Scholar / Practitioner Project Grant:

"At a time when most artefacts, systems and institutions are in an increasingly rapid state of change, the lack of constructive progress in basic problems of enclosure and movement is not merely depressing but also extremely dangerous. It is a cause for total concern when one of the major obstacles to the improvement through change of many activities is primarily hampered by the restriction of their enclosures."

Cedric Price – Works II 1984 [1]

"The current frontier for hackers, O'Reilly says, is not the purely mathematical realm of 1s and 0s but actual stuff – taking the same tear-it-down-and-build-it-anew attitude that programmers once took to compilers and applying it to body parts and wind-energy harnessing kites."

Steven Levy – Wired Magazine May 2010 [2]

Statement of Interest:

Over the past few years a vital social landscape has emerged as people have begun to build new lives, business and industries upon the back of technological change.[3] The root of this shift is explained by the growth of physical sensing technologies that support computational processes. No longer restricted to the digital realm, computational technologies are on the march. [4]

My interests in architecture, and the focus of my written and project work, are to advance the ways in which architecture can be extended and redefined through transposing new design values onto old ones through promoting bottom-up and direct responses to users and environment through new architectural technologies and design methods – a goal that seamlessly aligns with those of Michael Kalil and his memorial fellowship.

The changes that come about from this work are radical. Like the observations made by Steven Levy, this work is about applying the tear-it-down approach of programming to architecture for the purposes of encouraging beneficial change and the emergence of a fresh paradigm, one that relies on the meaningful application of contemporary technologies to inform architectural outcomes in very unconventional ways. This requires the involvement of users as a new form of architect that can inspire daily responses between their needs, the environment and space in an actively responsive architecture. Responsive architectures are those that employ sensing, control and actuation to effect persistent adaptation in buildings. The buildings that result operate as though they are giant robots, programmed by users to respond and adapt to their activities as well as changing environmental conditions.[5] They are buildings that support dynamic relationships, which can morph their shape, color, permeability and internal workings – mechanical, electrical and spatial. But perhaps more profoundly these buildings redefine the nature of who an architect is, what architectural design must do, and what built environments will become.

Opportunities for Change:

Design is about building relationships between things.

Statement of Interest:
(Continued)

Designers have always assembled materials to form purposeful connections between ideas and spaces, uniting the height of human thought with the great ability of people to shape the world with their hands and tools. People have understood this opportunity and used it to inform the material investments that they make in buildings.

When reflecting upon the past ten or so years of practice it is clear that some methodologies have matured. Professionals, academics and students have found new ways to connect thinking and doing. These connections have a different flavor and tend to feel more analytical to those once used. Previously internalized decisions are being made increasingly explicit by a generation of designers that has found a more meaningful overlap between the theories and procedures of design. The methods they use are visual, analytical, as well as intuitive, and encompassed within a whole gamut of tools such as Grasshopper, Ecotect, Digital Project and Generative Components. All of these tools provide opportunities for designers to inquisitively explore alternative formal, spatial and environmental relationships. The opportunities that are brought by increasing externalization are important. Design is at once turning away from its focus on the end result, be it a building or an interior, and toward a renewed interest in the design process itself. Brought about by encapsulating design principles into self-made tools, this shift has enabled families of formal outcomes rather than singular instances of 'pure' architecture. These multiple, equally valid, formal outcomes disrupt more traditional measures of formal legitimacy and help move architects toward more relational understandings of space, time and environment. Some see this approach as a move toward engineering, but it is not.[6] Architects have maintained the integrity of their professional boundary by using these processes to discover dynamic balances between buildings and their contexts. This move is driven by an ethical stance that focuses on bringing buildings, users and their environments together in beneficial ways. These technologies and the methods they support do not exclude the architect as author. Authorship simply takes a different form as the architect draws relationships from environments by choosing to more heavily interconnect those conditions that are considered more important. This role inspires a new form of balance that challenges traditional methodologies by motivating form generation through lenses of relational performance. At a recent Sci-Arc panel, Thom Mayne spoke to this point. To paraphrase he said that design is now connected to a broader set of processes and that the architect's role is evolving as design tools enable designers to discriminate by "making continual decisions of moving in one direction or the other" while in dialogue with operational methodologies that make architecture a more relational activity.[7]

