Technological Innovation in Architecture: The Role of the Aberrant Practitioner

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The Role of the Aberrant Practitioner

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Abstract

Technological innovation in architecture can often be attributed to the work or works of individual designers and their unique (tacit) working method. Through an analysis of my published work (articles, essays, edited, co-authored and authored books), I will present how the aberrant creative process which the economist Joseph Schumpeter described as the 'innovating entrepreneur' can enlarge the palette of technological possibilities for the architect and define a unique role within the construction industry. The published works survey and explore atypical and innovative technologies and working practices in relation to architecture. The 'McLean's Nuggets' column presented a series of short articles, factual and outliers (provocations in some instances) and established an expansive view of the variety and potential of technology and its application in architecture as a socially beneficial design tool. The essays, papers and books develop these themes in more detail in specific regards to five practitioners of architecture, engineering and art. The thesis has been developed through a literature review and additional interviews with featured professionals to help establish a socio-technical-historical context for the published works. The critical research commentary will draw together key themes of the work including innovative construction technologies and the relative acceptance and uptake of these technologies and how the architect designer through innovative or 'aberrant' modes of practice can better embrace these innovations in a sociotechnical understanding of architecture. This thesis features the work of five protagonists each working within the field of architecture and each of whom

has innovated as much through their working method as through the work itself.

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* See separate publications submitted with this manuscript

Acknowledgements

I would like to thank Prof. Lindsay Bremner, Dr Victoria Watson and Dr Christine Wall for their advice and guidance in preparation of this research work. I would also like to acknowledge the help and close collaboration of the practitioners Dante Bini, Adam Kalkin, Tim Macfarlane, Christian Müller (from the former office of Fritz Haller), and Graham Stevens.

Author's Declaration

I declare that all the material contained in this thesis is my own work.

1. Introduction

> *It is not just the physics that have to work in the successful launch of new construction technologies, it is also other, external factors … the metaphysics.*
>
> Dan Ptacek[1]

In writing about the interwar development of steel structures in the UK, Marian Bowley argues that "…no examples of innovations in techniques starting in the building industry and spreading to other industries have appeared.[2]" Bowley explains, "…that the building industry was dependant on other industries for new techniques[3]" with much of the innovation that time coming from shipbuilding and allied trades. So how is it possible to innovate in an industry, that is to paraphrase Bowley's book title, "resistant to change.[4]" I will outline the work of five very different protagonists – the architects Dante Bini, Fritz Haller and Adam Kalkin, the structural engineer Tim Macfarlane and artist Graham Stevens – and ask how they have managed to successfully innovate in their field and challenge Bowley's "resistance to change.[5]"

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[1] Ptacek, D. (2013). 'The Adjacent Possible.' Lecture at the University of Westminster 30/10/2013. Ptacek has worked with Birdair and Vector-Foiltec and has helped develop a number of 'disruptive' technologies successfully applied in the construction industry.
[2] Bowley, M. (1966). *The British Building Industry: Four Studies in Response and Resistance to Change.* Cambridge: Cambridge University Press, pg 76
[3] Ibid, pg 76
[4] Bowley, M. (1966). *The British Building Industry: Four Studies in Response and Resistance to Change.* Cambridge: Cambridge University Press
[5] Ibid

The measure of their particular success is relative, but in each case, it has been validated through professional recognition, commercial success or industry acceptance and adoption. The work of these innovating entrepreneurs[6] which I have written about in essays, papers and books, is set against a wider socio-technical background, established and documented in the 'McLean's Nuggets' column published in thirty-two editions of *Architectural Design* (*AD*) magazine between 2005 and 2010 (see 6.1 Published Works 1 – McLean's Nuggets). Each of these columns introduced new or re-discovered technologies illustrated through projects or ongoing research for the perusal of the designer/student reader. Written and compiled in the spirit of the 'Cosmorama' column (an *AD* feature from 1965–1971) these technologies were necessarily eclectic with many of them borrowed from other industries. In a challenge to the self-referential history of architecture, this new socio-technical history included programmatic imperatives of education, social trends and changing patterns of human use and desire as an inextricable corollary to technology.

> *The question of how technologies get taken up or ignored … It goes to the meaning of the word technology and the application of art in society. I would go as far as to say we were discussing 'evolutionary technology'; how humans use technology to adapt to their environment, which could now be said to have reached the stage of incorporating materials, machines and programmes into the body.*
>
> Graham Stevens[7]

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[6] Schneider, E. (1951). *Schumpeter's Early German Work 1906–1917*, in S.E. Harris (ed.) Schumpeter: Social Scientist, Boston MA: Harvard University Press, pp 54–58

[7] Stevens, G. An Interview by Will McLean, (29/04/2016).

Trevor Pinch[8], in defining a Social Construction of Technology (SCOT), discussed the limitations of a particular technology and its wider application being (in part) related to the (mis)perception of that technology as much as the technology itself. Pinch argued that, "SCOT focuses on the design stage of technology at the expense of users[9]". Accepting this problematic, Pinch[10] with Ron Kline cite the example of the Ford Model T and its atypical use in rural Kansas, where the motorcar becomes, in addition, a source of standing power for a washing machine and other agricultural uses and it is to this issue of reimagining or appropriation of technology that the 'McLeans Nugget's' column frequently returns.

Walt W. Rostow[11] cites Adam Smith and his examples of major discontinuous inventions in *The Wealth of Nations* such as water and windmills. For discontinuous inventions, we can read "disruptive technologies"[12]. Within architecture, engineering and construction, examples of disruptive technologies such as Buckminster Fuller's Geodesic Dome, and Dante Bini's Binishell are rare. The five featured protagonists in this thesis have all innovated in their field with either technical or social inventions (or both), and

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[8] Pinch, T. (1998). The Social Construction of Technology: A Review. In Fox, R. (ed.) *Technological Change: Methods and Themes in The History of Technology.* Amsterdam, Holland: Harwood Academic Publishers 17-35.
[9] Pinch, 31
[10] Ibid
[11] Higonnet, P. (1995). *Favourites of Fortune: Technology, Growth, and Economic Development since the Industrial Revolution*. Cambridge, Mass: Harvard University Press.
[12] Christensen, C. M. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Boston: Harvard Business School Press. p. xviii

they have all acted on their own to speculatively prototype and make work in the manner of an artist or entrepreneur. Arguably Tim Macfarlane is the exception as his innovations have been borne out of engagements in the design projects of others. In the case of Bini, Haller, Stevens and Kalkin however, they have all been physically in control of the making and testing of their ideas and as well as their inception and without this iterative process it is difficult to imagine the realisation of their work.

The Emergence of a Working Research Method

A repeated theme often returned to throughout the 'McLean's Nuggets' columns was to question the role of the designer in general and the architect in particular. How might a wider field of reference in regards to technology inform new modes of practice? And it was in this column where I first began to articulate the work and practice of the non-standard, unorthodox and perhaps aberrant work of designers such as Dante Bini and Adam Kalkin alongside an eclectic mix of news items covering technology, history and social trends digested into bitesize 'Nuggets' and served up as no more than useful provocations. On reflection, these provocations may have been more subtle and implicit than I had originally envisioned and as such I have used the thesis commentary to articulate, energize and contextualize a more direct and explicit argument for the promotion and understanding of the 'aberrant' practices and practitioners of art, engineering and architecture.

As a part of a working method I have established a working relationship with each of the featured practitioners (barring Haller). In the case of Adam Kalkin, I spent a six-month sabbatical in New Jersey, USA (2006) working with him on the first full-size prototype of the Quik House and subsequently writing and compiling material for the book *Quik House: Adam Kalkin's ABC of Container Architecture* (2008). The book was the first title to be published under the imprint Bibliotheque McLean, an independent publishing house that I established in 2008.

I had originally contacted the Italian architect and entrepreneur Dante Bini in 2006. Bini sent me pictures and details of some of his early Binishell structures for an article that I was writing as part of the 'McLean's Nuggets' column. We began a correspondence and I met Bini in his hometown of Arezzo, Italy to explore his archive of photographs, drawings and commercial literature in relation to his various Binishell experiments in thin-shell concrete and air-inflated formwork. This trip, documented in *AA Files,*[13] also included a visit with Bini to Castelfranco Emilia (near Modena), the original test-site for the Binishell (1965-1968), which had become informally known as the "mushroom farm"[14] by local farmers amazed at the quick sprouting concrete domes lifted and formed by air. During that visit plans were finalised for an English language version of his autobiographical recollections re-written by Bini and edited by myself with new previously unpublished images sourced

[13] McLean, W., (2015) Graham Stevens: Atmospheric Industries*. AA Files: Annals of the Architectural Association School of Architecture* **70** (Summer 2015), pp 134–139

[14] Bini, D. (2014). *Building with Air*. Bibliotheque McLean: London, p 42

from his personal archive. The book *Building with Air*[15] also included an essay – the epilogue by Prof Lucio Fontana about the Binishell house in Sardinia that Bini had constructed for Italian film director Michelangelo Antonioni and his then partner the actress Monica Vitti. Following the publication of the book I was contacted by the organisers of the Venice Biennale and commissioned to design and curate an exhibit on the 'Villa Antonioni'[16] for the Monditalia show, Venice Biennale (2014).

In the case of Graham Stevens and Tim Macfarlane I have used interviews to document their approach to both their own work and discussions around innovation and invention and what the necessary or desirable conditions for the realisation of new ideas are. Stevens and Macfarlane have both worked at the leading edge of a new technology albeit with a radically different approach – Stevens constant physical experiments created as full-size 1:1 artworks and prototype environments and Macfarlane's intuitive, but incremental experiments in glass through a series of seminal architectural projects.

Fritz Haller's work without Fritz Haller (1924-2012) might have been more difficult to illustrate, but I was fortunate enough to meet with his former colleagues at his office in Solothurn, Switzerland, and make visits to a number of his key projects. Through the close cooperation of Christian Müller (a former colleague of Haller's) I was also able to reference office documents

[15] Bini, D. (2014). *Building with Air*. Bibliotheque McLean: London
[16] McLean, W., (2014) *Fundamentals: 14 International Architecture Exhibition. La Biennale Di Venezia* (by Rem Koolhaas), Venice: Marsilio, pp 32–33

and drawings and gain a better understanding of his unique approach to Building with Systems[17].

Within this context my aims and objectives are to situate the published work within a wider sociological and historical discussion about innovations in architecture and construction technology framed by three key research questions:

1. What enables the success and adoption of new technologies or technological innovations in architecture and construction?

2. How does the work of highly individualised designer/constructors contribute to an evolving or expanded field[18] of technological development and innovation in architecture? And, to what extent is the development and implementation of new technologies dependent on the innovating entrepreneur[19] or aberrant practitioner?

3. How might a wider socio-technical understanding outside of the immediate business of construction expand the palette of materials and technological approaches available to the architect designer?

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[17] Haller, F. *Building with Systems*. Notes from the office of Fritz Haller (unpublished). Solothurn 27.06.2003

[18] Krauss, R. Sculpture in the Expanded Field, *October*, Vol. 8. (Spring, 1979), pp. 30-44

[19] Schneider, E. (1951). *Schumpeter's Early German Work 1906–1917*, in S.E. Harris (ed.) Schumpeter: Social Scientist, Boston MA: Harvard University Press, pp 54-58

I have attempted to describe a new framework for understanding a socio-technical approach to architecture and the uptake of technical knowledge into architecture. My original contributions to the field include the research into and the dissemination of previously unpublished materials relating to the works and role of design and construction innovators including; Dante Bini, Fritz Haller, Graham Stevens, Tim Macfarlane and Adam Kalkin. My contribution also includes the definition of a wider socio-technological context (largely described in the authored column for Architectural Design magazine entitled 'McLean's Nuggets') within which a recent social history of invention and innovation in architecture can be better understood. Using a *modus operandi* of direct, immersive research has resulted in collaborations with Kalkin and Bini as well as nascent plans for future projects including publications and exhibitions. This has aimed at promoting the work, in some cases previously unpublished works by Bini, Kalkin and Stevens, and the working methods of a very particular type of *aberrant* practitioner.

