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CON VERSATIONS

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cybernetics: state of the art

edited by liss c. werner

contributions

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Universitätsverlag der TU Berlin

Cybernetics is "a discipline which fills the bill insofar as the abstract concepts of cybernetics can be interpreted in architectural terms (and where appropriate, identified with real architectural systems), to form a theory (architectural cybernetics, the cybernetic theory of architecture)."

Gordon Pask, 1969

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Raoul Bunschoten and Liss C. Werner

'Cybernetics: state of the art'
edited by Liss C. Werner

The scientific series CON-VERSATIONS of Technische Universität Berlin is edited by
Raoul Bunschoten
Liss C. Werner

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The book series 'CON-VERSATIONS' engages with pressing questions for architecture, urban planning and infrastructure; in the age of increasing connectivity, AI and robotization; in an evolutionary state of the Anthropocene, perpetuating angst-ridden anxiety as well as excitement and joy of a future, that we will be able to predict with less and less certainty.

Raoul Bunschoten and Liss C. Werner

CONTENT

FOREWORD

Omar Khan

It was in 1949, at the sixth Josiah Macy conference on "Circular Causal and Feedback Mechanisms in Biological and Social Systems", that newly appointed editor of the conference proceedings Heinz von Foerster, exasperated by the conference's cumbersome title, suggested that 'Cybernetics', the title of Norbert Wiener's recently published book be adopted as the conference's title. Through this simple act of renaming, von Foerster can be credited with making cybernetics into a field of study. While Wiener's book *'Cybernetics: Communication and Control in the Animal and the Machine'* (Wiener, 1948) set the scientific framework for explaining cybernetics as a subject about communication, feedback and control, it is really in the auspices of the conferences that cybernetics developed into an epistemology applicable across multiple disciplines. It was through the heated debates between scientists, mathematicians, anthropologist, linguists and psychologist that cybernetics emerged as a way of knowing our world.

Currently, cybernetics as a subject on its own isn't taught at any university in the United States. Within the engineering sciences it is reduced to the concept of 'feedback', a conceptual stepping stone for topics like informatics, system science and artificial intelligence. In the humanities it is a studied as a historical event closely tied to the development of computers and the information environment. Within the European academic context, cybernetics continues to exist in pockets but in many cases paired with informatics or robotics to make it more relevant. As to whether it as an epistemology still exists is difficult to ascertain.

Clearly there are shades of it and it is in a conference like *Cybernetics: state of the art* and the present book that we may be seeing a reemergence of this. What is it about conferences that allows for such possibilities. For one they invite conversation and sharing; open to new interpretations and disagreements. They allow one to test ideas to see whether they have staying power without the constraints of titles and structures necessary when defining a subject. And this has been cybernetics privilege and curse. There are many jokes associated with this but perhaps Claude E. Shannon's advice to Wiener-

“Use the word ‘cybernetics’, Norbert, because nobody knows what it means. This will always put you at an advantage in arguments”- might be positively taken for cybernetics nuance and continuing relevance for many fields. And so for the state of the art in cybernetics to be hosted at a conference in a School of Planning Building and Environment seems entirely relevant and necessary. It is in such interdisciplinary contexts that cybernetics as epistemology has the room to grow and inspire new directions of inquiry. There are many influential cyberneticist to take direct lessons from—Ross Ashby, Stafford Beer, Gordon Pask, Ranulph Glanville, and others to rediscover—Heinz von Foerster, Gregory Bateson, Humberto Maturana and Francesco Varela, and those still in our midst like Paul Pangaro who can connect us to this influential intellectual tradition. Hopefully, with this new initiative we will shed some much necessary light on understanding our increasingly cybernetic world.

Omar Khan,
Buffalo, September 05th 2017

PREFACE

Raoul Bunschoten

We have had the luck to have Liss C. Werner on board the last two years at the Technical University of Berlin, and especially in our Chair for Sustainable Urban Planning and Urban Design. Together we have been able to start up a new process of linking the state of the art of cybernetics with today's global urban developments. Her research on the work of Gordon Pask, and her tremendous energy, ingenuity—and her continuing communication with a part of the relatively small club of cybernetic specialists—have acted as a tremendous catalyst.

Gordon Pask appeared in my life standing at the bar in the Architectural Association in London, when I walked into its building on Bedford Square in London for the first time in October 1983. Alvin Boyarsky, at that time Chair of the AA, had invited me to run a unit together with Donald Bates. We had been recruited through Daniel Libeskind, who had visited the AA the year before. Libeskind had taught at the AA himself previously, before becoming, via a stint in Kentucky, the head of the Cranbrook Academy of Art in Michigan, where Donald and myself graduated with an MA in Arts. Gordon was nurturing a glass of white wine, when he caught my attention and asked me if he could help me. He could, since I needed dinner, and he duly pointed out his favourite Indian restaurant near the AA; located in a warren of streets I failed to navigate afterwards. His instructions were fairly fuzzy. Or, to be fair, I had not yet gotten used to Gordon's way of expressing things and his very particular manner of speech. During the first three years of teaching at the AA, I regularly bumped into him in the corridors and lecture hall. He was always around in crits, lectures, parties, and I started to observe him speak, interact with audiences, think aloud, and of course drink at the bar where one could approach him informally for a chat. I did not understand him, and at that early stage I had no time, since I, like all young teachers at the AA, came with hugely ambitious new programs and were fired on by Alvin Boyarsky to perform great deeds, win competitions, publish, etc. to keep the AA at the world's center of architectural education, nor inclination to research deeper into his past. When I started a new Diploma Unit in 1986 in which my students worked on the dynamic undercurrents of urban emotions—we called them *Proto Urban Conditions*—Gordon started to get interested in our work and joined the studio on a regular basis. I realised that he had some incredibly new and fascinating thoughts to offer; provided one took the effort to listen carefully to his soft murmurings. In October 1986, we started teaching together for two years and ran a lecture series called *Order and Chaos*. By then I was well inducted in cybernetic history. Gordon remained at the AA until he passed away in 1996. My hunch is that Gordon remained at the AA mainly because of his earlier relationship with Cedric Price. As Cybernetic Consultant he worked for and with Cedric on the Fun Palace, commissioned by Joan Littlewood, a famous fun park owner in the UK. Alvin Boyarsky retained him as a roving teacher and consultant.

