Living Architecture Systems
*Notes on Progress*

Philip Beesley
*University of Waterloo, Canada*

Can artists, designers and engineers make living systems? Can the layers of new built environments – layers of architecture, sculpture and fashion – come alive? The ingredients that define living systems appear increasingly within the reach of contemporary architecture. Life-like qualities have been sought by artists since the beginning of recorded history, but this quest is being transformed by new ways of understanding the deeply interwoven living world, supported by surging technologies of artificial intelligence, responsive systems and engineered materials, and informed by new arts that permit visualization and conception of exquisitely sensitive complex environments.

Classical paradigms tend to emphasize clarity and unified integrity as self-evident necessities. The premises of classical rhetoric have tended to create polarized divisions between interior and exterior spaces, between human beings and things, and between the realms of technology and
nature. The papers of this gathering propose a fundamental renewal of such polarized realms. The new kinds of architecture implied by these studies might appear like a layered forest. The technical systems of this architecture tend to embrace inherently entropic and precarious conditions, far from equilibrium. The kinds of precisions gained from computational processes tend to be combined with physical and empirical methods in this work, lending meticulous attention to craft, material and fabrication alongside abstracted analysis. Extending these mutual exchanges are fresh approaches to physical computation and distributed controls that imply a continuous spectrum between sentience and physical fabrication. This is architecture that learns, plays, explores and is curious. It has the ability to act with intelligence, empathy and resilience.

The Living Architecture Systems Group (LASG) was conceived ten years ago, amidst collaborations extending the work of individual and small-group architectural researchers and creators in Canada, USA and Europe. An international collective group began work together with the support of a 2012 Social Sciences and Humanities Council of Canada (SSHRC) Partnership Development Grant. Funding in this first phase was combined with support from museums and galleries, making it possible to launch a series of immersive interactive environments accompanied by experimental workshops during 2012-16. Funds for a full SSHRC Partnership Grant were achieved in 2016, launching the public phase of the LASG. Multiple collaborators agreed to contribute, and the partnership formally began in April 2016. Five streams - Scaffolds, Synthetic Cognition, Metabolism, Human Experience and Interdisciplinary Methods - were first positioned to organize the group. In 2017, Theory was added, providing a stream enfolding philosophy and history. Overlapping creative, technical and scientific developments within diverse media are continuing with multiple intersections between these widely varying disciplines, inviting further extension of LASG ‘stream’ organization.

Integrated research and creation is a core of this collective work. Technical performance is converging with aesthetic language. The practice of research-creation supports integrated scholarship within a spectrum that combines art and science. Aesthetics, scientific analysis and innovative technical craft tend to be practiced in overlapping combinations within this approach.
The potential application of living systems to architecture is large, and the LASG’s contributions are necessarily limited. Research devoted to the technology and design of living architectural systems distinct from that of LASG contributors appearing within the current volume is evident at Stuttgart’s Institute for Computational Design and Construction (ICD), the Bartlett School of Architecture, the national Swiss facilities of ETH Zurich, Media Lab at MIT, the Institute for Advanced Architecture of Catalonia (IAAC), the Master’s programs in Emergent Technologies and Design (EmTech) at the Architectural Association, the Spatial Information Architecture Laboratory (SIAL) in Melbourne and new developments at Swinburne University of Technology, new facilities at Tongji in Shanghai, architecture research centres within Harvard GSD, SCI-Arc, Taubman College at University of Michigan, and the University of Southern California, and in interdisciplinary dialogues hosted by other disciplinary centres such as the Wyss Institute at Harvard and the specialized art and bioengineering facility within the University of Western Australia’s SymbioticA. Likewise, recurring conferences hosted by specialized knowledge-creation societies such as Academy of Neuroscience for Architecture (ANFA), ACADIA, eCAADe, CAADRIA, SimAUD, ROB|ARCH, Fabricate and CHI, journals such as the International Journal of Architectural Computing (IJAC) and general societies such as the Association of Collegiate Schools of Architecture (ACSA), include dedicated sections on closely related topics. These acknowledgements are incomplete by far, with many others playing important and leading roles. The diversity and energy of these numerous groups testify to the potency of the topic of living systems within contemporary architecture.

Broad themes of research can be seen within the papers presented here. Open boundaries and expanded dimensions run throughout the studies, exploring the scales of new adaptive and responsive architecture, from intimate personal spaces to regional infrastructures. Subtle phenomena and expanded perception frequently appear, exploring dimensions at the edges of human perception. These qualities move from primary, existen-tial qualities of light and dark through interwoven social realms. Immersive sonic environments and precise measurements using innovative sensors of physiology are included. A deep involvement in craft is offered, making matter vibrant and reflecting the unparalleled new abilities of designers to precisely address material performance. Striking qualities are being achieved by applying the principles of biological structures to architectural compo-nents. These qualities are underpinned by design ideas that are founded on
innovative conceptions of physics. Decay of organized systems may seem inevitable, but new conceptions suggest that living systems can thrive within the seemingly disordered spaces of turbulent, changing environments. Innovative design methods are included that combine meticulous control of computationally derived geometry with material craft.