2. McLean's Nuggets: Everything is Architecture

Action is Architecture!

Everything is Architecture! [20]

Wolf Vostell, Cologne 1969

The 'McLean's Nuggets' column was originally a one-off multi-part essay entitled 'Cosmorama of Now' that featured in Architectural Design (AD) magazine in May 2005. The title and inspiration for the piece came from the 'Cosmorama' feature in AD, which appeared in AD from July 1965 until November 1971. 'Cosmorama' was established by the then technical editor Robin Middleton and included short variously authored features on new buildings with particular emphasis on construction innovation and short pithy texts on contemporary technology more generally – covering areas such as transport, computing, cybernetics and housing. 'Cosmorama' boasted an impressive list of contributors that included (in just two sample issues from 1968) Erno Goldfinger, Roy Landau, Martin Pawley and Steven Mullin. In a contemporary celebration of this dynamic pluralism 'Cosmorama of Now'[21] featured 15 illustrated texts on the nascent Internet of Things, Deployable Structures, Acoustics and the unrealised proposal of the then government to levy a 'Fat Tax' on UK food products that would have outlawed the pork pie

[20] Vostell, V. Higgins, D. (1969). *Fantastic Architecture*. New York: Something Else Press, pg 3

[21] McLean, William (2005). A Cosmorama on Now. In: Hardingham, Samantha, (ed.) The 1970s is here and now. *Architectural Design*, 75 (2). John Wiley, Chichester, UK, pp. 6-11

The original ‘Cosmorama’ column captured an inventive attitude to the subject of architecture and technology in a way that was eclectic, and without judgement or easy categorisation, and which read more like a news in brief section rather than the lengthier and more detailed pieces on buildings and urbanism. Steve Parnell writing about the editorial policies of *The Architectural Review* (AR) and *Architectural Design* (AD) describes the introduction of ‘Cosmorama’ and quotes from Middleton’s original introduction to this new section of the magazine as “A commentary on buildings or on events throughout the world that impinge on architecture[22]”. Parnell explains the widening sources of reference for ‘Cosmorama’ and subsequently AD magazine as a whole, “Cosmorama quickly evolved into a scrapbook of ideas and processes that were relevant to architectural production, rather than of buildings[23]”. Parnell goes on to explain how this feature gradually “… became a magazine within a magazine and took over completely in 1970 … by the end of 1973, when ‘Cosmorama’ was discontinued AD had moved almost entirely away from buildings towards a wider and more conceptual definition of architecture’s role in society[24]”. Following the ‘Cosmorama of Now’ feature I was subsequently commissioned to write a bi-monthly column, which the editor Helen Castle entitled ‘McLean’s Nuggets’. The column was initiated in the spirit of the original column and in relation to my teaching became the repository of ongoing research interests and the backlog of cuttings and

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[22] Middleton, R. (1965). Cosmorama. *Architectural Design*, pg 315
[23] Parnell, S. (2012). AR's and AD's post-war editorial policies: the making of modern architecture in Britain. *The Journal of Architecture*, 17:5, pg 769
[24] Ibid., pg 770

references I had and continue to collect. The ‘Nuggets’ were typically presented as a double-page spread, sometimes extending to three or four illustrated pages. Each column consisted of three separate entries, focussing on an innovative technology; a social, scientific or environmental policy issue and new design applications. The research for the writings was widely drawn from current and historic technical literature as well as site and company visits, interviews and lectures. A number of the writings also document design and research projects in which I initiated or directly contributed and as an early part of the subsequent research for the PhD I attempted a thematic analysis of the texts looking for keywords and subject classes (Figure 1). My original interest in the original ‘Cosmorama’ column was not primarily historic or motivated by any retro sensibility. I was, and remain committed to the exploration and development of architecture and architectural thinking as an open medium. The tone of some of the entries are a provocation to the industry and suggest that architects and designers need to challenge themselves about the nature of their societal role.

Technology Transfer

> *…technology transfer either results from serendipitous curiosity on the part of individuals, or from a serious marketing effort by corporations intent on developing new outlets for materials or techniques.*
>
> Martin Pawley[25]

I have been collecting cuttings and references in relation to architecture, construction and social behaviour since I was a student of architecture. The range of these cuttings is diverse, but key themes tend to repeat and many of the pieces have turned out to be closely (if unintentionally) linked. Many of the articles refer to a specific technology or technological advance and whilst these references might not directly refer to architecture or construction it was with these disciplines in mind when the articles were collated. The "technology transfer"[26] that Martin Pawley described focused particular attention on the work of the English High Tech architecture of Richard Rogers, Norman Foster and subsequently Richard Horden and Future Systems. The technology transfer, was genuine insomuch as projects like Foster's Sainsbury Centre (1978) used processes like superformed aluminium for cladding panels in a technology which was previously only used in the aerospace industry. However, it was perhaps the adoption of a very demonstrative engineering style which links many of the key High Tech projects with these schemes

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[25] Pawley, M. (1987), Technology Transfer. In: Braham, W.W. and Hale, J. H. *Rethinking Technology: A Reader in Architectural Theory*. Oxford: Routledge.
[26] Ibid

doing less to reflect social patterns of change and instead becoming a recognisable aesthetic or identifying trope for the designers.

> *Given good insulating walls, the problem of heating houses entirely disappears. Indeed even in winter, the heat generated by the inhabitants of the houses would require some method of cooling to get rid of it.*
>
> J.D. Bernal

Writing in *The Social Function of Science* in 1939, J.D. Bernal presciently observes that new materials and new construction methods could be successfully employed for the "important and difficult"[27] problem of housing built "(a)round the requirements of the inhabitants". Bernal's thinking is predicated on the promotion of science and technology, but only in the useful service of society. In the case of housing this requires the successful definition of physical need as well as depending on social tradition, which Bernal identified as the stronger imperative.

What might appear an entirely eclectic and sometimes disparate series of observations, reportage and expositions can be situated in a series of broad categories, which include; materials and construction, transport, building physics, environmental design, teaching and learning. In an early attempt to

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[27] Bernal, J.D. (1939). *The Social Function of Science*. London: George Routledge & Sons, p 350

usefully analyse the collected works, a more generic series of categories emerged which included broader themed headings such as materials and construction, teaching and learning, health and social trends.

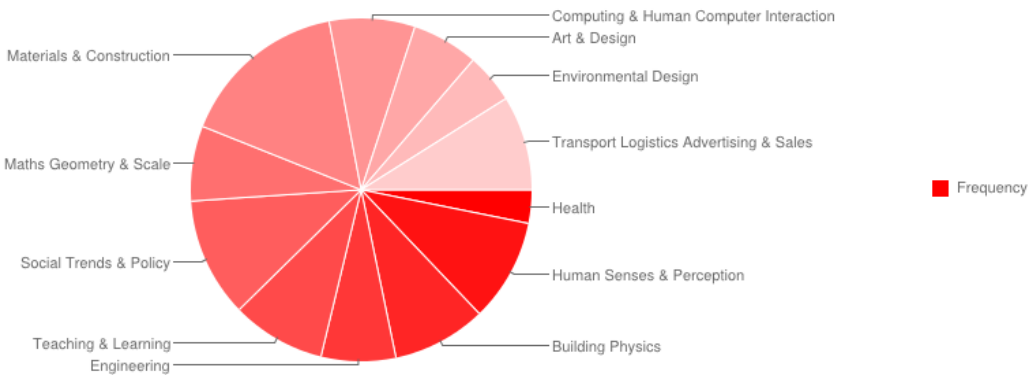

Figure 1. Diagram showing a thematic analysis of the 'McLean's Nuggets' column published in Architectural Design (2005-2010).

The Implicit Influence of Buckminster Fuller

> *The essence of Livingry is human-life advantaging and environment controlling*[28]*.*
>
> Richard Buckminster Fuller

A continual presence and common thread throughout all of my published works are the repeated references to the work of Richard Buckminster Fuller and in particular the set of broad socio-technical themes set out in his book *Critical Path* (1981) and his last written work, *Humanity's Critical Path: From*

[28] Fuller, R., B., (1983). Humanity's Critical Path: From Weaponry to Livingry. *Proteus, A Journal of Ideas*, Vol 1, Issue 1, pp 1–9

weaponry to Livingry (published posthumously in *Proteus*, autumn 1983). In both these texts Fuller lays out a chronology of his invented Livingry[29] artefacts, including the Dymaxion House, the Geodesic dome and the Tensegrity structure. Livingry is one of Fuller's less syntactically sophisticated linguistic agglomerations, but his opposite of weaponry is his most high-minded. Fuller acknowledges the unique potential of the architect as a comprehensive thinker and a schooled generalist whose job (amongst many) is to negotiate between specialist knowledge fields, work with multiple design imperatives and to invent new, hitherto unimagined solutions and strategies for the ill-defined problems of architecture.

> *… architects have tended to see the problem of shelter as one simply of creating more elegant spatial experiences, whereas Fuller has seen it as one of creating more and better-serviced volumes of habitation.*[30]
>
> Reyner Banham

In his essay for the Shippenberg University journal *Proteus*, Fuller describes the possibility of a "World-around Livingry Service Industry."[31] Fuller recognised the anti-entropic potential of the designer, (the architect) to invent new "human-circumstance-advantaging-technology"[32] obviating problems and creating new delight through the humane deployment of art and science. The

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[29] Fuller, R. B. (1981). *Critical Path*, St. Martin's Press: New York, p 268
[30] Banham, R. (1996). *The Dymaxicrat. A Critic Writes: Essays by Reyner Banham*. University of California Press, Berkeley, pg 94
[31] Fuller, R., B., (1983). Humanity's Critical Path: From Weaponry to Livingry. *Proteus, A Journal of Ideas*, Vol 1, Issue 1, p 6
[32] Ibid

architecture of Livingry presents a contemporary design philosophy, illustrated through a cataloguing of design and technology based artefacts and services, which include; specialised construction methodologies, alternative approaches to learning and the identification of new social behaviours, trends and policy. Fuller's new conception of human support systems, necessarily includes architecture and the built environment, but also energy systems, sanitation, world resource mapping and transportation. Fuller's technology transfer was to redeploy the ingenuity, logistics and technological knowhow and associated resources of the military for social service in what he described as Design Science[33] or Livingry[34]. In projects like his Dymaxion House (1948) the rethinking of a family home included super lightweight prefabricated construction, innovative material use including bioplastics and insulating films, a hypoallergenic air filtration system and the water-saving Dymaxion bathroom. Writing in *Critical Path* he is always very particular about referring to his works, such as the Dymaxion House or Geodesic dome as "artefacts" insomuch as these were products of their time, employing the most appropriate technology of their time and indeed responding or anticipating time-dependant problems or imperatives. So, whilst the artefactual inventions of Fuller have always been of interest to me as a designer fascinated by technology, it is primarily his thinking and comprehensive attitude to the useful deployment of all available means for the benefit of all humanity that is most critical.