Gordon Pask's importance for urban design was at that time possibly not understood and / or not well appreciated. John Frazer did realise his significance and drew him into the activities of his Diploma Unit 11, which he taught together with his wife Julia Frazer, a relationship possibly culminating in the experiments on artificial neuro-systems simulating urban decision making dynamics. In 1995 the AA published a book by John Frazer on the work of their Unit called 'An Evolutionary Architecture' which presents this work. But neither that cooperation, nor the very different ones with me and my students or Omar Khan, addressed the complexities of emergent technologies in urban contexts and the significance of the field of Cybernetics as a whole in the ensuing evolution in urban planning and design. At one stage Gordon moved into a different phase of life, and eventually passed away before any of us could restart this process. Only Ranulph Glanville, at that time working from a small cubicle in the basement of the AA, kept the link to Gordon and the wider field of cybernetics, architecture and design warm and alive.

In previous years, we dedicated several seminars to cybernetic research with students: a workshop with Omar Khan at London Metropolitan University, where I was teaching together with Tomaz Pipan, and at TU Berlin a workshop led by Tomaz Pipan, and various seminars organsied by Dietmar Köring and Holger Prang, the latter engaging in data-driven and data-based digital planning tools utilising cybernetic thought and cybernetic principles. Liss C. Werner approached the subject slightly differently—with a twist and fascination for the logic of cybernetic systems on one hand, and a passion for Gordon Pask, his diagrams and rather unusual cybernetic machines on the other. She visited the Gordon Pask Archive, located at the University of Vienna under Albert Müller, numerous times to examine the work of Gordon hidden in piles of papers and boxes. Beyond archival research Liss had regular conversations with myself, Ranulph Glanville—who taught Liss at the Bartlett—and Paul Pangaro, both former PhD students of Gordon, and other colleagues of that time, including John Frazer.

Now, approaching the 2020s, we have started to take stock of this situation. We have started a process at TU Berlin, through the vehicle of my Chair, to rekindle the links between urban design, architecture and cybernetics; and turn it into something new—driven by the global wave of digitisation with all its consequences and strings attached. After steam, oil and electronics, digitisation is sometimes called the 4th Industrial Revolution. The impact of digitisation on urban design, systems and dynamics is enormous. More indirectly is the legacy of cybernetics in this revolution. Underestimated, even forgotten, is its importance on today's machine-learning, system thinking, brain activities analysis and emulation and management of innovation. We hope to contribute to both, recognizing this legacy as well as pursuing the ongoing significance of cybernetics as a field of research and foundation for applications in urban and other disciplines. Last year's conference *Cybernetics: state of the art* was the first step, this book is the second. One of the things Liss and myself have set out to do with this book series is to address the relevance of cybernetics for current developments in architecture, urban design and planning.

Raoul Bunschoten,
Berlin, 20th August 2017

Pask, G., Foreword in *An Evolutionary Architecture* by John Frazer, London, Architectural Association Press, 1995, p.7.

Preface

"The role of the architect here, I think, is not so much to design a building or city as to catalyse them: to act that they may evolve."

Gordon Pask 1995

INTRODUCTION

Liss C. Werner

Cybernetics: state of the art' is the first volume of the book series 'CON-VERSATIONS'. 'CON-VERSATIONS' is based on and driven by cybernetic principles. It engages with pressing questions for architecture, urban planning, design and infrastructure; in an age of increasing connectivity, AI and robotization; in an evolutionary state of the Anthropocene, perpetuating anxiety as well as excitement and joy of a future, that we will be able to predict with less and less certainty. The editors acknowledge cybernetics as a contemporary, effective and efficient way of dealing with current and future challenges for humankind. We understand cybernetics as the art of interacting, listening, learning and conversing with environmental – internal and external—impulses and perturbations. It allows for comprehending the best part of our world as infrastructure and as system and to leave an object-oriented understanding behind. Although CON-VERSATIONS does not explore in detail the inter-, cross- and trans-disciplinary nature of cybernetics, nor its inter-sectoral and international approach, those characteristics are naturally deeply embedded in cybernetics. This first volume invites the reader to enjoy a glimpse into the past and to imagine a cybernetic future. At this stage the reader may ask the question:

> *What is this 'Cybernetics-Thing'?*
> *Isn't this all digital?*
> *Isn't this all about robots, and the Internet – and not about humans – about Cyberspace and virtual reality. About Cyber-hacking and machines that do what they want because of some smart-ass intelligent computer program?*

