronted with the 'stuff' of architecture, once the relative reality of the detail 'in action' becomes apparent, if not at school then certainly later in the office and on site. To detail effectively is to understand not only what the building 'is', but how it will be made. Only the truly ignorant will not be fearful of what can often seem an unbridgeable knowledge gap for the initiate. It is this tension of reconciling the legitimacy of being afforded a speculative head in the clouds while at the same time needing to ensure its attachment to a body that has its two feet firmly placed on the ground, that adds a certain frisson to any consideration of the detail. This is a big ask – a fusion between the creative engineer at one margin, and the visual philosopher at the other. Weaving through the interstices of this collection of essays I sought reconciliation between the ethereal and the real.

In Edward Ford's contribution, 'The Grand Work of Fiction' (pp 26–35), he posits three types of 'detailing narrative' for which dominance around any one of these particular narratives is cyclical: 'Even a cursory glance at the 20th century reveals that while architecture underwent the greatest technical transformation in its history, at this time the prevalence of one or the other of these approaches

to the joint occurred in a fairly cyclical way' (he then gives examples). Yesteryear's preoccupation with each of his three identified narratives – the 'articulated element, the seamless joint or the material collision' – will reappear as dominant at some point in the future. Of course I agree in one sense, as any proud owner of both volumes of his unparalleled tour de force *The Details of Modern Architecture*[3] (1990–94) would attest, but the very authority of this statement is also part of the problem that I encountered from the start of my own education: credible and credentialled orthodoxy is very effective at smothering other classes of genius.

This includes the 'free radicals' who blithely express tectonic intoxication not necessarily as a deliberate counter-current, but certainly with great confidence, almost as artists, and sometimes with an obscurity that in part has led to their own personal obscurity. In one of our classes, for example, the recently opened Sydney Opera House (1973) was briefly discussed quizzically at best before it was quickly dismissed as an example of extravagant colonial try-hard gaucheness. It was certainly very 'different', but the images we were shown focused only on its original and surprising formal qualities; if our lecturer actually knew how exquisite the surfaces are when seen from close-up with their reptilian tessellation of tiles in two shades of white, he never let on. But then he probably had not seen the building, as would have been the case for many of its distant critics whose very reaction to the image of it rather than its detail helped dampen any curiosity to go see for themselves. Readers who have never visited this remarkable building might Google for images of 'Sydney Opera House' and compare the results with a similar search for 'Sydney Opera House tiles' to see the point I am making here: we cannot easily see the trees for the wood. Ironically, as the story of the Sydney Opera House's quest for constructability emerged in the decades that followed, regardless of its formal and visual value this particular building had a far-reaching influence for later projects with similar ambitions: a veritable game-changer.

So, can we truly ponder the future of the architectural detail if as designers we keep our distance from Ruskin's 'quarry'[4] and the craftsman's hammer and chisel, and are thus more encouraged to be persuaded by theoretical propositions? To what extent do we remain victims of an inadvertently contrived separation of design from making? In his contribution to this issue of Δ, 'Details Around the Corner' (pp 36–43), Editor-in-Chief of *DETAIL* magazine Christian Schittich suggests that there remains in some countries a fruitful relationship between architect and builder ('Depending on the particular culture, solutions may even be developed while talking to craftsmen on the building site, without any retrospective documentation'), but for most this contemporary epoch dominated by the influence of the ubiquitous quantity surveyor, building lawyer and project manager offers no such advantage.

Students are hyper-aware of the commitment that comes with building, because when they commence their studies their complete ignorance of the craft of building hoves quickly into significance as the difference between the practical (building science) and the less tangible (design theory) plays out.

Even during the five decades of the Modern Movement that preceded our ever more risk-adverse times, the gifted could, and can still, fend for themselves, drawn as they are to materials and constructability, as much by tactile instinct as anything else, including prior knowledge. Others, the majority probably, and especially those emerging from today's large classes, have to rely on construction learning from teachers who typically come from a pool of building scientists, corduroyed historicists who, never having held a chisel in some creative context, interfere with an ideological bent, or a futurist for whom the bits-and-atoms siege breakers are already in sight: new knowledge to dispense utterly with the old.

As several writers acknowledge, and Dennis R Shelden in particular (see his 'Information, Complexity and the Detail', pp 92–7), the future might already be here, but the past is still here too, waiting to catch up. As Shelden asks: 'Will limitless freedom of materiality result in the same loss of direction and recourse to decoration that the modern steel frame and curtain wall did for the last generation?' By this I draw attention to one of the least acknowledged motivating ingredients to great architecture, one that in my view ought to claim similar territory as the intellectual, practical, financial and emotional considerations that drive architectural detailing, and this is the visceral. When visceral investment in a work is encountered, we know that there is a powerful and committed intelligence and sensitivity on offer that transcends emotional drivers such as nostalgia, memory, prior association, sense of the exquisite and wonder to name a few. The visceral plumbs depths that sometimes not even the author can fathom, but such deep feelings are clearly felt and transferred through the work to others.