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[33] Fuller, R. B. (1981). *Critical Path*, St. Martin's Press: New York, pp 246-47
[34] Fuller, R., B., (1983). Humanity's Critical Path: From Weaponry to Livingry. *Proteus, A Journal of Ideas*, Vol 1, Issue 1, p 8

Richard Buckminster Fuller was a serial entrepreneur who established multiple businesses and filed patents for new building materials, structures, systems, houses and vehicles. Whilst much has been written on the relative failure of those businesses (Herbert 1984, Pawley 1990), less has been written on the success of other aspects of his business interests such as the licensing of his patented geodesic structural systems. Martin Pawley describes Fuller as a "…futuristic and prophetic designer…"[35] and as such it is the promise of his ideas and his promotion of *Design Science*[36] and concepts such as *Livingry*[37] that are arguably his most enduring legacy. Fuller himself was deliberate in his description of his inventions as "artefacts" in that they are time-dependant products he created in relation to a given imperative or need and as such are not a universal or permanent fix.

The *McLean's Nuggets* column was a contemporary response to the spirit of Fullers 'Livingry' and as a useful reminder that the designer (specifically the architectural designer) need not remain hamstrung by a solipsistical, self-referential and reverential architectural press. In addition to seeking inspiration from outside of the discipline as professionally defined, the architect might usefully study material innovations, patterns of social change, behaviour and resourcing. McLean's Nuggets presented a challenge to the architect, perhaps not explicit (or explicit enough), but a gentle needling, an

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[35] Pawley, M. (1990). *Design Heroes: Buckminster Fuller*, Grafton: London, pg 14

[36] Fuller, R. B. (1981). *Critical Path*, St. Martin's Press: New York, pp 246-47

[37] Fuller, R., B., (1983). Humanity's Critical Path: From Weaponry to Livingry. *Proteus, A Journal of Ideas*, Vol 1, Issue 1, p 8

irritant, asking whether architecture and thus the purveyors of said products are doing their job and perhaps re-asking, what is the job of architecture.

The McLean's Nuggets column was an attempt to search out and highlight useful, interesting and novel technologies in the service of architecture, construction and education whilst simultaneously drawing attention to new social trends, needs and challenges. It is as much the theoretical promise of technology (alongside the actual) that motivates this thesis. In his foreword to the works of German architect Ludwig Leo, Peter Cook identifies what he calls "…the ferreting out activity"[38] and that "…making the circulation of mind-provoking work a key part of one's commitment to the development of the art." Ferreting out was an important impetus for the McLean's Nuggets column, not as end in itself (of which Cook warns), but a starting point for a different cataloguing of architecture, one concerned with human-life advantaging technology.

[38] Buchholz, A., (2015) *Ludwig Leo Ausschnitt*. London: Architectural Association, pp 6-7

3. Alternative Practice

> *This may be taken as typical of the profession's professional attitude to the impact of technological and scientific alternatives for the art of building. The profession tolerates a few peripheral radicals, whose ideas call the whole professional apparatus in question. Such a man is Buckminster Fuller, recently made a member of AIA, and thus accepted as relevant to architecture in the professional sense. But it is clear that Fuller is admired for his structures and accepted as a form-giver, while his elaborate body of theory and fundamental research into the shelter-needs of mankind is mostly dismissed unread.*[39]
>
> Reyner Banham

As part of Reyner Banham's series 'Architecture After 1960' published in Architectural Review, 'The Future of Universal Man' was discussed at a lunchtime symposium (1960) with architects Anthony Cox and Gordon Graham along with John Page (then a lecturer in building science at Liverpool University) and the critic and director of the Institute of Contemporary Arts (ICA), alongside Banham himself. The conversation ranged from the seemingly trivial matter of architects "drawing on the back on envelopes"[40] excused by Graham as an understandable side effect of those "…concerned

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[39] Banham, R. (1960). Architecture After 1960, 1. *Architectural Review*, 127, no. 755, 94

[40] Banham, R. (1960). Architecture After 1960, 5. "The Future of Universal Man Symposium with Anthony Cox, Gordon Graham, Lawrence Alloway," *Architectural Review*, 127, no. 758, 254

with visual matters …"[41], but dismissed by Alloway as "an occupational gimmick"[42]. Perhaps more pertinent was the discussion of the relationship between architect and science and the resistance to empirical data and the input of specialist knowledge in both schools and practice. Page explains "I think one thing is very important to the architect … he should learn how to observe and look at things as they are and not as he wants them to be."[43] In order to cope with the increasing complexity of architecture and construction, Page advocated a changing role for the architect – "There isn't an individual architect who can solve all the problems, so he's got to draw on these people[44]", 'these people' were sociologists, structural and heating engineers. "I think in the schools there is a great tendency to push the concept of architecture as being not a team effort, but essentially the creation of one mind of artistic ability.[45]" Page saw this as a "universal man[46]" problem "… this lack of specialization that you get and the architects who have to branch into absolutely every field of knowledge, which of course they can't do competently.[47]" John Page subsequently became professor of architecture at Sheffield, establishing a unique cross-disciplinary course of architecture, which gave students access to academic specialists and specialisms across the institution. The artist Graham Stevens and one of the featured protagonists of my research was a student of Page's at Sheffield and Stevens

[41] Ibid
[42] Ibid
[43] Ibid p 255
[44] Ibid
[45] Ibid
[46] Ibid p258
[47] Ibid

acknowledges that it was through the specific experiments into immersive colour fields that allowed Stevens to experiment with inflatable and air-supported structures for the first time. In Banham's conclusion to a later discussion as part of the 'Architecture After 1960' series, which he entitles "Science for Kicks?"[48] he states "…for an architect to pretend to take science 'seriously' is an act of monstrous arrogance…"[49] and that "the insistence that science must be taken seriously too often means that science must be taken owlishly, solemnly, reverently – which manifestly is not the way that scientists take it, as anyone who has heard a Hoyle or an Eysenck holding forth on their respective specialities – or Buckminster Fuller on his. The man who plays science for kicks is committed to a growing enjoyment of a growing body of ideas and experience."[50]

> *… if architects cannot offer the kind of service that the world needs then architects will go the same way as rain makers and witch doctors and other pseudo-technicians who were preserved by cultural inertia in spite of declining evidence of performance – but were preserved only for so long.*[51]
>
> Reyner Banham

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[48] Banham, R. (1960). Architecture After 1960, 5. *Architectural Review*, 127, no. 760, 388
[49] Ibid
[50] Ibid
[51] Banham, R. The Dymaxicrat. *A Critic Writes: Essays by Reyner Banham*. University of California Press, Berkeley, 1996, pg 95

In the introduction of Banham's 'Architecture after 1960' series he identifies three major cultural and theoretical interests: "One is science, constantly modifying the way in which an architect can act; the second is his view of the profession itself, affecting the subjects on which he permits himself to act; the third is the study of history, constantly modifying his view of what he has done after he has acted."[52] It is the first two of these interests which this thesis addresses. Banham identifies that the service of architecture need not require the architect and that the "…increasing range of technological alternatives to bricks and mortar may yet set a term to the custom-sanctioned monopoly of architects as environment-purveyors to the human race."[53] This challenge to the orthodoxy of the role of the profession is also extended to the nature or scope of the discipline: "These alternatives whose justification is measurable performance rather than some cultural sanction, extend, however, beyond the provision of the technological services as well, so that it becomes possible to define 'home' without reference to hearth or roof, but simply as the integration of a complex of intra personal relationships and mains-servicing."[54] Banham's thesis supports the contentions and ambitions of Buckminster Fuller's design science and concept of Livingry. This might also read as tacit support for the work and ideas of the then emerging young architect Cedric Price. Cedric Price maintained a friendship and correspondence with Fuller over twenty years until Fullers death in 1983, exchanging ideas about their shared

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[52] Banham, R. (1960). Architecture After 1960, 1. *Architectural Review*, 127, no. 755, 10
[53] Banham, R. (1960). Architecture After 1960, 1. *Architectural Review*, 127, no. 755, 94
[54] Ibid

interests in both the technology of architecture and the possibilities of "anticipatory design"[55], which necessarily debunks the orthodoxy of assumed or inherited professional roles, technical knowledge and programmatic logic.

In a lecture recorded for Monica Pidgeon's Pidgeon Audio in 1979 entitled "Technology is The Answer but What Was The Question?"[56] Price offers a useful reduction or encapsulation of an approach to design, where the essence of a given problem or desire is answered not through the problem-solving lexicon of architectural and construction orthodoxy, but the seemingly radical, but utterly reasonable assessment of information, need, desire, resource and cost.

> *Architecture should have little to do with problem solving - rather it should create desirable conditions and opportunities hitherto thought impossible.*[57]
>
> Cedric Price

In his obituary to Fuller, Price highlights Fuller's commitment to anticipatory design.

> *Frequently his work on housing was accurately prophetic or, as he would prefer to describe it, anticipatory. For instance, such predictions of the 30's and 40's as related to change in numbers, longevity of*

[55] Fuller, R. B. (1981). *Critical Path*, St. Martin's Press: New York, pp 246-47
[56] https://www.pidgeondigital.com/talks/technology-is-the-answer-but-what-was-the-question-/
[57] Price, C. (1984). *Works II*, Architectural Association: London, p 92

> *occupancy, the availability of resources and so on were the tips of the iceberg of his conviction that anticipatory design is the only design, that there is no future for deception or self-deception and that there can be no return to 'business as usual.*[58]
>
> Cedric Price

This 'business as usual' was also challenged (perhaps surprisingly) by the architects John Gloag and Grey Wornum in their book *House out of Factory* (1946). In the book, the post-war imperative for house-building and promotion of new prefabricated approaches is clear, and succinctly expressed with ten chapters all posed as questions, such as 'How Long Will it Last?' And 'How Much Will it Cost?' But the authors go further in a challenge to the very profession to which they belong:

> *If enough people would forget their pre-conceived ideas about architecture and building and make up their minds to live in their own stimulating, convenient and revolutionary century, all the people could have good, cheap, comfortable houses … Homes made in the factory are the product not of 'architectural' but of 'industrial' design.*[59]
>
> John Gloag and Grey Wornum

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[58] Price, C. Buckminster Fuller: 1895-1985, *Architectural Design*, August 1983, pg 4

[59] Gloag, J. and Wornum, G. (1946). House Out of Factory. London: George Allen & Unwin, pg ix

4. The Aberrant Practitioner

> *So why do we not admit that what distinguishes architecture is not what is done – since, on their good days, all the world and his wife can apparently do it better – but how it is done.*[60]
>
> Reyner Banham

Whilst I do not believe that "creative destruction" is the necessary or desired outcome of innovation by the entrepreneur as described by Joseph Schumpeter in his book *Capitalism, Socialism and Democracy*, Schumpeter's definition of "innovation and entrepreneurship"[61] and the role of the entrepreneur as neither exclusively an inventor or business person is useful in being able to describe the roles of the featured protagonists in this thesis. Schumpeter also makes the point that these characters needn't necessarily be inventors per se, with innovation and entrepreneurship being "effectuation of new combinations[62]" and "besides, the innovations which it is the function of entrepreneurs to carry out need not necessarily be inventions at all[63]".

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[60] Banham, R. (1996). *A Black Book: The Secret Profession of Architecture. A Critic Writes: Essays by Reyner Banham.* University of California Press, Berkeley, pg 294

[61] Trumpeter, J. (1983). *The Theory of Economic Development*, New Brunswick: Transaction Publishers, pg 89

[62] Schneider, E. (1951). Schumpeter's Early German Work 1906-1917, in S.E. Harris (ed.) *Schumpeter: Social Scientist*, Boston MA: Harvard University Press, pp 54-58

[63] Trumpeter, J. (1983). *The Theory of Economic Development*, New Brunswick: Transaction Publishers, pg 89

The published works and associated research aim to highlight a number of alternative approaches to the design, technology and making of architecture. These approaches have necessarily required a very special and close relationship between the innovator, the specific rigmarole of their working process and a technological and or social imperative. Marian Bowley writing about the disconnect between architects, engineers and builders between the world wars describes a kind of blame game where "builders are apt to regard architects as ignorant aesthetes.[64]" Whereas each one of the featured practitioners has, through their own particular technical or social innovation necessarily connected up different parts of the industry through innovative practice.