The answer to the first question is no, if we differentiate between natural systems and machines, and those that are man-made, and if we claim that a conversation between humans is different in scope, meaning and complexity than a conversation between machines or a human and a machine. The answer to the second question is yes, if we consider all systems as being digital, if we consider all systems as binary working agents, and, if we consider those agents to be connected in a complex fashion—independent of being 'natural' or 'artificial', man or machine. And surely—the answer to the third question—cybernetics includes all systems from natural organic, including humans, to artificial intelligence, immaterial conversations, learning algorithms and of course hybrids of the two or more of the above mentioned. The field has started through information exchange, reaches via design to ethical questions within second-order cybernetics (von Foerster 2003) as well as teleological approaches triggered by e.g., cyber-hacking. I will refrain from venturing a more detailed discussion of the definition of the term machine at this stage, since it would open up topics related to trivial and non-trivial machines, natural machines, man-made machines, the machinic and last but not least the human-machine relationship. For ease of understanding, let's define any organization as a machine that processes something, from energy generation via knowledge transfer to metabolism. Machines can be natural, artificial or hybrid. A natural machine—generally understood as a living organism—for filtering water could be a naturally grown coral reef, a man-made machine —generally understood as a non-living apparatus—for filtering water could be an filtration plant utilizing biomimetic technology. A mushroom colony, for instance, is a natural machine made of an intricate network passing nutrition through its 'veins'; a natural brain is an intricate network, transmitting impulses from which meaning can be constructed; a city functions similarly. So does the natural Internet: our intricately woven web of data-autobahns that spans and merges between intelligent physical and virtual sub-systems equipped with artificial intelligence —or, to paraphrase the previous paragraph, 'with some intelligent computer program'. The fact that the artificially grown coral reef is composed of living organisms that operate like the natural structure on which it is modelled, and that the Internet is defined as a naturally-grown network triggers a debate on what absolute distinction or boundary, if any, can be drawn between the artificial and the natural. Following this line of thought, the question of whether cybernetics only relates to computers becomes obsolete. Human and machine feedback are equally relevant to cybernetics and for the topics covered in CONVERSATIONS. The subject matter becomes rather difficult and ungraspable once not only objects, humans or machines are part of the equation, but also relationships, systems, infrastructure and interaction. The term cybernetics was first coined by Norbert Wiener in 1948 in his treatise *'Cybernetics: Or Control in the Animal and the Machine'* (Wiener 1948). It stems from the Greek word Κυβερνήτης (kubernetes) and means steering, governing, regulating or managing. Cybernetics is concerned with systems. Cybernetics had existed for centuries before being articulated explicitly to the world by Norbert Wiener. In the late 1940s, cybernetics was largely regarded as dealing primarily with information transfer as represented by the Shannon-Weaver model, described in *'A Mathematical Theory of Communication'* (Shannon 1948) and *'Communication Theory of Secrecy Systems'* (Shannon 1949); the latter at that time unknown and classified. The model proposes that information that is transferred from one place to another, is subjected to noise (small perturbations) when traveling from a sender (encipherer) to a receiver (decipherer). Research on control systems of navigation and communication carried out between the World Wars, e.g., by *Bell Telephone Laboratories*, established a first phase of cybernetics – mainly focusing on war-related applications. The Evolutionary Biologist David A. Mindell describes this in his book *'Between Human and Machine: Feedback, Control and Computing before Cybernetics'* (Mindell 2002). The Shannon-Weaver model mentioned above, a model of first order cybernetics did not allow for and did not desire feedback. Models of and for second-order cybernetics developed shortly after were built on feedback. Cybernetics, the art of governing and steering was soon defined by Margaret Mead as

> *"…[T]he set of cross-disciplinary ideas which we first called 'feed-back' and then called 'teleological mechanisms' and then called … 'cybernetics' – a form of cross-disciplinary thought which made it possible for members of many disciplines to communicate with each other easily in a language which all could understand."*
>
> Mead, 1968

Cybernetics is a tool, a strategic weapon, a way to understand the world as a constantly changing network constructed of communicating objects designing ways and instruments of communication and information delivery and exchange – living, non-living, organic, non-organic, artificial and natural. It is not a model for linearity and feed forward. Cybernetics is a mindset orchestrated by feedback.

Volume 1

'Cybernetics: state of the art' was conceived as an anthology of chapters following a conference with the same title. The event was held at the Institute of Architecture at Technical University Berlin between 09th and 10th June 2016 and extended into a complimenting exhibition during the 'Long Night of Sciences' a day later. The exhibition was shown in the Forum of the Institute of Architecture. It orchestrated a journey from first writings on cybernetics, architecture and urban design via project work investigating data driven design processes, interactive/reactive architectural structures, and provided an insight into the Brainbox, a design negotiation and planning tool renamed to 'CCL—Conscious City Lab' in 2016. The idea of the event was, to (re)start and continue the conversation about cybernetics as an active and living mindset. We intended, curated and achieved a conference to review and preview cybernetics as design strategy in computational architecture, urban design and socio-ecological habitats—natural and artificial—if there can be registered a difference at all. The book is largely influenced by the great cybernetician Andrew Gordon Speedie Pask, who developed Conversation Theory, comprising influential concepts of Second-order cybernetics relevant to architecture and design. In 1969, Pask introduced cybernetics as

> *"[...] a discipline which fills the bill insofar as the abstract concepts of cybernetics can be interpreted in architectural terms (and where appropriate, identified with real architectural systems), to form a theory (architectural cybernetics, the cybernetic theory of architecture)."*
>
> Pask, 1969