We can think of these design strategies as promoting a more mutually dependent mode of practice, where architectural expression is grown from a series of influences all of which deserve some degree of respect. Inspired by this egalitarian-like mode of thought architects have begun to develop conditional understandings of architecture. For the practitioners who have made this leap, architecture has transformed from being about the production of space defined by larger ideas to being a profession that is committed to finding spatial relationships that spark cognate form.[8] Certainly we are talking about a flip in the logic of design that finds benefit, and perhaps even a new type of freedom, in adopting a more modest bottom-up approach.

The Case for Robotics:

Robotic systems are material assemblies that support adaptable, actuated form.

Statement of Interest:
(Continued)

If the primary outcomes of persistent methodologies are a new inquisitiveness and variety of participatory architectural expression, then we must ask how these ideas can be instantiated within today's material world.

Perhaps the first thing to say is that architecture has generally accepted the freezing of the form of a building at the point of its construction. This acceptance is not shaped by a theoretical ambition but, rather, the practical difficulties of producing more dynamic building methodologies. As a form of material system, robotic media will enable buildings to alter form through time to produce controllable and dynamic architectures. With the richness of parametric systems already informing a good portion of design, robotics will empower those architects who wish to elaborate upon the digital aesthetic but to do so directly in materials that are dynamic, unfrozen and free of former restrictions.

Responsive architectures are behavioral. They have the power to evoke deliberate change in building fabrics and thus provide architects with opportunities to tie the formal configurations and qualities of a building to social and environmental events. Billowing walls or envelopes can be programmed to reflect a change in season, the passage of the sun or the energy consumption, work and location of building users. This is the freedom of a responsive architecture that is supported by robotic technologies. But for these responses to be purposeful and meaningful they cannot be random. Just as with parametric methodologies, where formal relationships are deliberately, purposefully and explicitly struck between elements, so too sensing, control and actuation technologies must be purposefully crafted.[9]

The brightness of light, its direction and polarity, humidity, temperature, wind direction, pressure and speed, the location of people, their movements, gestures and voices, the location of inanimate objects and their loads all become potential drivers for this type of architecture. Determined at the discretion of the occupant–architect, each has the opportunity to become an element of a larger functional or aesthetic behavioral choreography. Buildings might re-shape to form spaces that support the desire of users to reduce artificial heating while staying warm in the winter, or alternatively the shape of a space might be formed in a particular way just because a user appreciated that particular spatial quality. And as a pure, or perhaps less than pure form, the configurations programmed by users might drift slowly through time, or if demanded, speed up to provide a new type of balance – a balance that extends the thinking of parametric design directly into the world, its events and ever changing quality. This architecture will constantly vary and be open to persistent re-design. But does this balance alter what is necessary or meaningful in architecture? It does not. Responsive architecture, like all architecture, must provide the people it serves with shelter, a sense of place and an environment that can be appreciated in a meaningful and poetic way. And like all architectures, the poetry of its form will be found in the balance it strikes between the many requirements of site, program, construction methods and discourse. All of these requirements must be integrated into responsive architecture to enable its poetry a chance to consult not just with the concerns of today but also with the legacy of construction techniques and design methodologies that architecture has inherited. In other words, to forge the poetry of responsive architecture we must be able to marry the concerns of nature, resource use and the industrial processes that have shaped building with the benefits of responsiveness.

Description of Project:

To produce a series of 6 actuated structural tube prototypes for implementation in future lightweight skyscrapers that are capable of varying the characteristics of their form [rigidity/shape] to improve structural performance.

Project Proposal:

The final outcome of this project proposal is to produce a series of actuated structural tube prototypes for use in future lightweight skyscrapers. It aims to produce a series of structural prototypes that question the current engineering paradigm of using massive structures to produce stable form, by embedding shape change intelligence into structural systems.