Aberrant Behaviour

> *As soon as one says the word "alternative" it begs the question: "alternative to what?" In order to establish an alternative it is first necessary to define the norm against which it is set …*[65]
>
> Awan, Schneider and Till.

Reflecting on the practice methods and means of my five protagonists (Bini, Haller, Kalkin, Macfarlane and Stevens) it is important to establish commonalities between the distinct (or aberrant) behaviours of each, as regards their approach to the development of their work. The work of each of

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[64] Bowley, M. (1966). *The British Building Industry*. Cambridge: Cambridge University Press, pg 51

[65] Awan, N. Schneider, T. Till, J. (2011). *Spatial Agency: Other Ways of Doing Architecture*. Routledge: Oxford, pg 25

the five is distinct and in that sense incomparable, but what is common to all five is the direct physical engagement with their work and materials, which is also true of the working method of Jean Prouvé and Buckminster Fuller whose existential influence on this thesis is evidenced and referenced throughout my published work in books, essays and the ‘McLean’s Nuggets’ column. The engagement with and testing of the physical properties, fabrication techniques and construction processes of materials should not be especially unusual regarding the respective professions of artist, architect and engineer. However, the direct engagement of these designers in the invention and or innovation of fabrication and assembly processes is exceptional and unusual in contemporary architecture and construction, and in that respect, may be described as aberrant.

4.1 Dante Bini: Construction Automation

The edited book *Building with Air*, which I edited and published (2014) is the first English language book on the work of Italian architect Dante Bini (b.1934) and documents his unique suite of building systems, which utilise the strength and economy of air as a construction material. Best known for his Binishell concrete dome structures, the book features previously unpublished archival photographs and drawings, in particular of the house he designed and built for film director Michelangelo Antonioni on the Island of Sardinia. As a result of the publication of *Building with Air,* I was invited to design and curate a display of the 'Villa Antonioni' for Fundamentals: 14 International Architecture Exhibition, La Biennale Di Venezia (2014).

Primary research for this book included visits to the original Binishell construction sites accompanied by the architect Dante Bini, and the collation of Bini's archive of previously unpublished original photographs, drawings, diagrams, technical and commercial papers. In 2012 and as a part of the research process I organised a short lecture series in London for Dante Bini (his first ever talks in the UK) and he spoke to large audiences at the Architectural Association, The University of Westminster and the Building Centre.

> *The array of explicit knowledge about buildings is vast … Nevertheless, the central issue of building technologies is often remote, partly tacit.*
> Steven Groak[66]

[66] Groak, S. (1992). *The Idea of Building: Thought and action in the design and production of buildings*. London: E&FN Spon, p 67

Figure 2. Dante Bini at the ‘mushroom field’ site of the original Binidome constructions, Castelfranco Emilia, Modena, Italy 2013. Photograph by author.

Dante Bini is an inventor and business man and perhaps of the five protagonists studied as a part of my research he best fits the description of innovative entrepreneur. One of his earliest inventions was the novel packaging of a case for wine designed for his family business, which provided a novel (and safe) means of handling twelve bottles, whilst boldly displaying corporate provenance and saving on packaging materials and thus money. Brilliantly emblematic of his subsequent approach to construction, Bini continually challenged the construction industry to cut down on waste materials, innovate or automate the construction process and systematize a construction method for ease of repetition. The outward facing component of this business are very important for Bini where he presents a series of patented construction systems including Binishell, Minishell and Binistar marketing materials such as brochures and pamphlets. Bini was selling a product and in some cases a process; as his technology was subsequently licensed to different companies across the world such as Parashell in the UK who successfully constructed three projects. In relation to architectural history, Bini's work was virtually unknown until the recent rediscovery of the Villa Antonioni[67], a commission which Bini undertook under the strict understanding that its provenance, whereabouts, or even existence would be kept a secret whilst his clients were still alive. This promise was kept and it is only now that this one-off (albeit a one-off which utilized a 30 metre diameter Binishell) has now been inducted into architectural history.

[67] Bini, D. (2014). *Building with Air*. London: Bibliotheque McLean, pp 147-159

Dante Bini has acknowledged the influence on his work with thin-shell concrete domes by architects such as his professor Adalberto Libera and Pier Luigi Nervi. Nervi was himself the designer, engineer and builder of his own most notable works and he pushed at the boundaries of the technology of reinforced concrete and registered a patent for Ferro-cemento (1943). So, whilst Bini did not invent the dome, or indeed the reinforced concrete thin-shell dome, he did invent new ways of constructing such structures, quickly, minimising construction waste in a repeatable process as part of what he described as construction automation. It is doubtable that Bini would have developed the Binishell if he had not been able to concurrently develop the necessary technology to do so through his original physical experiments and structural testing.

In 2013 I was fortunate enough to visit the original test site of Binishell structures accompanied by Dante Bini. The site at Castelfranco Emilia, near Modena, Italy was named the “mushroom farm”[68] by local farmers on account of its rapidly sprouting domes is home to a number of differently sized and composed thin-shell reinforced concrete structures that explore differing cross-sectional geometry, material composition and finish. The development of the early Binishells was not a theoretical design exercise, but an active laboratory, a test-bed designed to provide a proof of concept, that was in

[68] Bini, D. (2014). *Building with Air*. London: Bibliotheque McLean, p 42

some senses legitimised by the visit of noted structural engineer Professor Mario Salvadori[69] in 1968.

Are Bini's working methods aberrant behaviour for an architect working in the 20th Century? It is certainly not the orthodoxy and importantly the imperative for such innovation was not at the behest of a paying client. Dante Bini had an idea (initially technological) about how the plastic substrate of concrete could be shaped and formed by air. This idea was then made manifest through a series of differently formed and sized prototypes. Bini can be described as an innovative entrepreneur as he is the inventor, builder and advocate for his construction systems. Bini is also a natural salesman who takes great pleasure in expounding his views about both the limitations of current practice and the opportunities for innovative approaches to architecture and construction. Upon finishing his architectural studies in 1958 Bini established Old Home, which sought to work within the restrictive and tightly controlled planning regime of Bologna and encourage the reuse, adaptation and refurbishment of existing housing stock. Bini as a designer had already successfully launched various innovative and award winning packaging designs for his families' wine business.

I first wrote about the work of Dante Bini and in particular his Binishell construction system[70] in 2007. I had contacted Bini for more details and was

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[69] Salvadori, M. (1967). *Structural Design in Architecture*. New York: Prentice Hall

surprised by his quick response. Two years later I obtained a book of Bini's work published in Italian and after corresponding and meeting, Bini agreed to publishing a revised and expanded English edition of his professional memoirs. Bini's work with pneumatic construction systems is unique; and although a similar system had been developed by US architect Wallace Neff in the 1940's, there was an important distinction. Neff had utilised a hemi-spherical fabric formwork to shape his inexpensive housing system, but the fabrication process involved covering the inflated fabric sphere with steel reinforcement and subsequently spraying with concrete. Bini's process went further and utilised inexpensive air pressure and an innovative reinforcement system of large steel springs to lift and reinforce thin shell reinforced concrete domes, which were variously named Binidomes, Binishells and Minishells and produced by the Binishell Company until the mid 1970's. This novel system of construction was borne out of technical innovation, the availability of skilled local labour and potential need for simple large span enclosures generated by economic development.

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[70] McLean, W. (2007). McLean's Nuggets. *Architectural Design*, **77** (5), pp 138-139

4.2 Fritz Haller – Designing for Change

> *…since the early 1960s Haller's Solothurn studio has represented an incredible architectural laboratory in which every preconception architects have had about building (in terms of rigidity, inflexibility, and the restrictions of certain materials) has been carefully and systematically deconstructed. I am by no means the first to recognise this. When Mies van der Rohe visited Haller's offices, more than half a century ago, he is said to have remarked, "Now that Fritz Haller is here, I no longer need to continue to work.*[71]
>
> Norman Foster

Published on the occasion of his 80th birthday the University of Karlsruhe produced a festschrift to celebrate the work of Fritz Haller with testimonials from Norman Foster, Günther Behnisch and Richard Horden among others. Remarkably, Foster's tribute is one of the very few English language texts on Haller since the publication of *Integral Urban: A Global Model*[72] Haller's utopian global plan for housing and transportation published in 1968. I was introduced to Haller's work by Peter Sulzer the author of *Jean Prouvé Oeuvre complete* and a mutual friend of both Prouvé and Haller. I had begun research on the work of architect Ezra Ehrenkrantz and the origins of his work on systems architecture and in particular his Californian School Construction

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[71] Foster, N. (2004). *Fritz Haller zum Achtzigten Geburtstag: Reflexion*. Karlsruhe. Universität Karlsruhe, pp 14-15.
[72] Haller, F. (1968) *Integral Urban: A Global Model.* Olten: Walter Verlag.

Figure 3. Name plaque outside the office of Fritz Haller, Soluthurn, Switzerland, 2011. Photograph by author.

Figure 4. Fritz Haller pictured with Konrad Wachsmann. Wachsmann is seated on USM Haller furniture. Pacific Design Centre, Los Angeles, 1980.

Systems Development (SCSD) programme. With Haller's work, I was interested to study the work of an architect where the system had not perceivably failed, as by the late 1980's along with words like flexible or adaptable, the notion of a systems approach to architecture seemed to have faltered, or at least failed to fulfil its promise.

> *Systems that point the way to the future, especially building systems, have to be open for different purposes and changing uses, for improvements and further developments. Our work led us from the modular component systems to a kind of systematics for building. It has developed into a body of rules and regulations for construction processes and buildings, into proposals as to how individual parts can relate to each other and how they can be adapted to each other in a modular approach. We place in the foreground not the manufacturing of a product, but the way towards the solution of the task.*[73]
>
> Fritz Haller

In 1961 architect Fritz Haller completed the Ulrich Schärer Münsingen (USM) Factory in Münsingen, Switzerland. Haller developed a design, which became a prototype for his 'MAXI' system with the local industrialist Paul Schärer. Haller's MAXI system (1961) was based on a module of 1200 mm / 600 mm and was predicated on total structural and organizational flexibility, which allowed for the easy relocation and replacement of exterior and interior

[73] Haller, F. *Building with Systems*. Notes from Fritz Haller (unpublished). From the office of Fritz Haller, Solothurn 27.06.2003

finishes including windows and doors. As a part of the factory in Münsingen, Schärer had also commissioned Haller to design a complimentary suite of modular furniture for the company offices. This furniture system later became known as USM Haller (1963) and features an eight-way spherical connecting node and interchangeable struts and panels. Schärer was evidently so pleased with these furniture designs of cupboards, filing, tables and shelving that he subsequently turned over his factory primarily for the manufacture of this new system, which continues to be mass-produced at the same site (since 1969) to this day and sold across the world. Haller's ideals of designing for change were imbedded in his projects and his open MAXI system prototyped at Münsingen was designed for future flexibility and the structure has indeed been flexed during several subsequent successful expansions and reconfigurations. The narrative neatness of the Münsingen site (a modular building) that manufactures modular furniture is compounded when you spot Paul Schärer's house perched on a ridge above the factory, itself a prototype of another of Haller's systems – the MINI. In all, Haller designed three construction systems, MAXI (1961), MINI (1967) and MIDI (1972) in addition to the USM furniture system (1963), arguably his most recognised work outside of Switzerland. Schärer also worked closely with Haller on the actual construction of his factory building and in 1966 added Haller's MAXI system and later the MINI system to products produced by the Münsingen facility. With the MINI system, it is interesting to note the use of Jean Prouvé style lightweight 'cold-rolled' and perforated beams and columns.