Born in 1928 in Derby, UK, Pask studied engineering and was awarded a PhD in Psychology from University College London, UCL in 1964. He joined the Architectural Association in London where he taught until 1996, partly with Raoul Bunschoten, partly with John and Julia Frazer. He acted as cybernetic consultant for the *Fun Palace* designed by Cedric Price, commissioned by Joan Littlewood in 1964, and exhibited his cybernetic machine *A Colloquy of Mobiles* at the exhibition *Cybernetic Serendipity* in 1968, curated by Jasia Reichardt. In this volume, we discuss cybernetic principles and devices developed in the late 20th century, to learn from for the current state of the art. The book juxtaposes cybernetic-architectural theories with applications and case studies. We were rather modest and did not engage biological computers or humanoid deep learning systems that might disrupt current human existence and condition eventually. I also refrained from discussing the 'hacked body or the extended phenotype' as introduced in my lecture at the Digital Bauhaus in 2015, which—inspired by Ríchard Dawkins' book 'The extended Phenotype' (Dawkins 1980)—suggests a novel, alien iteration of the mechanically intelligized human being living mutually with the biologically humanized machine. Instead I intended a humble juxtaposition of selected historical events and current streams of cybernetic applications ranging from cybernetic machines via participative design processes to policy-making. The first include Stafford Beer's Cybersyn (1971-1973) (see Espejo ch. 2), Ross Ashby's notion of 'Design for a Brain', (Ashby 1954) and the legendary legacy of Gordon Pask, the latter including cybernetic approaches to urban design in China and design strategies for land-use in the US. All chapters in this book tackle the underlying question of whether there is a difference between hardware and software, between human communication and machinic communication. Thus, the chapter also invites to a philosophical approach towards the definition of matter in an era that embraces the bit-based virtual as well as the atom-based material and encourages a multiple, almost avataresque, existence in a multitude of time-zones and geographical locations.

Contributions and chapter structure

The book comprises nine contributions written by an international group of authors from four academic generations: (in alphabetic order) Raoul Bunschoten, Raul Espejo, Delfina Fantini van Ditmar, Michael Hohl, Tim Jachna, Arun Jain, Kristian Kloeckl, Paul Pangaro and Liss C. Werner; with a foreword by Omar Khan. In order to follow our plan to 'review and preview cybernetics' we decided to structure the book into two complimenting parts. Part one 'A Concept and a Shape' focuses on the history and theory of cybernetics, its disappearance and future impact. It comprises chapters 1-4. Part two 'System 5' focuses on applications—with people, the individual and human feedback in mind. It comprises chapters 5-9. All chapters embrace the relevance of uncertainty, unmanageability and surprise as drivers for a governing improvisation; an unplanned and highly appreciated phenomenon. Kristian Kloeckl (ch. 8) specifically engages with the interdependency and synergy of improvisation and public life in cities. Our aim is to steer towards an interdependency-considering systemic design approach with the goal to develop resilient, sustainable, iterative and happy projects. The reader may decide to read the book back-to-back, which certainly is beneficial for a complete understanding. Chapters, however, do not build up upon each other, and can be read independently. The title for part one

'A Concept *and a Shape'* derives from Gordon Pask's paper *'The Conception of a Shape and the Evolution of a Design'* (Pask 1963). In the entry paragraph, he states:

> *"In this paper we consider a Cybernetic view of the designing process. To restrict the field we shall discuss only those systems which can (in principle) be physically realized. Thus, although we are chiefly concerned with design as it occurs in man, most of our arguments apply also to mechanisms that design."*
>
> Pask, 1963

Pask describes the concept of Musicolour, his interactive music-color-machine as an example for "a Cybernetic view of the designing process". In Musicolour, communication between a 'light organ', musicians, an amplifier and sensors created a communication system, which equally was an ongoing design process of a conversation between musicians and a light-organ. The system was driven by the reaction of the musicians and in return the reactions of the machine. Pask introduces the notion of 'perception'. The design principles Pask presents in 'The Conception of a Shape and the Evolution of a Design' are exemplary for the chapters in part one. The title for part two 'System 5' finds its origin in the Viable System Model developed by Stafford Beer in 1979. The VSM is a model of an organization in which five distinct subsystems, with distinct functions, are coherently sitting next to each other. By feeding back to each other, the subsystems together keep the whole system alive, running and sustainable. The model was initially designed for managing and regulating markets and partly applied in the project Cybersyn in Chile 1971-1973 (see ch. 2, Espejo). System 5 in Beer's VSM is responsible for policy decision making within the organization. Its function is to regulate and steer the system. According to Stafford Beer, system 5 is 'the people'. We have chosen 'System 5' as the title for part two, since all chapters engage with the people, the human, as governor for the system as a whole. Part two encourages further thoughts and projects towards human-centered computer-aided design, a strand on which we are planning to focus in future volumes. In the remaining paragraphs, I will briefly summarize the individual chapters:

1. In the first chapter, **Paul Pangaro** introduces the subject matter of the book with his chapter *'Cybernetics as Pheonix: Why Ashes, What new life?'*. **The**

chapter reflects on questions and answers why cybernetics dissipated in the 1980s. One of the reasons, Pangaro states, is that (second-order) cybernetics is anti-objective, an attribute not embraced by the traditional sciences. Pangaro leads us through a journey that allows glimpses into some of the key-projects / -developments / -events of cybernetics in the last half of the 20th century, including Heinz von Foerster's BCL (Biological Computer Laboratory), Marvin Minsky's development of the perceptron at MIT and Rittel and Webbers notion of 'wicked problems'. Pangaro leads us further into the year 2017 to discussing cybernetics in the context of design. The chapter concludes with an edited transcript of a conversation between Paul Pangaro, Kristian Kloeckl, Omar Khan and myself, recorded on June 9th 2016 during the conference 'Cybernetics: state of the art'.

2. **Raúl Espejo** provides the reader with a colorful and critical (re)view of the project Cybersyn (1970-1973) in Chile by combining historic and personal with an insight into the system behind Cybersyn. In his contribution *'Cybernetic Argument for Democratic Governance: Cybersyn and Cyberfolk'* he highlights Cybersyn's conceptual strengths and vision: Beer's Viable System Model. **At the core of Espejo's chapter stands a model that has the desire to enable democracy on all levels of organizations of different kinds. He emphasizes on the strength of a Matrioshka-like formal organization, in which numerous subsystems are sitting within higher-level systems.** Graphic illustrations describe the VSM's seemingly autonomous units coalescing in cohesion of their individual functions. Information transfer and feedback were the drivers for a self-organizing resilient system, conceived and born out of a Utopian vision. Espejo further introduces Cyberfolk, a mechanism, a tool, a method for the people (on Chile) to communicate with politicians and policy-makers. The idea, which reminds at today's 'openly spoken word' using social media channels, was to enable real time responses of the people by activating Cyberfolk's algedonic loop, stating satisfaction or dissatisfaction. In the context of this publication, Raul Espejo's chapter acts as an incubator from the past for a cybernetic future.