The 'free radicals' that I refer to above are swimming against the current; they are the inadvertent counter-culture exponents whose architecture confounds any extant

**Josep Maria Jujol i Gibert, Can Negre, Sant Joan Despí, Catalonia, Spain, 1930**
Jujol's gradual makeover of a classical Catalan farmhouse (*masia*) exhibits élan that in no way presages the fundamental values of the Modern Movement that had just begun.

orthodoxy for their time, and they have always affected me in a way that reaches beyond any of the iconicity that features so strongly in our conventional architectural acclamations. Architects such as the Catalan Josep Maria Jujol most likely had no intention of being subversive within a prevailing zeitgeist, but their creative ebullience was obviously something that they were unwilling to keep in check. Every one of Jujol's projects, most of which are extraordinarily modest, shares a unique appreciation of light, colour and sheer joy. His church at Vistabella in Tarragona, Spain (1924) shows a stunning spatial complexity, but at the level of detail its humility is itself humbling. As they assembled for mass, parishioners apparently brought rocks from their fields to aid the construction effort. Even Jujol's reform works such as Can Negre in Sant Joan Despí (1930), a typical Catalan farmhouse (*masia*), is evidence of his unbridled creative zeal.

Jujol died a poor man, and has languished well outside any of the great 20th-century architectural literary accounts, coming into wider recognition only recently. Within five years of the completion of his church at Vistabella, however, Mies van der Rohe completed his temporary German Pavilion, more commonly referred to now as the 'Barcelona Pavilion' (1929). Following its eight months in the sunshine and despite its subsequent removal, its post-mortem influence reverberated sufficiently to lead ultimately to its reconstruction and reopening to an adoring fan base in 1986. Looking at the half-built construction of the original, we can interpret Mies's 'less is more' less charitably, for we see that he is unabashed in his use of luxurious materials with great simplicity but without sincerity. Its apparent structural system is a lie. What appear to be massive slabs of green marble, onyx and travertine assembled precisely (and improbably) into freestanding walls are in fact the equivalent of kitchen worktop slabs invisibly attached to the hidden steel framework with the added conceit of the 'butterfly effect' of the cut slabs hinged apart from each other to boot.

Perhaps Mies was a touch uncomfortable with this ingenuousness in an early work, for two decades later he was more ruthlessly 'honest' in his Farnsworth House near Plano, Illinois (1951), for which he fastidiously specified that the steelmaker's embossed name be ground off on the exposed structural elements. As Peter Macapia observes in his '*Un détail de ce qui change*: Function of a Function' on pp 68–77 of this issue, the Barcelona Pavilion's cruciform steel columns are shrouded in cruciform chromium casings ensuring that the steel frame appears nowhere at all – a far cry from Jujol's parishioners with their pockets full of rocks.

If Jujol is at one end of the commitment spectrum and Mies is at the other, there are many other 'unique' or 'unorthodox' figures who offer solidarity to Jujol, including Sigurd Lewerentz, Carlo Scarpa and Erik Bryggman. They are not a movement, but united by their varying degrees of audacity. Mies and colleagues actually contrived to create

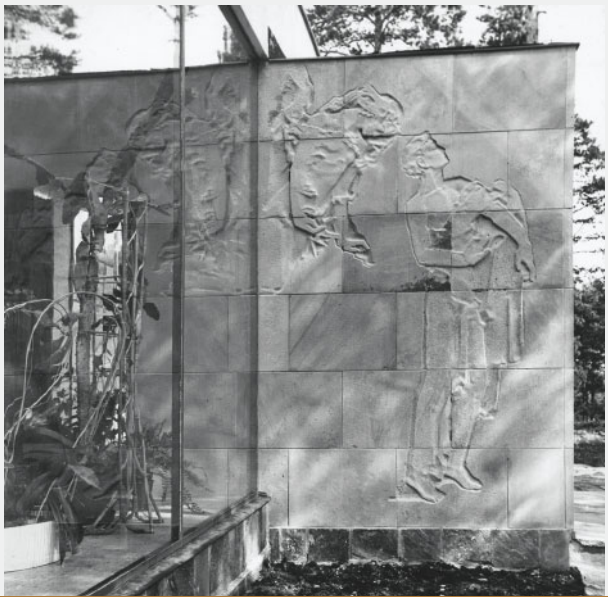
**Carlo Scarpa, Castelvecchio Museum, Verona, Italy, 1973**
*top*: The Equestrian Statue of Cangrande I della Scala (1291–1329) was architecturally integrated by Scarpa in his remodelling of the museum. Every button is pressed: spatial sensibility, respect for the past, technical virtuosity (note the cantilever and use of concrete) and, most notably, materiality.

*bottom*: Only Scarpa could originate such 'simple complexity' with his use of locally sourced rose-coloured marble in a highly considered grid of varying textures. His drawing of their positioning for this, the 'Sacello' – the sanctuary that protrudes into the courtyard at the Castelvecchio – is one of modern architecture's great surviving hand-drwan documents.

**Sigurd Lewerentz, St Mark's Church, Björkhagen, Stockholm, Sweden, 1960**
Lewerentz's bricks shout their purpose far more loudly than Louis Kahn's ever asked to do.