Haller's original MAXI system was informed by his friend and mentor German engineer Konrad Wachsmann[74], but was less focussed on the perfection of specific technological connections. The system comprised a two-way grid system of welded steel truss and cruciform steel columns. The columns formed from four large rolled steel angle sections are connected, but sufficiently disaggregated as to form a relatively large footprint, although visually transparent and providing a useful service zone for wiring, plumbing and drainage. This innovative column design also provides sufficient bracing for the overall structure, obviating the need for cross-bracing and thus allowing for the future expansion and re-configuration of the manufacturers plant, which was so important to Schärer. The modularity and systematic nature of this structure was and remains a genuinely working exemplar of how Haller's ideals of 'designing for change'[75] were imbedded in his projects.

Whilst initially researching the work of Fritz Haller, I was in touch in 2010 with his office in Solothurn, Switzerland. It was explained that I would not be able to speak directly with Haller who was very unwell at the time and he subsequently passed away in 2012. Haller's office had changed its name to 2bm and was run by Remo Bill and Christian Müller, both of whom had worked closely with Haller. The practice, were undertaking new commissions, but interestingly they were continuing to work on existing Haller projects at

[74] Konrad Wachsmann ran a Graduate Program in Industrialisation at the University of Southern California, Los Angeles. Haller taught there as visiting professor between 1966-71.
[75] Haller, F. *Building with Systems*. Notes from the office of Fritz Haller (unpublished). Solothurn, Switzerland 27.06.2003

USM and SBB (Swiss Railways) on reconfigurations and extensions using Haller's original system. None of this should be unusual, but it is hard to think of similar 'systems' projects by other designers that have been as successful post occupancy. The promise of the flexible system design and useful modularity so often remain simply a promise with subsequent changes to a given system involving wholesale demolition or the addition of new unrelated forms and different construction methods. Whether it is the luxury of a Swiss client and culture as Andrew Rabanek[76] suggested to me I am not sure, and it seems too easy to dismiss the relative success of these projects through some local cultural difference whilst agreeing with David Yeoman's[77] assertion that construction remains a curiously parochial business.

In *Building with Systems*[78] Haller explains that systems thinking reflects human nature and our desire to identify, organise and classify information and that far from being about de-personalisation "…the development of systems is an indispensable tool for our times, the prerequisite for mobile life and global communication"[79].

In 2010 I visited the Münsingen headquarters of USM with Christian Müller a former colleague of Haller's. Upon completing a tour of the factory and site I was presented with brochures and booklets that celebrated the remarkable

[76] Architect Andrew Rabanek had worked with Ezra Ehrenkrantz on the Californian School Construction Systems Development (SCSD) scheme.
[77] Yeomans, D. (1997). *Construction Since 1900: Materials*. London: Batsford
[78] Haller, F. *Building with Systems*. Notes from the office of Fritz Haller (unpublished). Solothurn 27.06.2003
[79] Ibid.

collaboration of industrialist Paul Schärer and architect Fritz Haller. I was also presented with a key ring – a small loop of woven wire cable attached to a USM eight-way spherical connector. The connector is like a Hallers's genetic code or shorthand for an approach to the design and fabrication of buildings and products, systematic and organized, but open-ended and adaptable.

4.3 Graham Stevens: Air Structures

> *What is new is a confluence between changing taste and advances in plastic technology. The taste that has been turned off by the regular rectangular format of official modern architecture and Bauhaus-revival modern-antique furniture, is turned right on by the apparent do-it-yourself potentialities of low-pressure inflatable technology. Transparent Mylar and related materials are temptingly easy to work with, and the inflating mechanism need be no more complex than a domestic vacuum cleaner.*[80]
>
> Reyner Banham

In the late 1960's and early 1970's the artist Graham Stevens led the emerging field of pneumatic or air architecture alongside the Eventstructure Research Group (Theo Botschuiver and Jeffrey Shaw) and architect Mark Fisher. As early as 1966 Stevens was exhibiting air structures at events like 'Pneumatic Environment' an exhibition in Battersea designed to coincide with Gustav Metzger's 'Destruction in Art' symposium. Stevens co-curated the influential 1967 show 'The Unstable Environment: The Use of Pneumatics in Art and Architecture' at the Institute of Contemporary Arts, London and the following year he was invited to exhibit in the 'Structures Gonflables' exhibition at the Musee d'Art Moderne, Paris. These seminal exhibitions prompted the influential US artist and curator Willoughby Sharp to invite Stevens to take

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[80] Banham, R. Monumental Windbags. *New Society*. April 18, 1968, 569

Figure 5. Interior of Hovertube by Graham Stevens, Cornwall, 1970. Photograph Andrew Tweedie / GASACT.

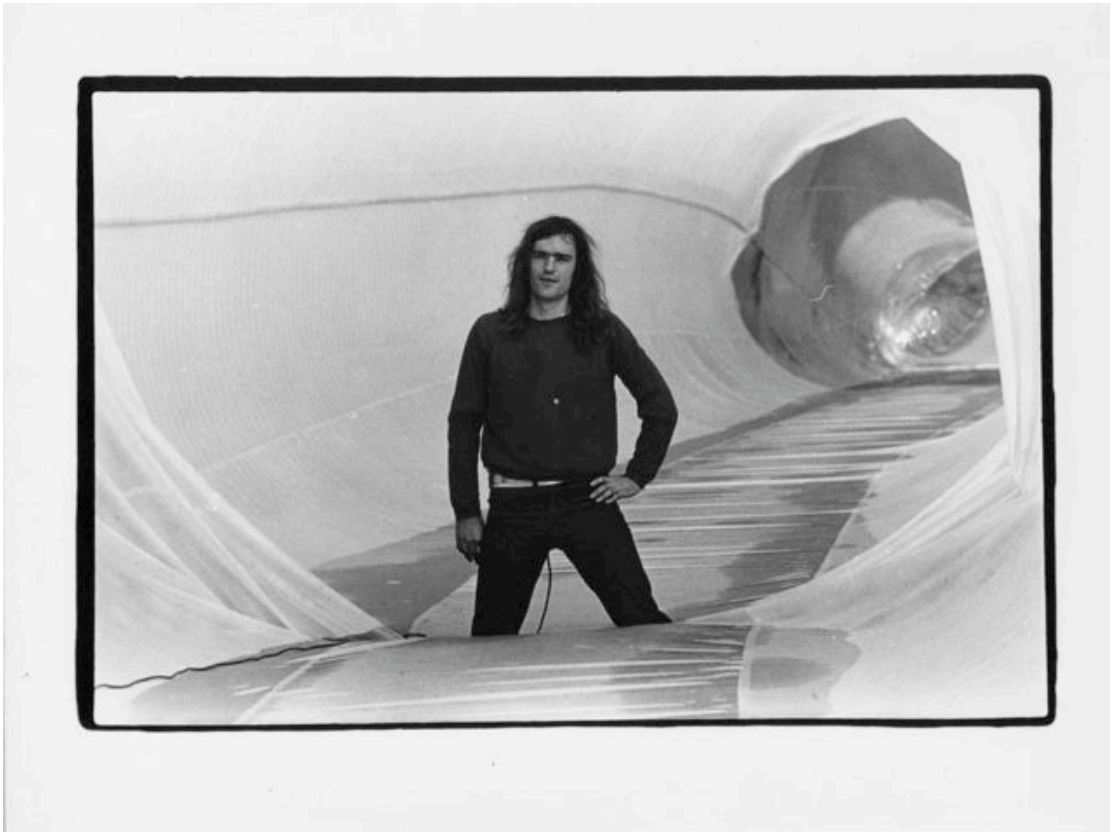

Figure 6. Interior of Hovertube by Graham Stevens, Cornwall, 1970. Photograph Andrew Tweedie / GASACT.

part in the ‘Air Art’ group exhibition in Philadelphia in 1968 where he exhibited work alongside work by Robert Morris, and Andy Warhol. In 1973 Stevens produced a film entitled ‘Desert Cloud’, which documented his most audacious and technically complex buoyant inflatable structure.

Following this critical artistic success, Stevens began to work on a larger commercial / agricultural scheme with Sugar company Tate + Lyle, which aimed to utilise Stevens increased technical knowledge of inflatable and fabric membrane structures. The project floundered with Stevens disillusioned and at one point re-training for the bar council. The consequence of Stevens’ virtual disappearance from the world of visual art is that much of his work and thinking has not recently been seen or has become difficult to find. A renewed interest in the architectural possibilities of air structures as well as a re-assessment of the work of the late 1960’s and early 1970’s has led to a renewed interest in Stevens work, which has always straddled the world of art and architecture. As a consequence, the Centre Pompidou has purchased key early works, some of which were exhibited at the Centre Pompidou-Metz in the 2016 exhibition ‘Sublime: The Tremors of the World’. Stevens work was also recently featured in the exhibition ‘The New Inflatable Moment’[81] at the Boston Society of Architecture, which featured Stevens photograph of his Desert Cloud sculpture as the promotional image. I have met, and consulted

[81] The New Inflatable Moment. An Exhibition curated by Mary E. Hale and Katarzyna Balug, Boston Society of Architecture (May 3 -September 30, 2017).

with the curators of the exhibition and my essay about the work of Stevens[82] will be republished in a forthcoming book of the show published by Actar, 2018.

In 1967 Frei Otto hosted and chaired the '1st International Colloquium on Pneumatic Structures' at the University of Stuttgart organised by the International Association for Shell Structures (IASS). The Stuttgart colloquium welcomed an impressive list of contributors and attendees, with all the key figures in the field of pneumatic and air structures represented including Walter Bird, Victor Lundy, Dante Bini, Nikolaus Laing and Cedric Price. Price, along with structural engineers Frank Newby and Robert Suan subsequently authored *Air Structures: A Survey* for the Department of the Environment, published by HMSO in 1971, which remains one of most definitive documents in this field and features the works of both Dante Bini and Graham Stevens.

Stevens, an attendee at the 1967 colloquium had studied architecture at Sheffield in an experimental and cross-disciplinary course headed by Professor J.K. Page who contributed to the WMO report 'Climate in Towns' (1959). The close study of art and science as well as the new addition of a plastic welding machine led Stevens to experiment with his first air-supported environments. Stevens remained working in and out of the milieu of architecture; and he regularly met and consulted with Cedric Price and

[82] McLean, W., (2015) Graham Stevens: Atmospheric Industries*. AA Files: Annals of the Architectural Association School of Architecture,* **70** (Summer 2015), pp 134-139

engineer Frank Newby who had established The Lightweight Enclosures Unit (LEU) 1966-1986, which was based in Price's office for the collation and dissemination of technical and supplier information in specific (but not exclusive) relation to air structures. Stevens worked with Cedric Price on his Phun City[83] project (1970) a music festival in Sussex, which featured the first UK performance of cult US political rock band MC5. Stevens developed a series of inflatable enclosures for the festival.

Working as a sculptor Stevens had developed a sophisticated tacit knowledge of structure and materials and the behaviour of these full-size prototypes in the environment. From 1966 Stevens had begun to develop ways of walking on water, which including inflatable shoes and a variant of his Transmobile structure, a giant tetrahedron within which the artist could traverse water. Subsequently Stevens developed Pontube and Hovertube (1970), which were giant inflated tubes, the continued plenum of air pressure creating a remarkably robust and traversable structure held in place by a thin layer of polythene.