Specialized studies in theory and craft of artificial intelligence are now being applied to large-scale architectural environments. A synthetic approach to cognition demonstrates new understanding of how interactive machine learning might be implemented within large distributed systems involving multiple viewers and occupants. Software applications support distributed mesh and field-based multi-sensory expression. Stage and dance performance-based interactive works couple actors and audience members with immersive environments. Kinetic architecture documents contain evolving research in dynamic, adaptive construction and mechanisms that transform the fabric of architecture. Integrated robotic construction systems offer efficiency and versatile expressive manipulations of form. Elastic and resilient mechanisms provide transformed kinetic qualities that approach empathetic, emotional gesture. Within the Toronto-based LASG studio, mechanisms are designed in ways that emphasize subtle movements that include vibrating and trembling. Sensors are designed to respond to slight movements and gestures, encouraging sensitive, gentle play. Small movements take minimal energy, while offering ‘precarious’ reactions that respond to the gentlest of stimulation.

These studies are in turn framed by theory, history and philosophy. Reflections on past and future Living Architecture offer new reflections that place the work of the LASG within traditions including historic conceptions of Organicism, 20th century participatory art and open systems, and radiant geometries related to Aquarian Age conceptions. New, mutual relationships that couple human, animal and mineral realms are invoked. Such hybrid approaches demonstrate an extraordinary efflorescence of hybrid architectural constructions that cross traditional boundaries between nature, technology and urban realms. Precisions are emerging that offer highly developed technical craft and nuanced aesthetic language. Every study within this gathering is interdisciplinary. The sheer diversity of these studies suggest that the topic of Living Architecture is volatile, testing the limits of classical disciplines.
The scales engaged by researchers and creators contributing to the current White Papers 2019 volume span from microscopic dimensions to urban and regional development. Urban and regional studies within this volume include a bioregional network being organized in Appalachian states by Eric Mathis, conceptions of adaptive, regenerative infrastructures of the future by Douglas MacLeod of Athabaska University, transformations of high building layers by Sheida Shahi of Waterloo, and visionary urban fabric by Terreform ONE, New York. The language and practice of complex spatial modeling coupled to material qualities is being expanded by practices including CITA at the Royal Danish Academy of Arts and the Sabin Lab, associated with Cornell. Concentrations in biologically-inspired design and biomaterials are emerging, including new contributions from Petra Gruber’s Akron, Ohio-based laboratory, Dana Cupkova’s Epiphyte Lab at Carnegie Mellon University, and material-based research extending Manuel Kretzer’s Europe-wide materiability network. Expressive kinetic constructions based in next-generation performance have been documented by Vera Parlac of the Laboratory for Integrative Design (LID) at Calgary. LASG collaborator Iris van Herpen has fostered widely celebrated collaborations within couture, extending vivid imagery and formal expressions of material craft. Collaborations with the Delft University of Technology are now extending both Van Herpen’s experimental couture and the Toronto-based environments of the LASG.

New systems of complex-systems dynamic visualizations are in development within a research cluster led by Katy Börner of Indiana University (IU). Börner and IU colleagues including Andreas Bueckle have conceived of ‘macrosopes’ complementing traditional microscopes, reinforcing the value of LASG installations as large-scale architectural testbeds supporting collection of unique, enriched data. Techniques of dynamic digital visualization and information-gathering offer valuable methods for effective design of interdependent relationships. Maya Przybylski proposes general terms of data quality and relative positioning of frames of reference. Specialized craft is demonstrated in Codrin Talaba’s augmented reality study, and is extended by the contemplative poetics of Michael Awad’s continuous-scan collaborative work.

New understanding is emerging of how interactive machine learning might be implemented and verified within large distributed systems involving crowds, led by Dana Kulić of Waterloo and Monash. Software supporting distributed mesh-based multi-sensory expression and control is in progress,
with multiple contributions that include York University and OCADU’s Artificial Nature collective. Sha Xin Wei and the Synthesis Center at Arizona State University have led stage and dance performance-based interactive works coupling immersive environments with actors and audience members. Nima Navab and Desiree Foerster propose subtle phenomena within aerial and fluid realms as a design medium. Granular synthesis controls for the architectural medium of sound are offered by Amirbahador Rostami. Immersive sound performances with Amsterdam-based partner 4DSOUND have been staged in Toronto, Bloomington and Berlin, with surging progress in control and visualization of distributed sound.