**Erik Bryggman, Resurrection Chapel, Turku Cemetery, Turku, Finland, 1941**
*top:* Bryggman combines the best of Modern Movement priorities with highly personal sensitivities, providing an extraordinary setting for the communal commemoration and grieving that takes place in the chapel.

*bottom:* Detail of the flattened sandstone friezes that are part of Bryggman's project at Turku (seen at the far right of the image above). Ennu Oka (1913–1940), the sculptor selected by Bryggman to create the sculptures, was killed mid-work at the end of the Winter War in 1940. The work was continued and completed by Jussi Vikainen, who defined the programme as transitioning from the shadows to the light.



a unifying language through which their standardised approach to detail was the conforming lexicon.

To read this entire issue of Δ is to look over an uneven landscape, a variable terrain with some regions bogged down by an unwillingness to let go of the past, others realistic about the rapidly evolving conditions of today, and also unexpectedly vast areas nearer the horizon where enthusiastic voyagers dream of escape from the mundane: more beguiled by tomorrow than shackled to the present. Whether a virtual speculative terrain glorying in the immaterial or the eternal hope of a release from the everyday via new technologies and materials, some future architectural detail prognoses mercifully completely dispense with the history of construction as we have come to know it.

If there is a strong flavour of the speculative within this Δ, then let its counterpoint be the quieter transcendences born through unexpected combinations of the tactile, the unusual, the unfamiliar, the artful, the committed. Compared with architecture, furniture designers have had access to 'wonder' materials for a very long time yet we still see timber very much in use in their work. Fundamentally, the future of the architectural detail is surely a greatly expanded field, and not a blinkered drive towards a future invented at the expense of the past? Bits-and-atoms enthusiasts can dream of living in infinitely reconfigurable caves while the rest of us, charged with the task of building architecture today, and over the next few decades, can revel in the extraordinarily expanded pallet of new materials and technologies ready for absorption into our existing repertoire.

This embarrassment of riches may well help prevent any latter-day Le Corbusiers, Mieses, Kahns *et al* from asserting their authority in quite the same way as their antecedents: today we are more adept at spotting the Jujols, Lewerentzs, Scarpas and Bryggmans and giving them breathing space than we might have been in the past. The question of commitment, however, remains an open one, and ever more new materials and esoteric assembly processes could fuel even deeper fears of ignorance, limiting rather than widening our repertoire. Perhaps this circumstance is only relevant if the architect continues to strive to detail the whole. Nevertheless, if we do not commit to the nitty gritty, are we still really architects? ɒ

**Notes**
1. From 'On Restraint on Design', *New York Herald Tribune*, 28 June 1959.
2. As recently re-quoted in the *Guardian* in 2013: www.theguardian.com/artanddesign/2013/feb/26/louis-kahn-brick-whisperer-architect.
3. Edward R Ford, *The Details of Modern Architecture, Vols I and II*, MIT Press (Cambridge, MA and London), 1990–94.
4. In John Ruskin, *The Stones of Venice: The Nature of Gothic*, Book II.VI.XXI, 1853.

**Rachel Armstrong** is a co-director of the Advanced Virtual And Technological Architectural Research (AVATAR) group, specialising in architecture and synthetic biology at the Department of Architecture and Landscape, University of Greenwich, London. She is also a 2010 Senior TED Fellow, and a visiting research assistant at the Center for Fundamental Living Technology, Department of Physics and Chemistry, University of Southern Denmark. She is a sustainability innovator who investigates a new approach to building materials called 'living architecture', which suggests it is possible for our buildings to share some of the properties of living systems. Her TEDBook, *Living Architecture: How Synthetic Biology Can Remake Our Cities and Reshape Our Lives*, is available as a Kindle single on the Nook, i-Book and Kindle platforms. She is the guest-editor (with Neil Spiller) of AD *Protocell Architecture* (March/April 2011).

**David Benjamin** is Principal at architecture firm The Living, and Director of the Living Architecture Lab at Columbia University Graduate School of Architecture, Planning and Preservation (GSAPP). The practice and the lab emphasise open-source research and design. Recent projects include Living City (a platform for buildings to talk to one another), Amphibious Architecture (a cloud of light above the East River that changes colour according to conditions underwater), Living Light (a pavilion in Seoul that displays air quality and collective interest in the environment), and Proof (a series of design studios at Columbia that explore testing as a design methodology and evolutionary computation as an exploration technique). Before receiving a Master of Architecture degree from Columbia, Benjamin graduated from Harvard with a BA in Social Studies.

**Ben van Berkel** is the Co-Founder and Principal Architect of UNStudio in Amsterdam and Shanghai. He studied architecture at the Rietveld Academy in Amsterdam and at the Architectural Association in London, receiving the AA Diploma with Honours in 1987. UNStudio is a network of specialists in architecture, urban development and infrastructure. Current projects include restructuring the station area of Arnhem, the Raffles City mixed-use development in Hangzhou, a dance theatre for St Petersburg and the design and restructuring of the Harbor Ponte Parodi in Genoa. Van Berkel is currently Professor Conceptual Design at the Staedelschule in Frankfurt am Main and was recently awarded the Kenzo Tange Visiting Professor's Chair at Harvard University Graduate School of Design.