With his Desert Cloud (1974) project Stevens further pushed the propositional and technical nature of his work and Desert Cloud provides a wonderfully iconic image of his work, which embodies technical invention, environmental sensitivity and no small amount of artistry. Created for his film of the same title, Desert Cloud is a buoyant structure held aloft by the relative density of

[83] Hardingham, S. (2016). *Cedric Price Works 1952-2003: A forward-minded retrospective*. London: Architectural Association, pp 334-339

heated air; a cloud which provides shade via a mirrored underside, creates lift by converting light to heat and can condense water from the arid desert air. In Stevens' film Desert Cloud, the structure is filmed in the Arabian desert near Kuwait and captures not only the eponymous solar elevated canopy, but also deliberately situates the work in the context of the oil crisis and the mythic power of the sun in human development.

4.4 Tim Macfarlane: Structural Glass

> *The eternal journey for the engineer, the eternal city for the architect and the eternal return for the craftsman/maker… A manufacturing society needs to develop and change or become moribund … and the best way to develop is not through the industry itself but get architects and engineers dreaming up ideas. The properties and behaviour of materials tested initially in small projects. However well an idea is presented or talked about, to actually see a realisation of a technically complex or challenging idea in a building or prototype is incredibly important ... There is nothing like a realised project to change the whole game and that is what happened with the all-glass Mather project.*
>
> Tim Macfarlane[84]

After first interviewing structural engineer Tim Macfarlane in 2009, I compiled a short overview of his key projects, which features in *Structural Engineering for Architects: A Handbook.*[85] and in a feature about reciprocal structures.[86] Following a further interview in 2016 I produced a paper entitled 'Building with Glass: Tim Macfarlane and the Development of Glass as a load-bearing

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[84] Macfarlane, T. An Interview by Will McLean. (2016).
[85] McLean, W., Silver, P., Evans, P., (2014). *Structural Engineering for Architects: A Handbook.* London: Laurence King, pp 166–171
[86] McLean, W. In the Frame. *The Architectural Review*. **230** (1377), 2011, pp 97–101).

Figure 7. Tim Macfarlane pictured with art critic Mel Gooding and artist Bruce McLean, collaborating on ‘Schools of Thought’ proposal, London 1999. Photograph by author.

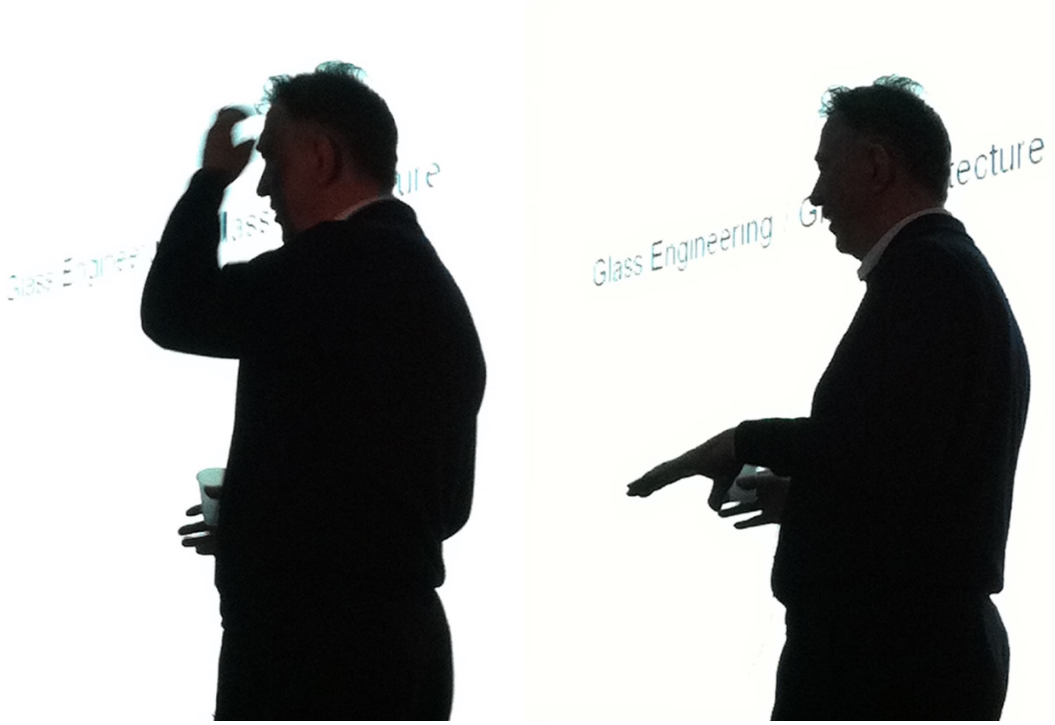

Figure 8. Tim Macfarlane giving a lecture in the Department of Architecture, University of Westminster, 2011. Photograph by author.

Structural Element'[87] for the Construction History Society. Amongst Macfarlane's numerous awards he was made an honorary fellow of the RIBA in 2000 for services to architecture and engineering.

Tim Macfarlane[88] has helped to change the way in which glass is understood as a structural material through his collaborations with architects such as Eva Jiricna and Rick Mather. He likens this process to "making rules up as you go along" insomuch as the structural properties and material-performance expectations of glass were not previously codified (certainly not comprehensively) for the engineer. Macfarlane also draws parallels with the proliferation and wonderful diversity of reinforced-concrete use as architects and engineers began to test the limits of this new material at the beginning of the twentieth century. Robert Maillart, Auguste Perret and Pier Luigi Nervi, were all great structural artists, but they were not following rulebooks and instruction manuals for their structural and architectural experiments. They were all exploring the relatively new material of reinforced concrete, each in their own highly individualized way and with differing programmatic and technological imperatives. After this flowering of diverse and intriguing technological approaches to the use of reinforced concrete, Macfarlane suggests that a kind of Fordism takes over and industrial efficiency tends to

[87] McLean, W. 2017. Building with Glass: Tim Macfarlane and the Development of Glass as a Load-bearing Structural Element. Campbell, J. (ed.) *Building Histories: Fourth Annual Construction History Society Conference*. Queens' College Cambridge, 7-9 Apr 2017. Cambridge: Construction History Society, 2017, pp. 457-467.
[88] Macfarlane, T. An Interview by Will McLean. (2009). *Research material for Structural Engineering for Architects: A Handbook*. London: Laurence King.

normalize and thus limit possibilities. So, whilst Macfarlane understands the usefulness of codification of the structural properties of materials, he is also concerned that the unintended consequence may be an unnecessary limiting of possibilities. As with an over reliance on mathematical modelling (as opposed to physical prototyping) to create a design, this is only one approach, and Macfarlane states: “Maths has never led me to a solution, but has helped to determine how to represent the solution.”[89] Macfarlane also adds that the full extent or knowledge of a material and its properties are virtually unfathomable, and therefore structural possibilities and strategies should not be limited by our own experience. The evolution of Macfarlane’s work with structural glass can be understood through a series of key projects and at variety of scales with some of the most technically challenging projects, the seemingly modest architectural set pieces of a staircase or lean-to. Each project explores and pushes at the known limits of glass as a structural material. Macfarlane could not work from a code of practice, which did not exist and so every innovation was made incrementally across a range of projects. Macfarlane wanted to establish “… An engineering practice that set out to realise architectural ideas … to facilitate an architect’s composition, structurally so that it fitted and suited what could be made.”[90] Which is modest insomuch as Macfarlane has managed to extend what could be made through his tenacity and single mindedness as an engineer.

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[89] Ibid.

[90] Interview with Tim Macfarlane. 21.04.2016. At his London office.

Macfarlane is clear when recalling his work on the ground-breaking Keats Grove project that however much modelling and calculations he undertook, his construction innovations in glass needed to be scrutinised during construction "… the best I could think was that as it went up, I would be there and push and pull it, and physically feel it".[91]

The professionalisation of practice and the increased commodification of building products as opposed to building materials and components has arguably led to a more arms-length relationship between designer and maker and in respects to structural engineering it might also be argued that increased use of computational analysis tools does not necessitate any time spent with actual materials and material processes. The incremental development of structural glass for which Macfarlane has been responsible was only achieved with the close collaboration of a glass processor (Firman), a willing contractor and the material testing laboratory of City University. Macfarlane has always been very clear to credit these co-collaborators without whom he is clear, his work and innovations would not have been possible. Macfarlane had been told by the inventor, patent holders and market leaders at that time, Pilkingtons Glass that what he was trying to achieve with engineered glass was a technical impossibility. It was only through his own empirically evidenced experiments/tests and associated calculations that he

[91] McLean, W. (2017). Building with Glass: Tim Macfarlane and the Development of Glass as a Load-bearing Structural Element. Campbell, J. (ed.) *Building Histories: Fourth Annual Construction History Society Conference*. Queens' College Cambridge, 7-9 Apr 2017. Cambridge: Construction History Society, 2017, pp 457-467.

was eventually able to verify his professional hunch that glass could indeed perform structurally in ways hitherto thought impossible.

4.5 Adam Kalkin: Quik House

> *He proffers a consumer product – A hand-crafted and artistically signed version of an industrial object – even as he gently reminds us of the paradoxical pressures and systems of consumer desire. He takes a mundane and ubiquitous relic of our contemporary global commercial culture and offers it back to us at a slight mark up in price, a huge increase in value, and an even greater quotient of that complex set of open ended meanings that we expect of art.*[92]
>
> Prof Barry Bergdoll

The authored and edited book, *Quik Build: Adam Kalkin's ABC of Container Architecture* is a catalogue of US architect Adam Kalkin's projects utilising re-purposed shipping containers. The book documents my primary research collaboration with Kalkin in 2006 on his Quik House prototype; a 200 m2 prefabricated modular dwelling designed and fabricated in his fabrication facility, Kenvil, New Jersey. I worked with Kalkin for six months, working between the Kenvil workshop and his design office. Design research included approaches to standardisation, fabrication and assembly and the quantifying of the materials, labour and processes required to prefabricate and install a low-cost family house. The publication of *Quik Build: Adam Kalkin's ABC of Container Architecture* by Bibliotheque McLean, collated this research for the first time, and was published to coincide with the exhibition 'Home Delivery:

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[92] Bergdoll, B. (2008). *Quik House: Adam Kalkin's ABC of Container Architecture*. London: Bibliotheque McLean, pg 11

Figure 9. Adam Kalkin pictured in his Bunny Lane House, NJ, 2005.

Figure 10. Adam Kalkin pictured at the Quik House factory, Kenvil, NJ, 2007. Photograph by author.

Fabricating the Modern Dwelling'[93] at The Museum of Modern Art (MoMA) in New York (2008), where Kalkin was an exhibitor.

> *Every building is a prototype. No two are alike.*
> Helmut Jahn

In 2006 architect Adam Kalkin launched Quik House a 200 m2 factory-built house made from recycled shipping containers. Kalkin, based in New Jersey, has been in private practice since 1990 and has designed and built a number of residential projects on the East coast of the US most notably the Bunny Lane house (2001). Through this series of private commissions, Kalkin had begun to utilise industrially produced construction materials for what in essence were upmarket dwellings. These products included steel doorsets and corrugated metal cladding more typically used in factory and commercial buildings, and large garage doors included as part of the main house (not as garage doors) and steel portal-framed shed type structures forming the main envelope of the house. In neat coincidence with my own research interests Kalkin published *The Butler Variations* in 2001, featuring seven utopian houses employing steel portal framed structures by Butler Manufacturing. *The Butler Variations* was published to coincide with the opening of 'The Collector's House'[94] designed by Kalkin at the Shelburne Museum, in Shelburne Vermont. 'The Collectors House' (also known as the Kalkin House)

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[93] Bergdoll, B. (2008). *Home Delivery: Fabricating the Modern Dwelling*. Zurich, Birkhäuser

[94] McLean, W. (2008). *Quik Build: Adam Kalkin's ABC of Container Architecture* London: Bibliotheque McLean, pp 50-51

used Butlers portal frame system for the main building enclosure and the house was the first of Kalkin design to feature shipping containers. In 1940 Richard Buckminster Fuller had designed an emergency shelter for the British government called the Dymaxion Deployment Unit (DDU)[95]. The DDU was fabricated by the Butler Manufacturing Company and utilised a modified version of a circular plan grain store, which Butler produced. The DDU's although originally intended for the UK were eventually launched in 1941 including the exhibition of a prototype at MoMA in New York with approximately 100 finding their way to military installations across the US.[96]

Another project featured in 'The Butler Variations' was 'A House for Anne and Matt' (subsequently published as the Adriance House), which featured 15 m x 12 m Butler portal frame and 12 shipping containers plugged in and situated within the larger volume. The modified shipping containers formed a series of smaller accommodation units for bathrooms, bedrooms, kitchen and library. Kalkin had become interested in the ubiquity and standardised variants of the ISO shipping container and was aware of its local provenance in design being originally developed in New Jersey by Malcolm McLean[97] (no relation).