This project carries forward existing, recognized, work produced by this proposal's author in a series of 6 reduced scale built prototypes. Three distinct phases of work are required to complete a prototype:

*Phase 1) To derive the structural geometry designs **

*Phase 2) To derive the control algorithms for use in driving actuated geometries **

*Phase 3) To produce a series of built prototypes into which structural geometry designs (1) become actuated via control algorithms (2) ***

** The author has already developed the software components required in phase 1, as well as the control algorithms and sensing / actuation methods required in phase 2.*

*** The intellectual and practical design goal of this project proposal is to produce a series of built prototypes that successfully demonstrate how each phase of work can be integrated into a unified whole and inform the production of a new architecture.*

Outline Budget:

5 prototype towers consist of actuation costs, sensing costs, microcontroller costs and part production. The necessary design geometry and control algorithms have already been developed and have no cost.

- *Actuators: $6.00 per piece, average tower actuation requirements estimated at 48 units, total costs for actuators expected to be $1,440*
- Sensors: $12.00 per piece, different strategies will be explored to minimize sensing requirements across the series of tower prototypes, average tower sensing requirements estimated at 24 units, total cost for sensors expected to be $1,440
- Microcontrollers: $18.95 per piece, average tower control requirements estimated at 12 units, total costs for control expected to be $1,137
- Part production / compression member prototyping: If identical pieces can be produced across each tower, it will be possible to reduce part production to 12 pieces that can be duplicated in a foundry in larger scale production process with small material costs. Estimated 3d-printing costs $300, estimated foundry production costs for 50 units per tower across 5 towers in cast Aluminum, $450
- Budget Total: Actuation ($1,440) + Sensing ($1,440) + Control ($1,137) + Part Production ($750) = $4,767

Production of Adaptable Structural Geometry (Phase 1 Support)

Sample supporting images for structural geometry results for producing adaptable and actuated structural tubes.

Supporting Images:

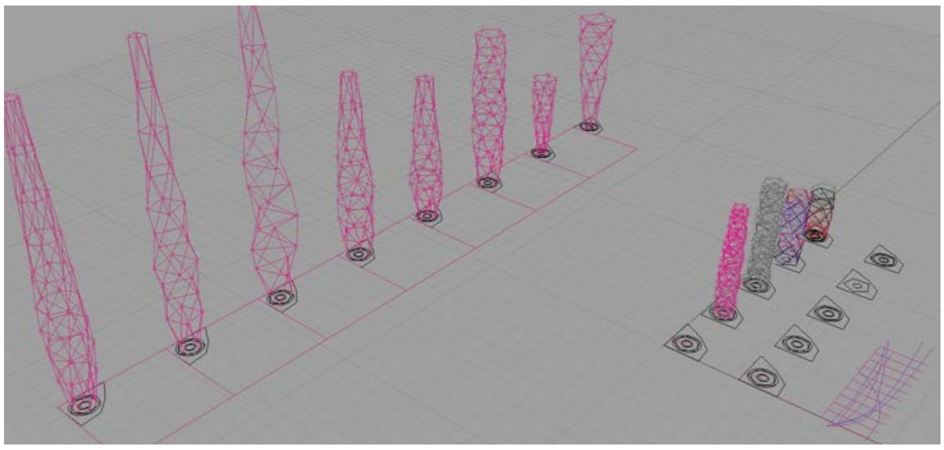
1) A screen snap of an early algorithm for producing the structural geometry of a class two actuated tower, various geometries are shown. The algorithm as since been generalized and broadened to enable class three structural tube surfaces, shown below (images 2, 3)