**Professor Mark Burry** is a practising architect who has published internationally on two main themes: the life, work and theories of the architect Antoni Gaudí, and putting theory into practice with regard to 'challenging' architecture. He has been Senior Architect to the Sagrada Família Basilica Foundation since 1979 pioneering distant collaboration with his colleagues based on-site in Barcelona. He is currently the Founding Director of RMIT University's Design Research Institute (DRI), established in 2008 to collaborate across the entire university design community, ranging from hard-core sciences and technology to applied arts. In 2001 he founded RMIT University's state-of-the-art Spatial Information Architecture Laboratory (SIAL) in Melbourne, established as a holistic transdisciplinary spatial design research environment.

**Matthew Claudel** studied architecture at Yale University. He has presented at TEDx, designed and authored several books, and completed architectural projects in Tokyo and St Kitts. His work has been published in the *Architectural Review* and *El País*, and featured in exhibitions at Yale. He was the recipient of the Sudler Prize, Yale's highest award for the creative and performing arts. He is currently a researcher at the Massachusetts Institute of Technology (MIT) SENSEable City Lab, working in design, writing and curation.

**Nic Clear** is Head of the Department of Architecture and Landscape at the University of Greenwich where he also teaches a postgraduate design unit that specialises in the use of film and animation to create speculative architectures. He has been published extensively on architecture and science fiction, and has written the architecture section of the *Oxford Handbook of Science Fiction*. He is the guest-editor of AD *Architectures of the Near Future* (Sept/Oct 2009).

**Hernan Diaz Alonso** is principal and founder of the Los Angeles-based design practice Xefirotarch, and Graduate Programs Chair and Distinguished Professor of Architecture at the Southern California Institute of Architecture (SCI-Arc). He has taught as a design studio professor at Columbia GSAPP, and he is the head studio professor in the 'Excessive' postgraduate programme at the University of Applied Arts Vienna. In autumn 2010 he was honoured by Yale University with the Louis I Kahn Visiting Assistant Professorship of Architectural Design, and will be the Eero Saarinen Professor of Architectural Design in spring 2015. His upcoming monograph will be published by Thames & Hudson in spring 2015. In 2013 he received the Progressive Architecture award for the Thyssen-Bornemisza Museum, Madrid. His work has been the subject of solo shows at the San Francisco Museum of Modern Art, the Art Institute of Chicago and the MAK Center, Vienna. His office is currently building the Center of Experience and Media for Boeing in Seattle.

**Edward Ford** is the Shea Professor of Architecture at the University of Virginia. He is the author of the two volumes of *The Details of Modern Architecture* (MIT Press, 1990 and 1994), and *The Architectural Detail* (Princeton Architectural Press, 2011). His architectural work is the subject of *Five Houses, Ten Details* (Princeton Architectural Press, 2009) and has been published in *The New American House, Japan Architect* and *Competitions*.

**Peter Macapia** is an architectural designer and theorist. He studied at the Rhode Island School of Design, Harvard University and Columbia University. He started labDORA in 2003 after receiving his PhD from Columbia, where he was the recipient of the Presidential Fellowship. His architecture focuses on the geopolitics of space, algorithmic computation, structural engineering, and the geometry and topology of matter/energy relations. In addition to Columbia University, Pratt Institute and SCI-Arc, he has lectured and taught internationally at Princeton, RMIT University, Tokyo University of Science, the École Spéciale d'Architecture Paris, TU Delft and elsewhere.

**Danil Nagy** is Associate Designer at The Living and Adjunct Assistant Professor of Architecture at Columbia's GSAPP. His work spans a wide range of scales and disciplines including software, installation, architecture

and urban design. His prime interest is in bridging these various scales through a common design intelligence based on specific lines of research and a focus on computation and digital methods.

**Carlos Olguin** heads the Bio/Nano/Programmable Matter Group at Autodesk Research, which is investigating the design spaces enabled by matter programming across different domains and scales. He is an interdisciplinary designer with more than 13 years of combined experience in domains such as design tools for 2D and 3D modelling, learning, GIS, risk management, network service brokerage, web search experience, online emergent social phenomena and, more recently, systems/synthetic biology. In 2001 he earned a Master of Science in Information Networking from Carnegie Mellon, and he holds a BSc in electronics and communications from ITESM Campus Monterrey (Mexico). He has also taken fully accredited courses in systems biology.

**Philippe Rahm** is Principal of Philippe Rahm architectes based in Paris. His work, which extends the field of architecture from the physiological to the meteorological, has received an international audience in the context of sustainability. In 2002 he was chosen to represent Switzerland at the 8th Venice Architecture Biennale, and he was one of the 25 Manifestos Architects of the 2008 Biennale. He has participated in a number of exhibitions worldwide, and in 2007 had a personal exhibition at the Canadian Centre for Architecture (CCA) in Montreal. He was a unit master at the Architectural Association (AA) in London from 2005 to 2006, and has been a visiting professor at the Mendrisio Academy of Architecture, the ETH Lausanne, Royal Danish Academy of Fine Arts in Copenhagen, and the Oslo School of Architecture and Design (AHO). From 2010 to 2012 he held the Jean Labatut Professorship at Princeton University. His recent work includes first prize for the Taichung Gateway Park in Taiwan (2011). Monographs include *Architecture météorologique* (Archibooks, 2009).