3. '*Cybernetification I: Cybernetics Feedback Netgraft in Architecture'* by **Liss C. Werner** suggests that the possibilities for design increase through digitization and digitalization given, that cybernetic principles are taken into account.

Werner's theory of cybernetification presents an extended ecology where nature and technology seem interchangeable and not differentiable. **She argues that the act of netgrafting—a networked ‚graftsmanship', a collaboration between humans and algorithms enabled by the infrastructure of the Internet—enjoys similar underlying rules of feedback that colonies in open systems found in nature are governed by, which eventually lead to physical unforeseen forms of the environment.** Werner further suggests that emergence is inherently to the process of design once opened up to an unknown but akin group of connected agents and devices. Werner underpins her argument through foundations in the theory of feedback (Ludwig von Bertalanffy), systems theory and cybernetics—by the cyberneticians Ross Ashby, Norbert Wiener and Gordon Pask—and ecology (Simondon). The author draws the relationship to evolutionary algorithms and computational architecture between the first digital turn to now. Her chapter is accompanied by the underlying debate about how digitally driven design strategies **"eventually can govern and feed back into practice and the art of architecture"**.

4. **Michael Hohl**'s chapter *'Designing designing: Ecology, System Thinking, Designing and Second-Order Cybernetics'* continues the design theoretical approach given by Liss C. Werner (ch. 3). The author is concerned with the issue of learning through applying a Second-order cybernetics approach as seen in nature. **Hohl supports his argument of learning from living systems by linking "systems thinking, Second-order cybernetics and designing with a dimension of ethics and values"**; he examines Linda Booth-Sweeney's 12 habits of mind of a system thinker. He starts with a quote by Terry Irwin, Head of the School of Design at Carnegie Mellon University, in which she asks the question:
"Are we failing to take into consideration the inter-connectedness and interdependencies that are present everywhere?"
Looking through the lens of second-order cybernetics Hohl leads the reader through a journey of biomimicry, second-order cybernetics, Horst Rittel's notion of Wicked Problems—as they occur constantly in every design context – and Terry Irvin's '10 living systems principles'; by doing so he constructs an ecology of possibilities for cybernetic learning, whereby the learning process is a design process. At this stage Hohl refers to Ranulph Glanvilles influential statement "[C]ybernetics is the theory of design and design is the action of

cybernetics." (Glanville, 2007). Michael Hohl's contribution concludes part one of and hence the theoretical framing of the subject matter. Part two of the book focuses on applied cybernetics beginning with the chapter 'The Second Skin – from Cybernetics to Conscious City' by Raoul Bunschoten that bridges the underlying and guiding principles, discussed in part one and part two.

5. In chapter five, *'The Second Skin – from Cybernetics to Conscious City'*, **Raoul Bunschoten** imagines that the intelligence of urban systems, emerging through a smart network fed by a mix of data, **"in an ideal case scenario enables humans to increase their health, comfort and wealth as well as design plans and processes for an efficient use of natural resources."** The second skin acts as an extension to the first skin of the earth, namely the natural crust. Bunschoten grounds his vision of an increase of living quality on the strong believe in intelligent and 'conscious' communication between objects and processes in an urban environment; he finds the foundations for communication and conversation between devices in cybernetics. Bunschoten suggests that Industry 4.0—the use of networked design processes and digital manufacturing processes in combination with automated construction—"can improve the living conditions of billions of people". His projection is strong in its intentions – quantitative proves of concept and scientific references from collegial Smart City labs, such as the ETH's Future Cities Lab in Singapore or MIT's Department of Urban Studies and Planning are still to come. Raoul Bunschoten introduces the digital negotiation tools 'Urban Gallery' and 'Conscious City Lab'; the latter developed as Brainbox by Holger Prang, Arne Siebenmorgen, Dietmar Köring and others at TU Berlin—fostering participative and democratic urban planning.

6. *'Managing (with) the Unmanageable City'* by **Tim Jachna** tackles a number of real-world issues in urban design and planning, through a case study on the Pearl River Delta (PRD) in China, which he and his students examined in a workshop. He guides the reader towards the core subject of his chapter by setting a conceptual background based on understandings of risk and resilience. Jachna introduces the notion of "unmanageable" systems written about by Ranulph Glanville in 2000 in order to then engage with key steps in the development of 'Cybernetics and the City", including Forrester and Brown's cybernetic descriptions of urban dynamics in 1969, Reyner Bahnham's Four Ecologies' of Los Angeles in 1971, 'S, M, L, XL' by Koolhaas & Mau in 1997, and Mostafavi

& Doherty's 2010 understanding of "cities as complex heterogeneous systems, that are in constant interaction with natural ecosystems". **Tim Jachna constructs a picture of the challenges global societies face to (re)create urban ecologies / ecological urbanism in the Anthropocene era. He suggests a "shift in the way of thinking about the built environment, shifting away from a focus on monuments and objects, towards a focus on environments, 'performativity' and social construction."**