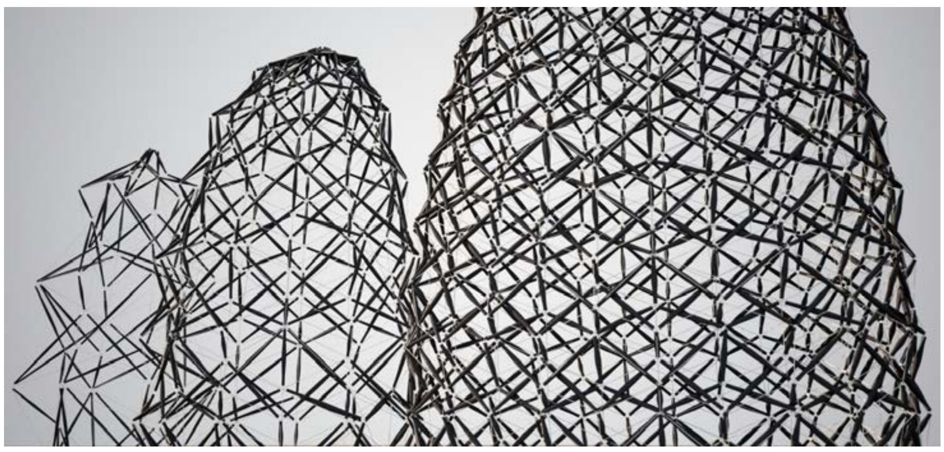
This work has not been published, however a very similar algorithm was used to produce sheet surface structures (image 4) an applied to a project produced by the author. The project, called "Prairie House: A House for a Fashion Pattern Maker & Fiber Artist" has subsequently been awarded an recognized in:

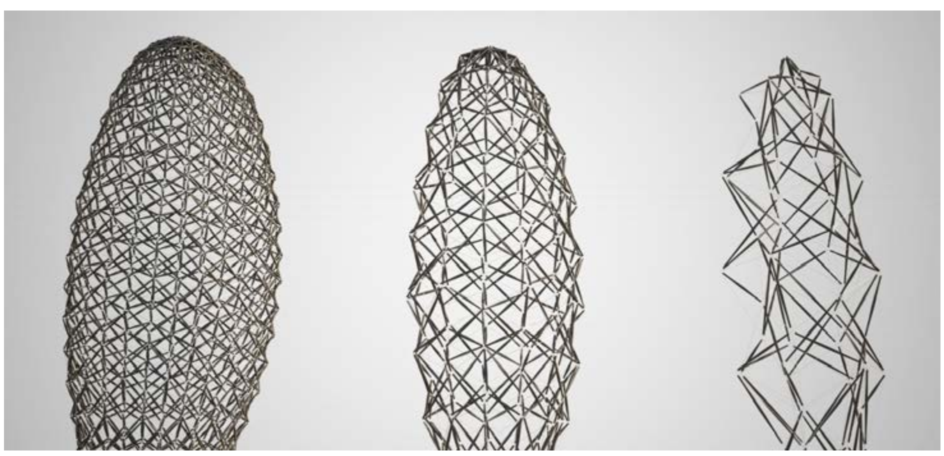
AIA Chicago, Award of Design Excellence with Special Recognition in the Unbuilt Works Category, 2011