Kalkin works as an architect on his own or with a small team of designers who help with production information. He had become increasingly fascinated by

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[95] Krausse, J. Lichtenstein, C. (1999). *Your Private Sky, R. Buckminster Fuller: The Art of Design Science*. Baden: Lars Muller Publishers, pg 212

[96] http://www.nytimes.com/2014/01/02/garden/war-shelters-short-lived-yet-living-on.html?_r=0

[97] Levinson, M. (2006). *The Box*, Princeton: Princeton University Press.

the seeming discrepancy of his interests in industrial construction materials and methods and the desire of his clients (whilst attracted by previous projects) for their own custom designs. Kalkin was interested in architecture as a semi-standardised product, whereas every design project needed to be sufficiently different to satisfy some client idea of an original or special design.

In 2002 Kalkin entered a design competition organized by *Dwell* magazine in the US, for an affordable and sustainable family house. Deliberately borrowing and subverting the product ident of 'Quik' from Nesquik, Kalkin, wittily repackaged the emotional relations of the client and designer and developed a housing product in the manner of a consumer electronic or automobile. In 2004 Kalkin exhibited a full-size prototype of this 200 m2 Quik House in a show entitled 'Suburban Kit House'[98] at the Deitch Gallery in New York City. Kalkin had invited a number of artist collaborators to work on the project on aspects of lifestyle accoutrements and products such as lighting, rugs and furnishings and was described by the gallery as a "full-scale suburban environment created by Adam Kalkin, with Jim Isermann, Martin Kersels, Aernout Mik, Tobias Rehberger, and Haim Steinbach[99]". To accompany the exhibition Kalkin produced a 14-page pamphlet, which described the basic technical specifications of the house as well as differently priced variants and optional extras.

[98] http://www.deitch.com/archive/suburban-house-kit
[99] Ibid

In 2005 Kalkin rented a large workshop facility in Kenvil, NJ in which to fabricate (off-site) his new Quik House design. Kalkin was committed to demonstrating how it was possible to be both the designer and fabricator of small-scale domestic architecture. During 2006 whilst on sabbatical from the University of Westminster I worked with Kalkin to standardise key construction details and make a detailed quantitative study of the materials and labour required to prefabricate and install a new Quik House in compliance with local building codes.

The Quik House as published in *Quik Build: Adam Kalkin's ABC of Container Architecture*[100] shows two variants; one a 200 m2, two-storey three-bedroom house and a 100 m2 single storey home for a retiree, which Kalkin described as The Old Lady House. During my time working on the project, it gradually became clear that it was the balance of what was prefabricated and what was later finished on site that became critical in cost and time delivery. One option, which quickly became popular, was a lower-cost semi-finished unit, which would deliver and install (with engineered ground-works) the basic structure and services, but omitting expensive glazing and internal finishing, which the clients would later undertake themselves. This ceding of design authorship from architect to client is almost a necessary outcome of projecting architecture as a product or service and removes the emotional relations between these parties, which Kalkin neither enjoyed or felt he was ever remunerated for.

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[100] McLean, W. (2008). *Quik Build: Adam Kalkin's ABC of Container Architecture* London: Bibliotheque McLean, pp 44–47 & pp 58–67

> *Any orthodox point of view … makes me very uncomfortable. Orthodoxy has really to do with smoothing over differences and coming up with some codified explanation. One of the things about life is that one of the essential experiences is the adjacency of all these totally different kinds of things, in what in architecture or architectural terms might be called Heterotopia … a place where things that are very different co-exist in the same time and place.*[101]
>
> Adam Kalkin

Architecture as product was one of the key motivating factors of Adam Kalkin's Quik House Project. Bourne out of a magazine competition (*Dwell*, 2003) and subsequently exhibited at the Deitch Projects gallery (2004), Kalkin launched the project (product) with a small pamphlet and a feature on his website. The Quik House brochure presents a limited menu of non-negotiable costed options and is upfront about practical features and specifications. There is to be no client architect relations barring this simple transaction, a tick-box choice of colour, finish and specification and an obviation of the pseudo psycho-analytical playground (or battlefield) of client relations.

There has been much research and discussion about the ways and means of procuring prefabricated architecture[102] and the question is often asked why

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[101] Dwell Design Leaders: Adam Kalkin 2008 http://youtu.be/oE-Ezg-piPg

[102] Egan, J. (1998) *Rethinking Construction: Report of the Construction Task Force*, London: HMSO

cannot architecture and in particular the house be delivered more in the manner of a vehicle – in quality, volume and efficiency. In Gilbert Herbert's book *The Dream of the Factory-made Home*, Herbert analyses the two seminal industrialised homes of the post-war period; the Packaged House by Walter Gropius and Konrad Wachsmann (1944) and Buckminster Fuller's Dymaxion Wichita house (1948). To a large degree, Herbert's analysis and detailed critique on these projects is technical in so much as it pertains to the specific technological ambitions of each housing product. In Kalkin's Quik House project there is also a technological ambition to largely prefabricate the houses off-site and to feature innovative materials and attendant material performance. Kalkin's program differs in so much as the project centres around the adaptive reuse (or upcycling) of the readymade ISO shipping container and to challenge the orthodox relations between client and designer. Kalkin redefines the client as consumer in a mode more akin to the purchasing of a consumer product. By removing any implied emotional relationship between client and designer, that Kalkin had no time for or interest in, he is able to independently develop his own brand of domestic architecture. For Kalkin, this is no academic posturing or cost-saving initiative although he does identify the economic idiocy of continuing to develop prototypes of one.

Interests in the industrial catalogues of systems and parts are reflected throughout Kalkin's work, notably the Bunny Lane house (New Jersey, 2001) and The Collectors House (Shelburne, Vermont 2001). At Bunny Lane Kalkin

employs a generic steel portal frame, which is wrapped around an existing 19th century cottage in the woods of New Jersey. This extraordinary composition or juxtaposition creates some intriguing spatial experiences, not least in the interstitial space between cottage and 'shed'. The house also features industrial glazed garage doors and steel escape stairs. As if ordered from a catalogue, these robust tried and tested ubiquitous components all form part of a usefully expedient design approach which is unprecious, direct and undisguised. What is perhaps remarkable is that so many architects also employ the use of readymade building products (windows and glazing systems in particular), but make great play of their custom and carefully crafted use as part of upselling in an ill-defined territory of domestic architecture. Kalkin's unvarnished genericism witnessed in the Quik House Brochure[103] is refreshingly direct and can also be understood as part of a tradition of architect entrepreneurs which included Buckminster Fuller's *Dymaxion House* and Walter Gropius's *Packaged House* system developed in collaboration with Konrad Wachsmann. The Shelburne museum in Vermont is home to a remarkable collection of artefacts, art and technology, which celebrate the history of North American folk art. The Collectors House, completed by Kalkin in 2001, was designed to create a new venue to view such work whilst also embodying the more recent traditions of American industrial design in its use of the shipping container (McLean 1956)[104] and the

[103] Quik House brochure, reprinted in (2008). *Quik Build: Adam Kalkin's ABC of Container Architecture*. London: Bibliotheque McLean
[104] Levinson, M. (2006). *The Box*, Princeton: Princeton University Press.

Butler building, a company that had collaborated on Buckminster Fuller's Dymaxion Deployment Unit[105].

Kalkin's innovation or professional aberrance in relation to his contemporaries is his 'set menu' and not the á la carte of the specialist snake-oil dining of design. Kalkin, deliberately and un-cynically presents 'cookie-cut' architectural product, which is 'rolled out' and made affordable, set against a wonderfully rich and complex personal intellectual project. This dichotomy or duality in Kalkin's work can be seen in the Quik House book, which is both a straightforward catalogue of his work featuring shipping containers (organized by size) and simultaneously a compendium of his idiosyncratic approach to the housing of people, activities and events.

[105] Fuller, R. B. (1983). *Inventions: The Patented Works of R. Buckminster Fuller*. New York: St. Martin's Press, pp 53-73

5.0 Conclusion

Dan Ptacek's quote in the introduction of this thesis makes the point that the relative success of a new construction technology is not simply the outcome of its relative technical brilliance, but the result of a more complex set of factors, which might successfully challenge vested interests, regulatory controls, accepted practices and the simple inertia of large organisations.

In the case of the architect Dante Bini, one of his biggest challenges was surprisingly, not the physical construction of large spanning domes from his new process of literally 'inflating concrete', but to subsequently provide the mathematical and engineering proof that these self-evident structures could actually stand up.[106] It might be that Bini's enduring legacy is not simply the architectural artefacts of his Binidome and Binishell systems, but his experimental approach to construction, which he calls *Construction Automation* (Bini 2015). Motivated by issues of need (emergency and permanent housing), and resource (the sustainable use of materials), Bini's work is based on a series of innovations and inventions most of which have been constructed or prototyped at full scale. Without their physical manifestation, these projects and techniques would have remained unimaginable, and the 'mushroom field' at Castelfranco Emilia (Modena, Italy) where Bini began using for testing in 1965 remains as a unique memorial that still, today, contains full-scale prototypes of construction systems unique to one man. Bini has acknowledged the inspiration of the thin-shell concrete

[106] Bini, D. (2014). *Building With Air*. Bibliotheque McLean: London, p 37-38

dome of Adalberto Libera (Bini, 2015), as well as describing his eureka moment when he witnessed the strength of air as a structural material that held tonnes of snow with a thin inflated membrane dome. However, the journey between these inspirations and the construction of his first Binishell structure (Crespellano, Italy, 1964) by lifting several tonnes of concrete with air is less easily explained. His family were in business and his interest in design was acknowledged and usefully employed in innovative packaging designs for his familiy's wine business. His next step was to build the headquarters for the new packaging company, which again is realised as a prototype, a test, an experiment. If Bini was lucky enough to have an early familial client, then there were also his own motivating interests in the potential of technology, that took him to meet his acknowledged heroes; Pier Luigi Nervi and Richard Buckminster Fuller.

With the work of structural engineer Tim Macfarlane, his innovations in structural glass are imbedded in a series of projects by other designers, most notably architects Rick Mather and Eva Jiricna. However, the singlemindedness of the Bini project is shared. Macfarlane, told of the technical impossibility of what he was trying to achieve by a large glass company is goaded into a proof of concept invaluably aided by the specialist knowledge of a willing fabricator, an engineering professor and a builder. His new technologies of structural glass are much copied and have been absorbed into the lexicon of the contemporary designer, whilst the pioneering

projects with Mather and Jiricna remain (for the most part[107]) as highly individualised and seminal works in the recent development of architectural technology.