**Carlo Ratti** is an architect and engineer by training. He practises in Italy and teaches at MIT, where he directs the SENSEable City Lab. He has co-authored over 250 publications and holds several patents. His work has been exhibited in several venues worldwide, including the Venice Biennale, Museum of Modern Art (MoMA) in New York and MAXXI in Rome. At the 2008 World Expo, his Digital Water Pavilion' was hailed by *Time* magazine as one of the 'Best Inventions of the Year'. He has been included in *Blueprint* magazine's '25 People who will Change the World of Design' and in *Wired* magazine's 'Smart List 2012: 50 people who will change the world'. He is curator for the 'Future Food District' at Expo Milano 2015.

**Christian Schittich** holds a Diploma in Architecture and Engineering. He undertook his studies at the University of Technology, Munich, which was followed by seven years' office and design experience as an architect. He is Editor-in-Chief of *DETAIL: Review of Architecture and Construction Details*. Under his direction, *DETAIL* has developed to become internationally one of the most widespread and distinguished magazines among architects. He is also the author and editor of numerous books.

**Patrik Schumacher** has been a designer at Zaha Hadid Architects (ZHA) since 1988. He is a partner of the practice as well as a co-author of all major projects such as the MAXXI: Museum of XXI Century Arts (Rome, 2009), Guangzhou Opera House (China, 2010), Heydar Aliyev Centre (Baku, Azerbaijan, 2007–) and the Dongdaemun Design Park and Plaza (Seoul, 2014). He has been teaching at various architectural schools in the UK, continental Europe and the US since 1992, and held the John Portman Chair in Architecture at Harvard University's Graduate School of Design (GSD) in 2013. He is founder of the AA Design Research Laboratory (AA DRL), where he has continued to teach since 1996. In 2010 and 2012 he published the two volumes of his theoretical magnum opus *The Autopoiesis of Architecture* with John Wiley & Sons.

**Dennis R Shelden** is a founder and Chief Technology Officer of Gehry Technologies, a building industry technology company formed in 2001 by the research and development team of Frank Gehry Partners. He is concurrently an associate professor of the Practice in Computation and Design at MIT, where he lectures and conducts research in building industry process advancement, parametric building information modelling, computational geometry and design cognition. He holds a BS in architectural design, an MS in civil and environmental engineering, and a PhD in computation and architectural design from MIT. He is a licensed architect in the state of California.

**Neil Spiller** is currently the Hawksmoor Chair of Architecture and Landscape and Deputy Pro Vice Chancellor of the University of Greenwich. Prior to this he was Vice Dean and Graduate Director of Design at the Bartlett School of Architecture, University College London (UCL). He enjoys an international reputation as an innovative, theoretical architect, and was one of the first architects to write and speculate through drawings on cyberspace, nanotechnology and synthetic biology, and what these might do to architecture. This has resulted in numerous publications. He guest-edited (with Martin Pearce) his first Δ, *Architects in Cyberspace*, in 1995, followed in 1996 by *Integrating Architecture*, then *Architects in Cyberspace II* (1998), *Young Blood* (2001), *Reflexive Architecture* (2002), *Protocell Architecture* (with Rachel Armstrong) (2011) and *Drawing Architecture* (2013). His books include *Visionary Architecture: Blueprints of the Modern Imagination* (Thames & Hudson, 2007), *Digital Architecture Now: A Global Survey of Emerging Talent* (Thames & Hudson, 2008) and *Educating 21st-Century Architects* (Thames & Hudson, 2014). His work has been exhibited internationally.

**Skylar Tibbits** is a trained architect and computer scientist whose research focuses on self-assembly and programmable material technologies for industrial applications. He was recently awarded a 2013 Architectural League Prize, the Next Idea Award at Ars Electronica 2013, the Visionary Innovation Award at the Manufacturing Leadership Summit, and a 2012 TED Senior Fellowship, and was named a Revolutionary Mind in *SEED* magazine's 2008 Design Issue. He has designed and built large-scale installations around the world and exhibited at the Guggenheim Museum in New York and the Beijing Biennale, and lectured at the Museum of Modern Art (MoMA) and SEED Media Group's 'MIND08'. He is the director of the MIT Self-Assembly Lab and founder of a multidisciplinary research-based practice, SJET LLC. He is also faculty in MIT's Department of Architecture.

INDIVIDUAL BACKLIST ISSUES OF Δ ARE AVAILABLE FOR PURCHASE AT £24.99 / US$45

TO ORDER AND SUBSCRIBE SEE BELOW

**What is *Architectural Design*?**
Founded in 1930, *Architectural Design* (Δ) is an influential and prestigious publication. It combines the currency and topicality of a newsstand journal with the rigour and production qualities of a book. With an almost unrivalled reputation worldwide, it is consistently at the forefront of cultural thought and design.

Each title of Δ is edited by an invited guest-editor, who is an international expert in the field. Renowned for being at the leading edge of design and new technologies, Δ also covers themes as diverse as architectural history, the environment, interior design, landscape architecture and urban design.