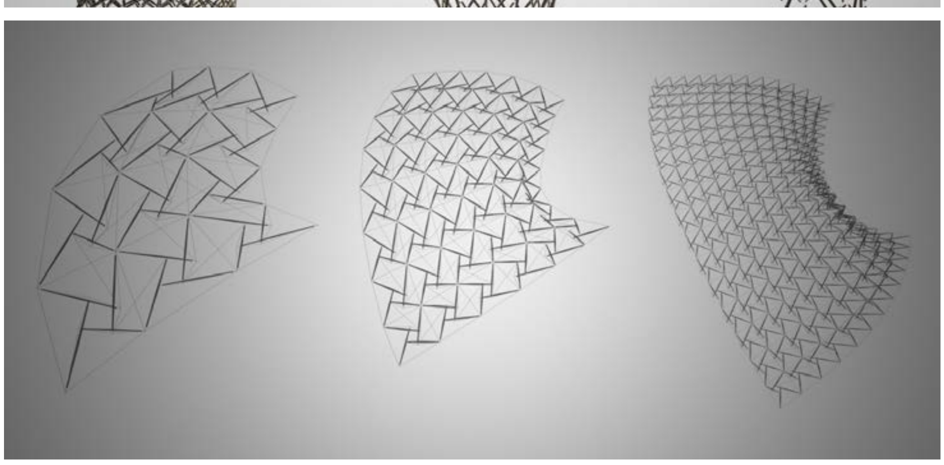
Mark Magazine, No 31, April – May, 2011

For these efforts, the author of this proposal was recently awarded the AIA Chicago, Dubin Family, Young Architect of the Year Award, Chicago IL 2011. These images were a part of a larger folio presented in the award submission.









Production of Adaptable Structural Geometry (Phase 2 Support)

Sample supporting images for built prototypes of actuated structures.

Supporting Images:

5) A full scale cast aluminium prototype of a class three actuated tensegrity structure with pneumatic actuators, built by the author. This work was most recently recognized in:

Mark Magazine, No 31, April – May, 2011

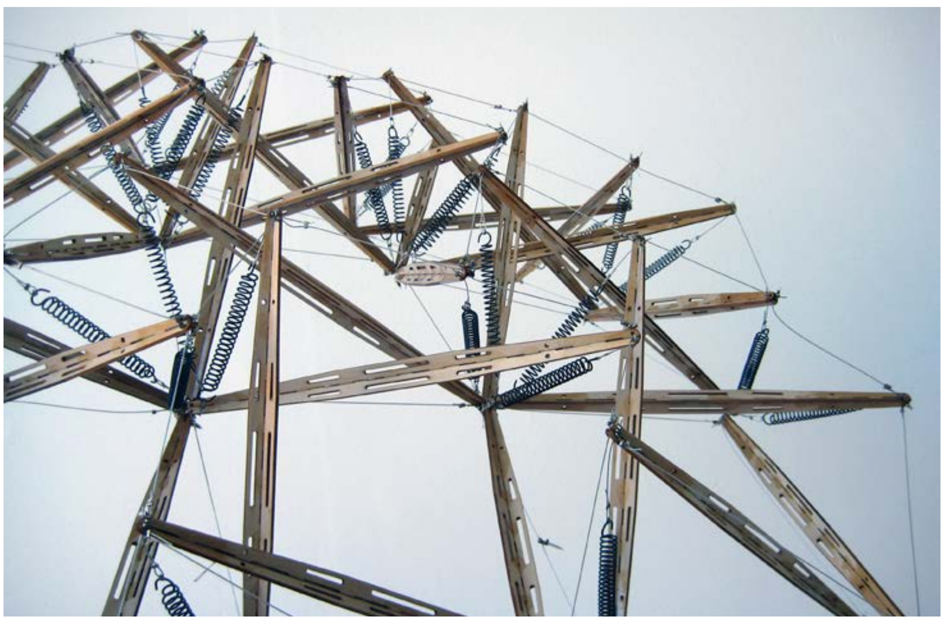
Move, Architecture in Motion, Dynamic Components and Elements , Birkhauser Press, 2010

The AIA Center for Architecture NYC, Exhibition entitled "Make it work", April 2009

6) A reduced scale cast aluminium prototype of a mixed class one & four, actuated tensegrity structure with NiTi thermal memory actuators, built by the author. This work was most recently recognized in:

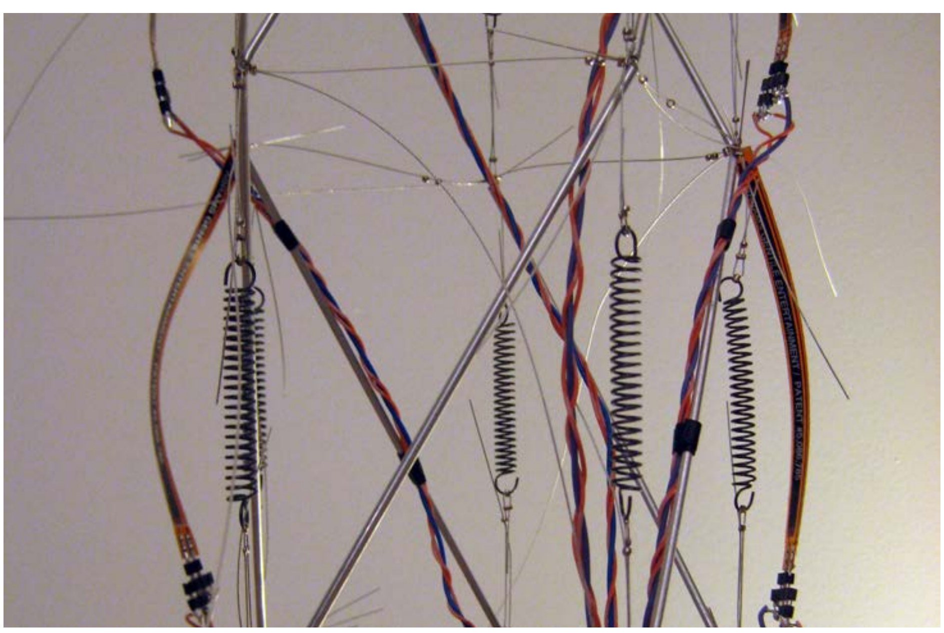
Mark Magazine, No 31, April – May, 2011

The AIA Chicago, Dubin Family, Young Architect of the Year Award, Chicago IL 2011 (as a part of a larger research and project portfolio submission).



7) An early working prototype for a class two actuated tensegrity tower built by the author. This photograph depicts an early instrumentation that has been generalized and advanced since. This work was most recently recognized by:

Discover Science TV on a documentary series of recent scientific and engineering advancement. The show specialized in examining balancing systems in nature and the built environment. The series was called "weird connections" and



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1. Price, C. (1984) Cedric Price Works II. Architectural Association (London, UK: E G Bond Ltd), p. 56.

2. Levy, S. (2010) “Master Minds”, in Wired Magazine, Vol 18 No. 5 (Conde Nast Media), p. 129.

3. A collection of articles in Wired Magazine, the first starting with Anderson, C, (2009) “The New Economy” and the final being by Kelly, K, (2009) “The New Socialism” each published in Wired Magazine, Vol 17 No. 6 (Conde Nast Media), pp. 99-121.

4. Sterk T, (2000) “The Synthetic Dialect & Cybernetic Architectural Form” in The Intersection of Design and Technology Proceedings of the 2000 ACSA Technology Conference. MIT Cambridge (Massachusetts) pp.117-122 – July 2000

also see: Sterk T, (2003) “Building Upon Negroponte: A Hybridized Model of Control For Responsive Architecture” in Proceedings of The 21st Annual Conference of the Education and Research in Computer Aided Architectural Design in Europe (Graz) pp.406-414 – Sept 2003

5. Sterk T, (2012) “Beneficial change: The case for robotics in architecture,” in Persistent Modelling: Extending the Role of Architectural Representation (P. Ayres, ed.), ch. 13, Routledge, 2012.

6. Sterk T, (2006) “Shape Change In Responsive Architectural Structures / Current Reasons And Challenges” in The Proceedings of The 4th World Conference on Structural Control and Monitoring pp.1-8 – July 2006

7. A lecture and panel event held at Sci-Arc on 15 September 2010. Lecture and panel can be viewed at http://www.sciarc.edu/lectures.php?id=1823 (accessed December 10, 2011).

8. Whiteman, J. (1987) “On Hegel’s Definition of Architecture”, in Assemblage No. 2 (Cambridge, MA: The MIT PRESS), pp. 6-17.

9. Sterk T, (2003) “Using Actuated Tensegrity Structures to Produce a Responsive Architecture” in Proceedings of The 22nd Annual Conference of the Association for Computer Aided Design in Architecture “Digital Fabrication” pp.84-93 – October 2003