The question of what is an aberrant practitioner and how to describe and define such characters is central to this thesis. Aberrant might mean non-standard, alternative or a practice which challenges the orthodoxy of a recognised technology or pedagogic approach. Adam Kalkin expresses his unease about accepted orthodoxy in the design process and with his Quik House project, he attempts to challenge the accepted conventions of client and designer relations. By deliberately de-personalising the transaction of the architect designed house, Kalkin offers a customisable product available in a limited range of variants and affordability. There is a sense of humour underlying Kalkin's work and so everything is not always as it seems, but his frustration with (and attempt to subvert) the commissioning and economy of architecture is intentional.

Fritz Haller's challenge to the orthodoxy of architectural design and construction is through his use of systems and a systematic approach to the design, fabrication and construction of his works. Even in 2011, and although Haller had long been retired through ill health, the principles of his open-systems were still being used in new-builds, and the extension and modification of key projects such as the USM factory in Münsingen (1961-

[107] https://www.expressandstar.com/news/2015/08/25/broadfield-house-glass-museum-to-close-after-35-years/

1987) and the SBB railway training centre at Löwenberg Murten (1980-2010). Like Kalkin, Haller's systems approach to architecture also presents a challenge to the orthodoxy of commissioning architecture and bespoke client relations, asking for a preference for a small (MINI), medium (MIDI) or large (MAXI) building. Haller understood the freedom of the system that, like a set of proportional relations, provides a starting point, which is infinitely structurally and programmatically re-configurable. The enduringly successful USM-Haller furniture is still produced in the Haller designed factory in Münsingen and is testament to his ideas of "…systematics for building".[108]

To what extent can (encouraged and promoted) the outlier be the pioneer and the spirit of the aberrant practitioner within the profession of architecture? And can this spirit of difference be, in anyway, taught? The danger of teaching is that what is taught is that which is known, whereas the tutored architectural project does, or at least should, allow for any number of different and unexpected (in some cases) outcomes. Are the activities of the aberrant practitioner a singular project, a personal 'mission' led by interests in technological innovation, or commercial and professional acknowledgment? In the case of Graham Stevens, is it enough to say that the very description of him as an artist defines his work and working trajectory as an ongoing method of enquiry? Stevens however, also trained as an architect and as well as

[108] Haller, F. *Building with Systems*. Notes from Fritz Haller (unpublished). From the office of Fritz Haller, Solothurn 27.06.2003

documented meetings and collaborative projects[109] with architect Cedric Price and structural engineer Frank Newby as part of their Lightweight Structures Research (Price 1971), he was at the forefront of a milieu around the emerging technology of the inflatable or pneumatic structure, documented in authored articles for Architectural Design magazine (Stevens 1973).

There are references to Richard Buckminster Fuller throughout my published books, papers and articles. His concept of Livingry[110] is a source of inspiration for these texts, but is a concept that remains largely unrealised, and misunderstood or unacknowledged (and Fuller remains a somewhat divisive figure) by the architectural academic. I return to the potential of Fuller's ideas throughout the 'McLean's Nuggets' columns as well as making connections between the shipping container adaptation and reuse by Adam Kalkin as an apt adoption of Fulleresque notions of logistics and technology. Fuller himself acknowledged that his inventions[111] were only the time-dependant artefacts of a specific programmatic need and thus the lazy characterisation by design professionals as the 'dome guy' subverts his role as a clear-thinking anti-entropic[112] designer.

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[109] Hardingham, S. (2016). *Cedric Price Works 1952-2003: A forward-minded retrospective*. London: Architectural Association, pp 306 & 338
[110] Fuller, R. B. (1981). *Critical Path*, St. Martin's Press: New York, p 268
[111] Fuller, R. B. (1983). *Inventions: The Patented Works of R. Buckminster Fuller*. New York: St. Martin's Press
[112] McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (1), p121

My research has been motivated by an attempt to describe and define the aberrant practitioner and their role in the innovation and implementation of new technologies in architecture. Whilst my list of protagonists is confined to five, it is not an exhaustive list and is necessarily expandable in my future research. The work of these practitioners is significant and it is recognised either through their technological innovations or their particular modus operandi, or both. My direct contact with the protagonists having worked with them in one capacity or other, (with the exception of Haller) represents an important methodology in relation to my own research and one which I will continue to develop. Whilst all of the five featured practitioners have been recognised in their respective fields they might also be characterised as peripheral (albeit intriguing) figures in the history of architecture. I have attempted to challenge this characterisation and highlight the important and vital role of the innovating entrepreneur, the artist and inventor in the continual development of the technology and practice of architecture.

Each protagonist featured in this research is either an innovator, an inventor, an entrepreneur or a combination thereof. I am making a specific case for the selected practitioners, but more generally acknowledging the importance of the individual who pursues a line of thought or an approach that drives innovation, invention or technological development in architecture. The role of the aberrant practitioner (both past and present) should be both appropriately acknowledged, supported and celebrated, and the insubstantial characterisation of such figures as mavericks, and their work as aberrant, will

continue to fail to recognise the potential of these exemplary characters as the pioneers of new ideas in architecture.

6.0 The Published Works

6.1 Published works 1: McLean's Nuggets

The journal column, which appeared in 32 separate issues of Architectural Design (AD) magazine over a five-year period from 2005 – 2010.

2005

McLean, William (2005). A Cosmorama of Now. *Architectural Design*, **75** (2), pp 6–11

McLean, William (2005). McLean's Nuggets. *Architectural Design*, **75** (3), pp 112-113

McLean, William (2005). McLean's Nuggets. *Architectural Design*, **75** (4), pp 135-136

McLean, William (2005). McLean's Nuggets. *Architectural Design*, **75** (5), pp 122-123

McLean, William (2005). McLean's Nuggets*. Architectural Design*, **75** (6), pp 120–123

2006

McLean, William (2006). McLean's Nuggets*. Architectural Design*, **76** (1), pp 120–121

McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (2), pp 122–123

McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (3), pp 126–127

McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (4), pp 129–131

McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (5), pp 134–135

McLean, William (2006). McLean's Nuggets. *Architectural Design*, **76** (6), pp 132–133

2007

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (1), pp 122–123

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (2), pp 140–141

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (3), pp 138–139

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (4), pp 124–125

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (5), pp 138-139

McLean, William (2007). McLean's Nuggets. *Architectural Design*, **77** (6), pp 148–149

2008

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (1), pp 134–135

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (2), pp 136–137

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (3), pp 120–121

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (4), pp 134–135

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (5), pp 134–135

McLean, William (2008). McLean's Nuggets. *Architectural Design*, **78** (6), pp 132–133

2009

McLean, William (2009). McLean's Nuggets. *Architectural Design*, **79** (1), pp 126–127

McLean, William (2009). McLean's Nuggets. *Architectural Design*, **79** (2), pp 136–137

McLean, William (2009). McLean's Nuggets. *Architectural Design*, **79** (3), pp 128–129

McLean, William (2009). McLean's Nuggets. *Architectural Design*, **79** (4), pp 128–129

McLean, William (2009). McLean’s Nuggets *Architectural Design*, **79** (5), pp 130–131

McLean, William (2009). McLean's Nuggets. *Architectural Design*, **79** (6), pp 142–143

2010

McLean, William (2010). Mclean’s Nuggets. *Architectural Design*, **80** (1) pp 134-135

McLean, William (2010). Mclean’s Nuggets. *Architectural Design*, **80** (2) pp 138-139

McLean, William (2010). Mclean's Nuggets. *Architectural Design*, **80** (3) pp 130-131

6.2 Published Works 2: Selected Essays and Articles

Nine published essays and articles up to and including 2017.

2007

McLean William (2007) April/May *Prefab Sprout* pp. 180 – 185 Wonderland Magazine, London, UK.

2010

McLean, W., (2010). Celebrate Everything You Normally Do: Will Alsop's Praxis. *Corridor 8*. **1**. pp 4–7

2011

McLean, W., (2011). A New Unintended Equilibrium of Functions. *AA Files: Annals of the Architectural Association School of Architecture* **62** (Winter 2011), pp 90–94

2013

McLean, W., (2013). Dante's Inflatables. *AA Files: Annals of the Architectural Association School of Architecture* **67** (Winter 2013), pp 19–23

McLean, W., (2013). Domes of Discovery. *The Architectural Review*. **233** (1392), pp 86–93

2014

McLean, W., (2014) *Fundamentals: 14 International Architecture Exhibition. La Biennale Di Venezia* (by Rem Koolhaas), Venice: Marsilio, pp 32–33

2015

McLean, W., (2015) Graham Stevens: Atmospheric Industries. *AA Files: Annals of the Architectural Association School of Architecture* **70** (Summer 2015), pp 134–139

2016

McLean, W., (2016). The Pneumatically Powered Construction Systems of Dante Bini. In: Campbell, J. W. P. et al, *Further Studies in the History of Construction: The History Society*. Queens' College Cambridge. 8-10 April 2016. Cambridge: Construction History Society, 2016, pp. 441-450.

2017

McLean, W. (2017). Building with Glass: Tim Macfarlane and the Development of Glass as a Load-bearing Structural Element. Campbell, J. (ed.) *Building Histories: Fourth Annual Construction History Society Conference*. Queens' College Cambridge, 7-9 Apr 2017. Cambridge: Construction History Society, 2017, pp. 457-467.

6.3 Published Works 3 - Authored, Co-authored and Edited Books*

Four books, two authored, one co-authored and one edited.

*See accompanying published books submitted as part of the PhD by published work.

2008

McLean, W., (2008). *Quik Build: Adam Kalkin's ABC of Container Architecture.* London: Bibliotheque McLean.

2014

McLean, W., ed., (2014) *Building with Air*. London: Bibliotheque McLean

McLean, W., Silver, P., Evans, P., (2014). *Structural Engineering for Architects: A Handbook*. London: Laurence King.

2015

McLean, W. Silver, P., (2015) *Air Structures*. London: Laurence King.

6.4 Published Works 3: Contributions to co-authored books

Air Structures – McLean, W., Silver, P. (2015). London: Laurence KIng

Will McLean is responsible for all research and text for *Air Structures*. Pete Silver is co-credited for his editorial advice.

Structural Engineering for Architects: A Handbook – Silver, P. McLean, W., Evans, P. (2014). London: Laurence King

Will McLean and Pete Silver are jointly responsible for origination of *Structural Engineering for Architects: A Handbook*. Will McLean is responsible for all research and text relating to the followings sections/sub-sections of the book (listed below). Original research included site visits by McLean to: France, Germany, Holland, Italy, Switzerland, Canada, and the US.

Introduction

Section 3 3.3 Visualising Forces

Section 4 4.1 Introduction

Case Studies: Will McLean was wholly responsible for the following:

4.2.7 Maggazzini Generali Warehouse

4.3.1 Crown Hall, Illinois Institute of Technology (IIT)

4.3.4 Geodesic Domes

4.3.5 Palazzo del Lavoro (Palace of Labour)

4.3.6 Concrete Shell Structures, Switzerland

4.3.7 Jefferson National Expansion Monument (Gateway Arch)

4.3.8 Maxi/Mini/Midi Systems

4.3.9 Tensegrity Structures

4.3.10 Munich Olympic Stadium Roof

4.3.11 Bini Dome–Inflatable Formwork

4.3.13 Structural Glass

4.4.1 Ontario College of Art and Design expansion, featuring the Sharp Centre for Design

4.4.2 Atlas Building

4.4.3 Het Gebouw (the Building)

4.4.4 Hemeroscopium House

4.4.5 Kanagawa Institute of Technology (KAIT) Workshop

4.4.7 Pompidou-Metz

4.4.8 Burj Khalifa

Section 2 Theory

While it was felt imperative that the structural engineering theory was explained by structural engineer (Peter Evans), both Will McLean and Pete Silver contributed to the choice and organisation of information in this section.

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