7. Moving deeper into large-scale regional planning **Arun Jain**'s chapter *'Uncertainty, Complexity & Urgency: Applied Urban Design'* focuses on cybernetic thinking and acting as valuable and necessary approach towards successful urban and regional planning. **Jain begins is chapter by defining urban design as "the process of defining and shaping urban settlements", and introduces relevant points in the history and understanding of cybernetics**: a) the extension or even the shift of computer-based and AI-related cybernetics to social-systems-based cybernetics in the 1970s, and b) the complexity of 'wicked' problems for urban planning, as defined by Rittel and Webber, also in the 1970s. Arun examines the subject *Cybernetics: state of the art* through the lens of a practitioner, an urban strategist and consultant. In his chapter, he introduces the Development Management Assessment Tool (DMAT), a support tool for planning and urban development, through the case study of Montgomery County in Maryland, USA. Aim of the GIS-based DMAT is to progressively subtract the regulated lands, e.g., erodible soils, parks, agricultural reserves or forest conservation easements, to show the remaining percentage of unconstructed land. Jain concludes with a forecast into the future, where "we will continue to struggle reconciling divisive individual and collective human impulses with our need for objects and logic driven decision platforms that are easy to comprehend.". He suggests that a combination of the two disciplines, urban planning and cybernetics, may be beneficial for better and sustainable decision- and policy-making.

8. **Kristian Kloeckl**'s chapter *'Open Works for the Urban Improvise'* examines the nature of responsiveness enabled by today's networks of connected technologies in urban environments and proposes an improvisation-based design model for work in this field. Technology supported interactions in today's hybrid cities involve sophisticated techniques of sensing, processing

and actuation. They are characterized by real time feedback loops that allow for deliberate and distinct responses to unique situations that go beyond a simple action-reaction coupling. Kloeckl notes a resemblance between this dynamic and that of improvisational interactions in the performing arts. Drawing from theoretical frameworks and practice-based methods of improvisation he adopts a system perspective of improvisation as proposed by Landgraf. **The chapter discusses improvisation as a process characterized by a simultaneity of conception and action, where iterative and recursive operations lead to the emergence of dynamic structures that continue to feed into the action itself.** By identifying the interactions in and with urban responsive environments and the art of improvisation as fundamentally related topics of investigation, Kloeckl identifies four underlying positions that point toward a foundational model for urban interaction design and that can provide a framework by which interactive urban systems might be more systematically understood. Through a critical analysis of Umberto Eco's seminal text "Opera Aperta" Kloeckl examines more in-depth the first of these four positions – Design for initiative ensures openness – and illustrates its relevance in relation to a number of contemporary projects of urban interaction design.

9. Based in the context of the growing market of the smart home the finishing chapter of the boo*k 'Deconstructing the Smart Home' by* **Delfina Fantini van Ditmar** leads us back into the human scale of the people and their 'intimate' environment. The author raises a critical systemic approach to 'smartness'; the smart home's users' 'upgraded life' merely envisioned under principles such as productivity, security, efficiency, optimization, convenience and automation. **Fantini argues that it is impossible to grasp human complexity through numbers and insists that humans must not be envisioned as linearly efficient consumers.** Instead she characterizes this quantified approach inherent in current notions of 'smart' technology, as the Algorithmic Paradigm. By providing a historical account, Fantini traces back the origins of technological 'smartness' to AI, a deterministic foundational epistemology very much revived these days in Silicon Valley.

Fantini's chapter indicates that applying second-order cybernetics provides opportunities to rethink the 'smart' home. The author suggests that by a systemic understanding embracing the impact of context and experience, a second-order cybernetics epistemology leads to the acknowledgement of the limitations of smart devices. With this in mind Fantini offers awareness of how ‘smart’ technologies are not free from bias indicating systemic and socio-political implications that goes beyond the technical domain of efficiency. She underpins her argument with a wide spectrum of related areas, which goes from architecture via current technological socio-political authors to second-order cybernetics and design.

Final note

The nine chapters headed by a foreword by Omar Kahn are aiming at actively rediscovering, brisking up and using cybernetics in a variety of contexts. The reader may want to research further by referring to the references given in the individual chapters. This book acts as a trigger for starting to re-learn cybernetics.

Liss C. Werner,
Berlin, 31th August 2017

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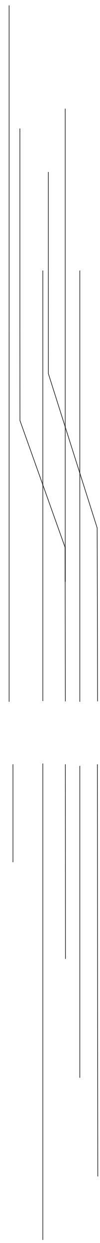

PART 1

A CONCEPT AND A SHAPE

Cybernetics as Phoenix: Why Ashes, What New Life?

Paul Pangaro

Cybernetics: Where have you been and where are you headed? Born in the 1940s and seeming dead from the 1960s, can you be a phoenix rising? Today, cybernetics seems to pop up more often than any time since its inception—at least in its most misunderstood form as a melding of biology and technology to make a robot or 'cyborg'. But even in its proper sense, as the science of effective action, cybernetics is undergoing a resurgence of interest even while its core values—the roles of variety and language in effective action—are still not widely applied. Here I will argue that cybernetics offers values and skills critical to the practice of design in a world of unpredictable, unknowable complexity. While its first-order systemics gives foundation to understanding emergence and unintended consequences, second-order cybernetics offers an ethical, clear-eyed argument for transparent, value-driven design processes. Can cybernetics be a core teaching for schools and design practitioners, such that ethics and responsibility may overtake the hegemony of AI and computing, governments and ideologies? What else is necessary even to begin to approach this naively optimistic and yet potentially world-changing vision?

Keywords: cybernetics, second-order cybernetics, design, design education, complexity, transdisciplinarity, antidisciplinarity

Phoenix

A world-famous media lab is arguing that cybernetics is central to the participation of science as a member of the toolset required to tame the wicked problems of the world.