Provocative and inspirational, Δ inspires theoretical, creative and technological advances. It questions the outcome of technical innovations as well as the far-reaching social, cultural and environmental challenges that present themselves today.

For further information on Δ, subscriptions and purchasing single issues see: www.architectural-design-magazine.com

**How to Subscribe**
With 6 issues a year, you can subscribe to Δ (either print, online or through the Δ App for iPad).

INSTITUTIONAL SUBSCRIPTION
£212/US$398 print or online

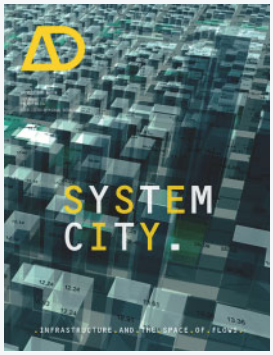
INSTITUTIONAL SUBSCRIPTION
£244/US$457 combined print & online

PERSONAL-RATE SUBSCRIPTION
£120/US$189 print and iPad access

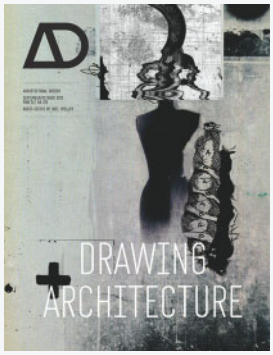
STUDENT-RATE SUBSCRIPTION
£75/US$117 print only

To subscribe to print or online:
Tel: +44 (0) 1243 843 272
Email: cs-journals@wiley.com

Δ APP FOR iPAD
For information on the Δ App for iPad go to www.architectural-design-magazine.com
6-issue subscription: £44.99/US$64.99
Individual issue: £9.99/US$13.99

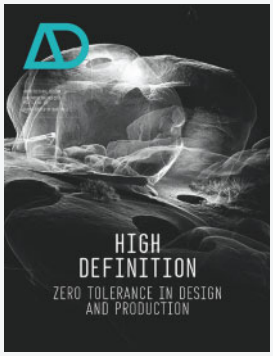



Volume 83 No 4
ISBN 978 1118 361429

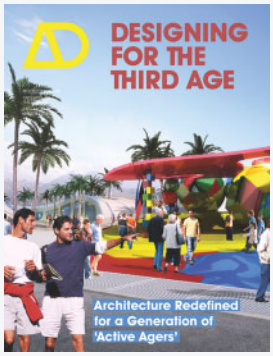



Volume 83 No 5
ISBN 978 1118 418796


Volume 83 No 6
ISBN 978 1118 361795

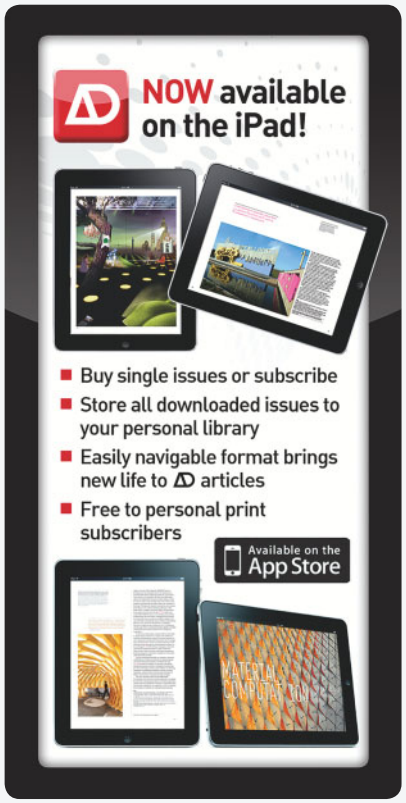



Volume 84 No 1
ISBN 978 1118 451854

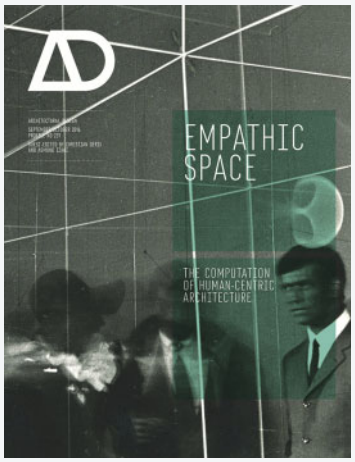



Volume 84 No 2
ISBN 978 1118 452721


Volume 84 No 3
ISBN 978 1118 535486



# △ ARCHITECTURAL DESIGN
# FORTHCOMING △ TITLES

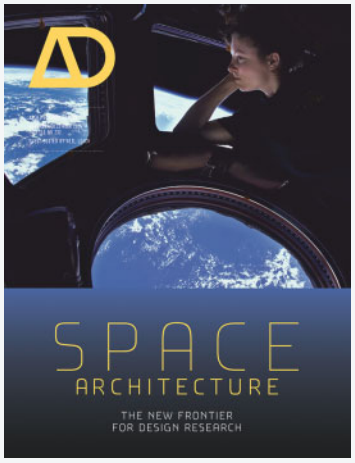



Volume 84 No 5 ISBN 978 1118 613481

SEPTEMBER/OCTOBER 2014 - PROFILE NO 231
## EMPATHIC SPACE: THE COMPUTATION OF HUMAN-CENTRIC ARCHITECTURE
GUEST-EDITED BY CHRISTIAN DERIX AND ÅSMUND IZAKI