Providing a broad context of philosophy and theory, Sarah Bonnemaison of Dalhousie is developing reflections that place the work of the LASG within renewed conceptions of long architectural tradition of Organicism. Michael Stacey provides a fundamental history of adaptive architecture, focusing on British and European traditions. Mark-David Hosale’s ‘worldmaking’ extends related conceptions into vividly imagined future realms. Adam Francey contributes precisions of perceived agency, projected into machinic environments. Poignant reflections by Alexander Webb of the European Graduate School emphasize how increasingly intimate machine-human relationships are fraught with risk.

The White Papers 2019 represents a portion of an increasingly robust and involved community of research located within multiple international centres. Contributions made at the LASG 2019 Symposium in Toronto are published in a parallel volume of Proceedings. Demonstrations at the 2019 Symposium also include large-scale environments developed by a central cluster of architecture and engineering collaborators led by the author, focusing their work within a warehouse design and fabrication studio in Toronto, associated with the University of Waterloo. This location has become the headquarters of the LASG, providing a locus for workshops, testbeds and prototypes. Built works between 2016 and 2019 by members within the Toronto studio include permanent installations of testbed environments located at Indiana University in Bloomington, the China Academy of Art at Hangzhou, and Shangduli, Shanghai, together with recent temporary environments at Toronto’s Royal Ontario Museum, the Daejeon Biennale (Korea), MAK Vienna, Futurium Berlin and the Vitra Design Museum Basel.
Numerous participatory workshops have accompanied these built projects. Expert workshops support ongoing research within a continually evolving collaborative partnership that currently combines groups from Canada, USA and Europe. Public workshops and summer camps include offerings for students within Grades Six to Eight science classes, high school students entering University, and graduate and undergraduate design students. Research and design workshops for experts are now in development.

The experimental sculpture environments created by the Living Architecture Systems Group are now being extended to permit participatory design and open-ended creative exploration, led by Rob Gorbet of Waterloo’s Knowledge Integration, Lucinda Presley of ICEE Success, Katy Börner at Indiana, and multiple partners. A developing LASG STEAM (Science, Technology, Engineering, Art and Math) curriculum seeks to support wide and inclusive participation and equip emerging generations of designers with skills for working with complex, deeply interconnected environments. Kits for these workshops and classes contain electronics and sculpture building components. The kit components closely relate to the arrays of intelligent controls and lightweight custom fabrications within LASG installations, permitting individual exploration. Kits contain modular components and simple electronic controls designed for multiplication in arrays and chains, creating substantial networks. Construction kits that include digital fabrication patterns and prefabricated parts allow building of constructions similar to the deeply layered environments seen in recent LASG testbeds. Specialized modules permit connection and extension of systems contained within these existing sculpture environments and invite exploration of systems that could be developed in the near future.

The LASG kits are designed to encourage exploration of evolving, adaptive, responsive architectural spaces. Kits for young students include very simple, low-cost components and easily-found domestic materials that invite play and exploration at home. Clip-together modular construction elements are designed for laser cutting and 3D printing using machines commonly available in maker-spaces and schools, allowing new communities to share and expand the systems while keeping costs minimal. New generations of these materials will offer multiple components easily coupled together by experts and inexperienced users alike, creating constantly adapting
interactive prototype systems accompanied by vivid, evocative visualizations. Complementing the group’s contributions to precise knowledge, playful embodied interaction and mutual relationships lie at the heart of this community-based work.

This White Papers 2019 volume offers readers a sense of the variety and depth of research that is being conducted by Living Architecture Systems Group members. The adaptive and resilient qualities within this new experimental architecture can ultimately contribute to a more inclusive and empathetic built environment.

Philip Beesley (Canadian, 1956) is a multidisciplinary artist and architect. Beesley’s research is widely cited for its pioneering contributions to the rapidly emerging field of responsive interactive architecture. He directs Living Architecture Systems Group (LASG), an international consortium of researchers, creators and industry partners. LASG explores questions such as whether architecture can integrate living functions and future buildings could think and care. LASG’s immersive installations integrate expertise in architecture, environmental design, visual art, digital media, engineering, machine learning, cognitive psychology, synthetic biology and knowledge integration. Collaborations with LASG artists, scientists and engineers has led to a diverse array of projects, from haute couture collections to complex electronic systems that can sense, react and learn.

Beesley is a professor at the School of Architecture at the University of Waterloo and Professor of Digital Design and Architecture & Urbanism at the European Graduate School. He represented Canada at the 2010 Venice Biennale of Architecture. He has authored and edited numerous books and proceedings, and has been featured in Canadian and international media, including Vogue, WIRED, Artificial Life (MIT), LEONARDO, CBC, and a series of TED talks.