The phoenix is a mythical creature said to rise to new life out of its own ashes. The discipline of cybernetics emerged in the 1940s to influence generations and then burn out, its original intentions blurred by confusion with artificial intelligence and android robots. Never quite dead nor 'alive and well' neither, the meme of cybernetics, certainly at its beginnings, infused feedback and systemics into the popular imagination as well as the scholarly zeitgeist of countless fields. While there are many favored definitions[1], here we will call it the science of effective action and 'the science of effective organization' (Beer 1985). Also from its start it has been applying its principles to itself, emerging most recently as a rigorous way to view conversation, problem framing, and language-creation (Dubberly & Pangaro 2017). Today, cybernetics is being credited as foundational for interaction design (Dubberly & Pangaro 2015), design methods (Dubberly & Pangaro 2017), adaptive architecture (Pask 1969; Haque 2007; Sher, Chronis, and Glynn 2013; Beesley 2010), and antidisciplinarity (Pickering 2013). A world-famous media lab is arguing that cybernetics is central to the participation of science as a member of the toolset required to tame the wicked[2] problems of the world (Ito 2016).

Why Ashes

By way of preamble, it's important to spend a minute to theorize why cybernetics dissipated, in two senses.

Cybernetics infused many other fields with its fabulous ideas, such as information about consequences of action becoming feedback to a system as it acts to achieve its goals.[3] Foundational among the fabulous ideas of cybernetics is that systems can be construed to have their own purpose (Pask 1962) and can be studied from the frame of information rather than functional organization—or, according to Ashby—'the immaterial' rather than the material (Ashby 1956). This gave primacy to purpose, for which cybernetics stands out from other systems approaches.[4] Surely the power of that insight helped to propel it into the cultural consciousness of academia across disciplines.[5]

Foundational among the fabulous ideas of cybernetics is that systems can be construed to have their own purpose.

But why did it dissipate, in the sense of diffuse and lose its identity while strongly influencing other realms. For one thing, beyond that ability to capture the imagination of the time, there was no machinery of cybernetics that would demonstrate its power and its practicality. Its dark twin, artificial intelligence, was far more fortunate. AI would come not just to dominate but to nearly eradicate cybernetics in part, if not largely, because it had immensely powerful machinery to demonstrate the apparent practicality of its ideas: the digital computer.[6] No one cared (indeed, few seemed to notice) that AI's claims were consistently implausible and over-blown; because who could disagree with the promises of a 'smaller, cheaper, faster' future. Given only better hardware that was obviously coming every

AI would come not just to dominate but to nearly eradicate cybernetics in part, if not largely, because it had immensely powerful machinery to demonstrate the apparent practicality of its ideas.

day, surely this path would inexorably give us 'smart machines.' (Not.) Perhaps in part it's because the concept of purposive systems didn't have a home in an existing discipline. At MIT there was no department where the great Norbert Wiener could live happily[7], except perhaps that of mathematics, his primary field, which was not the same as cybernetics—they are as different as a scientific law is from a story. Each of the disciplines that have been seriously influenced by cybernetics, perhaps anthropology as an example of a soft science, or a hard science such as biology, or an applied discipline such as engineering—none of these departments could contain a novel concept that was yet broader than any of them.

Indeed, the term now coming up is 'antidisciplinarity', coined by Andrew Pickering (2013). The term may sound like it's against being put into any discipline's silo, and also against being put into a single frame or vocabulary. It's brash enough to also be fighting the paradigm[8] which holds that silos are the only way to go.

From its inception until now, embrace of the discipline of cybernetics itself has not broadly occurred, though some off-shoots and tools did arise from it (first-order feedback, of course, and to much less extent, the rigorous concept of 'variety' from Ashby 1956).[9] Surely we can uncover some valid reasons for this. First, there are some disconcerting things about cybernetics. It zooms out rather than zooms in, and it's hard for most human beings to zoom out and maintain confidence in the face of uncertainty and a great increase in complexity. Whereas if you zoom in and you split the world into smaller and smaller pieces, as Heinz von Foerster would point out, you are then well-able to say more and more about less and less. And this can be very satisfying, at least for scientists, our custodians of 'science'—a term that comes from 'schism', splitting the world into smaller and smaller pieces (von Foerster 2014). This is one way of looking at what the hard sciences, such as physics, do.

And this can be very satisfying, at least for scientists, custodians of 'science', from 'schism', from splitting the world into smaller and smaller pieces.

Science is a process designed to increase confidence, after all. Why would we expect it to help with 'wicked problems' in the strict sense of Rittel and Webber 1973, where uncertainties abound. For example, what are the actions that might be taken (a full set of solutions cannot be enumerated) or when might we stop (impossible to know since the problem can never be fully eradicated).[10] Statements of what is possibly wrong and how a situation may be improved—so-called 'problem statements'—are subject to beliefs and values, and therefore framing and argumentation, rather than objective and easily agreed-upon facts (Rittel & Weber 1973). In wicked situations, the process of framing problems-to-solve will not look like a process of reaching a desired state from a current state. Such a pure cybernetic framing of convergence to goals is appropriate only once the goals are agreed. Instead, we need a way to track the process of formulating problems-to-solve based on the invention of new language, which may then be found to be viable by the range of variety it manages to span (Dubberly, Esmonde, Geoghegan & Pangaro 2002).

Another reason why I believe cybernetics dissipated: it's not only anti-disciplinary, it is anti-objectivity.

Another reason why I believe cybernetics dissipated: it's not only anti-disciplinary, it is anti-objectivity.[11] Cybernetics, particularly in its 'second-order' form, denies the right to objectivity that scientists sometimes claim—erroneously, of course. The Heisenberg Uncertainty Principle makes clear that the very question asked—the framing of the situation—has irrevocable implications for any answers that follow. Observation invites a framing of the situation, hopefully one from which the system being observed can be 'best' seen, where 'best' is some yardstick based on coherence for explaining the observations; based on measures of variety; and, ultimately, based on the viability of possible actions that stem from the chosen frame.