In recent years, questions of space have gained renewed momentum in architecture and urban design, as adaptation, densification and sustainable regeneration have become an increasing priority. While most computing-based design tends to emphasise the formal aspects of architecture, overlooking space and its users, the 'original' computational design approaches first spearheaded in the UK in the 1960s and 1970s tended to be focused on behavioural and occupational patterns. Over the last decade, a new generation of design research has emerged that has started to implement and validate previous investigations into spatial computation, aiming to understand how to design spatial configurations based on user experiences. This revives an interest in the experiential that was first explored in the early 20th century by German and Nordic organic architects, who invented design methods that correlated cognitive responses of buildings' occupants to spatial structure. The current revival of human-centric design, however, represents the first design approach that synthesises spatial design and algorithmic techniques with organic design thinking, which could also be regarded as a return to the 'first principles' of architectural design.

**Contributors include:** Paul Coates, Christian Derix, Olafur Eliasson, Lucy Helme, Bill Hillier, Åsmund Izaki, Prarthana Jagannath, Dan Montello, Juhani Pallasmaa, Philip Steadman, Guy Theraulaz.
**Featured architects/designers:** Aedas|R&D, Stan Allen, Jussi Ängeslevä (ART+COM), Markus Braach (KAISERSROT), Herman Hertzberger, Kazuhiro Kojima (CAt), Pablo Miranda, Rafi Segal.




Volume 84 No 6 ISBN 978 1118 663301

NOVEMBER/DECEMBER 2014 - PROFILE NO 232
## SPACE ARCHITECTURE: THE NEW FRONTIER FOR DESIGN RESEARCH
GUEST-EDITED BY NEIL LEACH

Forty years on from the first moon landing, architecture in Space is entering a new era. Over the last decade, there has been a fundamental shift in the Space industry from short-term pioneering expeditions to long-term planning for colonisation, and new ventures such as Space tourism. Architects are now involved in designing the interiors of long-term habitable structures in Space, such as the International Space Station, researching advanced robotic fabrication technologies for building structures on the Moon and Mars, envisioning new 'space yachts' for the super-rich, and building new facilities, such as the Virgin Galactic 'Spaceport America' in New Mexico designed by Foster + Partners. Meanwhile the mystique of Space remains as alluring as ever, as high-profile designers and educators – such as Greg Lynn – are running design studios drawing upon ever more inventive computational design techniques. This issue of △ features the most significant current projects underway and highlights key areas of research in Space, such as energy, materials, manufacture and robotics. It also looks at how this research and investment in new technologies might transfer to terrestrial design and construction.

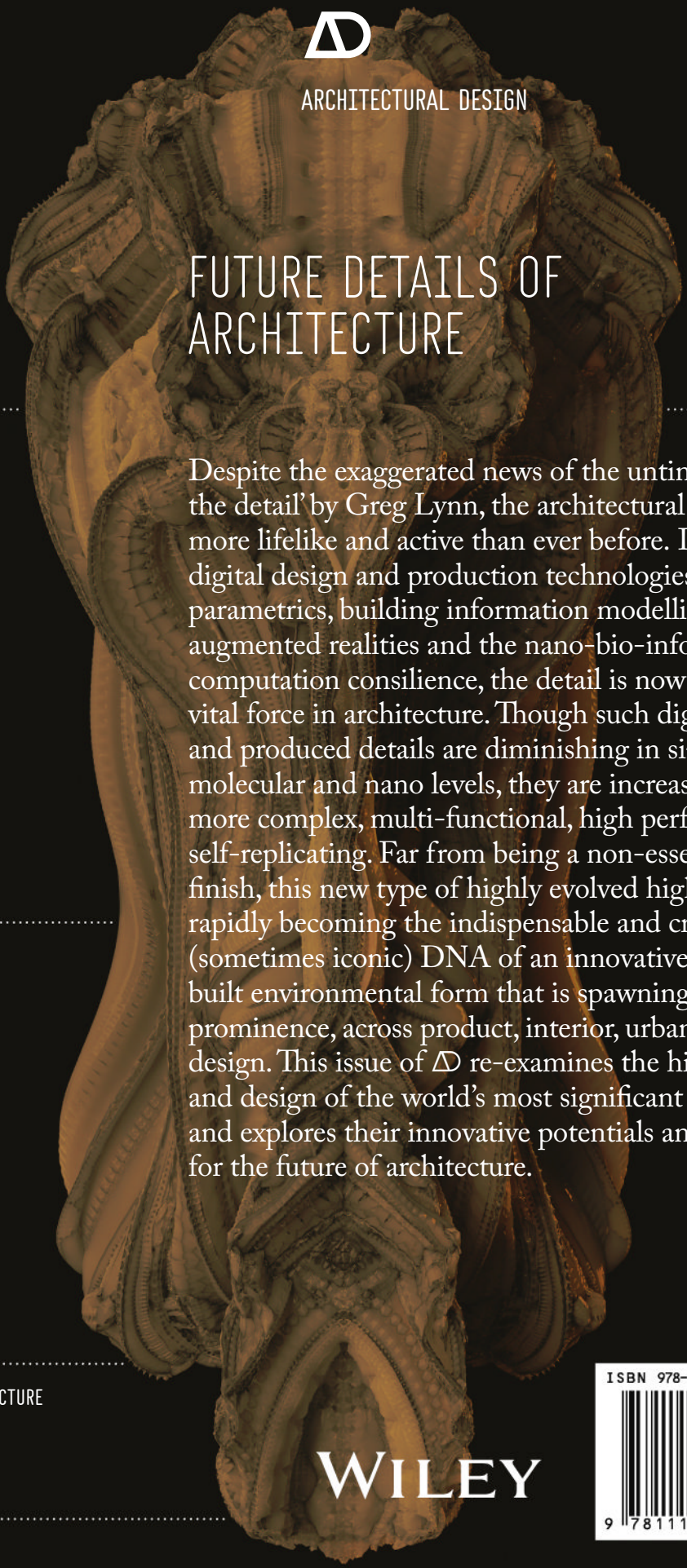
**Contributors include:** Anders Carlson, Anita Genupta, Behrokh Khoshnevis.
**Space architects**: Constance Adams, Marc Cohen, Ondrej Doule, Scott Howe, Brent Sherwood, John Spencer, Madhu Thangavelu, Andreas Vogler.
**Architects:** Bevk Perović Arhitekti, Dekleva Gregorič Arhitekti, Foster + Partners, Neil Leach, Greg Lynn, OFIS architects, SADAR+VUGA.


Volume 85 No 1 ISBN 978 1118 759066

JANUARY/FEBRUARY 2015 - PROFILE NO 233
## UAE AND THE GULF: ARCHITECTURE AND URBANISM NOW
GUEST-EDITED BY GEORGE KATODRYTIS AND KEVIN MITCHELL

At the end of the 20th century, Dubai attracted international media attention as the world sought to make sense of the city's extraordinary growth. Exuberant projects such as the Burj Arab, the Burj Khalifa and the Palm Islands attracted investment in dreams to transform the region. While the global financial crisis kept dreams from becoming reality, this issue of △ seeks to present a view of architecture and urbanism in the United Arab Emirates (UAE) and other states in the wider Gulf Cooperation Council (GCC) at a time when greater economic stability promises new beginnings. The issue presents examples of architecture that transcends preoccupation with fabricating images, and traces the process of making contemporary Gulf cities, from material tectonics to large-scale masterplans. By presenting the architecture of UAE and the Gulf within the context of broader regional developments and global trends, it highlights how projects in the UAE, Qatar, Kuwait and Saudi Arabia have contributed to unprecedented urban growth, while emphasising the continuing environmental challenges of building in the region. In addition to highlighting various sustainable initiatives intended to counteract these challenges, the issue also explores how computational design and new technologies are being innovatively employed to mitigate the impact of arid climates.

**Contributors include:** Ahmad Abdelrazaq, Ameena Ahmadi, Kelly Hutzell, Varkki Pallathucheril, Todd Reisz, Rami el Samahy, Malcolm Smith.
**International architects:** Foster + Partners, Frank Gehry, HOK, IM Pei, Rem Koolhaas, Legoretta+Legoretta, Jean Nouvelle, Jørn Utzon.
**Regional architects:** AGi (Kuwait), DXB.lab (UAE), X Architects (UAE).



ARCHITECTURAL DESIGN

GUEST-EDITED BY
MARK GARCIA

# FUTURE DETAILS OF ARCHITECTURE

Contributors:
**Rachel Armstrong**
**Nic Clear**
**Edward Ford**
**Dennis R Shelden**
**Skylar Tibbits**

Featured architects:
**Ben van Berkel**
**Hernan Diaz Alonso**
**Peter Macapia**
**Philippe Rahm**
**Carlo Ratti**
**Patrik Schumacher**
**Neil Spiller**

Despite the exaggerated news of the untimely 'death of the detail' by Greg Lynn, the architectural detail is now more lifelike and active than ever before. In this era of digital design and production technologies, new materials, parametrics, building information modelling (BIM), augmented realities and the nano-bio-information-computation consilience, the detail is now an increasingly vital force in architecture. Though such digitally designed and produced details are diminishing in size to the molecular and nano levels, they are increasingly becoming more complex, multi-functional, high performance and self-replicating. Far from being a non-essential and final finish, this new type of highly evolved high-tech detail is rapidly becoming the indispensable and critical core, the (sometimes iconic) DNA of an innovative new species of built environmental form that is spawning in scale and prominence, across product, interior, urban and landscape design. This issue of AD re-examines the history, theories and design of the world's most significant spatial details, and explores their innovative potentials and possibilities for the future of architecture.

FUTURE DETAILS OF ARCHITECTURE
JULY/AUGUST 2014
PROFILE NO 230
WWW.WILEY.COM

WILEY

ISBN 978-1-118-52253-0
54500
9 781118 522530