By the way, the frame of 'framing' says that science is not about objectivity. It's a frame based on a process by which its self-defined advances are made, where the process is called 'the scientific method.' Cybernetics dethrones science as the custodian of truth and objectivity, so it removes the claim to power made by conventional scientists (consciously or not). Certainly, when I was at MIT as an undergraduate from 1969 through 1974, it was clear to me in conversations with faculty as well as students that they wanted to be right and know the truth and know the world. Anything other than that would castrate them. Another reason for the dissipation of cybernetics, as described in the biography of Norbert Wiener called 'Dark Hero of the Information Age', is that Wiener contradicted the political directions of the US after World War II by refusing to do any further war work (Conway & Siegelman 2009). This made him immediately suspicious as untrustworthy, perhaps a security risk. He also had mental health issues which further eroded trust in him, and therefore by association, cybernetics.

At least in one important instance—one that I and others heard from the lips of Heinz von Foerster more than once—a single refusal was a proximate contributor to dissipation. For some time von Foerster's Biological Computer Lab at the University of Illinois in Urbana-Champagne was funded from the US government. For years Heinz would go to Washington DC and discuss his next round of funding and then receive it at his lab directly from the government. In this way, he would maintain the extraordinary run of his BCL of some 20 years or so (Umpleby 2003). Yet as Heinz tells the story, one year he went to Washington as usual and was told that he was not going to get the money directly; instead, he would have to approach an individual through whom they were centralizing distribution. So, as he was instructed, Heinz went to Cambridge to MIT and requested funding from Marvin Minsky, the man now in charge of dolling out the money for AI and related research. And Marvin just said, 'No.'[12]

But perhaps in the end, the overarching reason for cybernetics dissipating and losing to AI was this: cybernetics did not have central problems that were clearly articulated, that many researchers could work on, and—most crucially of all—for which they could get paid. AI had the success of digital computing and therefore computer science departments as career paths, but cybernetics had none of it. (Cariani 2017). This is all part of our history, one way or another.

Now the legacy of cybernetics at MIT becomes fascinating.

What New Life?

Now the legacy of cybernetics at MIT becomes fascinating. The head of the MIT Media Lab, Joi Ito, published an initial volley for the resurgence of cybernetics in a journal called "Design + Science" (Ito 2016). I recommend to read it, partly because it's a curiosity.[13] Ito wants to reclaim antidisciplinarity as key to the future of science in combination with design, which all together become a means to solve the world's wicked problems. Here he is speaking about the pubpub.org online publishing platform:

> *"I believe that by bringing together design and science we can produce a rigorous but flexible approach that will allow us to explore, understand and contribute to science in an antidisciplinary way… Our thinking is to create a vehicle for the exchange of ideas that allows all those working in the antidisciplinary space between and beyond the disciplines to come together in unexpected and exciting ways to challenge existing academic silos. Our aim is to create a new space that encourages everyone, not just academics, to come together to create a new platform for the 21st century: a new place, a new way of thinking, a new way of doing."*
>
> Ito 2016

Rather than for publishing, I prefer to read him as speaking of 'space' in form of rich conversations he might host at the MIT Media Lab, erminiscent of the Macy Meetings from the 1940s and 1950s.

I know Ito slightly, from three separate conversations across several months. In the first, I was expecting to talk about his interest in the revitalization of Detroit—he is from nearby and I'm currently chairing an MFA program in Interaction Design at the College for Creative Studies near downtown Detroit. In an email prior to the meeting he said he was interested in talking about cybernetics because he was trying to apply design to science and felt that 'second-order cybernetics X design X some modern version of the Bauhaus' is what is needed 'to fix science' (Ito 2016b). I thought I was hallucinating when I saw this and I had to read it five times. When we met, instead of talking about Detroit he asked probing questions about the history and viability of cybernetics as an exemplar of antidisciplinarity. He specifically asked whether the MIT Media Lab should take up the banner of cybernetics.[14]

I thought I was hallucinating when I saw this, and I had to reread it five times.

A few months later he texted me about his piece in Design + Science before publishing it, seeking feedback. We had a 90-minute conversation about a few factual things, such as dates, which weren't hard to fix. But there were other things I voiced concerns about, that were not much changed when published, which I accept may have been a conscious desire to simplify.[15] He used the field of cybernetics as a primary example of antidisciplinarity, which in his terms is the breaking down of the silos of existing disciplines.[16] He speaks of cybernetics as having the power to aid action in the context of deep complexity, even unknowability—recognizing that is the world we live in today. How do we tame systems—*can* we tame systems, particularly those that overlap wicked problems. Surely something of the depth and power of a system science like cybernetics could help us in a world where we can't simply *know*, that is, we cannot have enough reliable information to act with high certainty. We don't know all the interactions. We don't know how conditions will change. And we don't know the unintended consequences.

So is cybernetics a science? Certainly it's a discipline—where the prime attention is on actions taken to perform well, actions to achieve goals, as opposed actions of a science to acquire knowledge.

Can cybernetics help here?
Could it, were it a science?
(Or, to Ito's point, help more so if it is not?)

Certainly it's a discipline—where the prime attention is on actions taken to perform well, actions to achieve goals, as opposed to actions of a science to acquire knowledge. This is the distinction Pickering makes when he calls cybernetics a 'performative ontology' (Pickering 2013). I'm not saying science is bad, but it's different than a discipline whose focus is to act well in the world, rather than to gather knowledge about the world. So, Ito would claim (Ito 2016)—and I and many others would also—that science doesn't really cut it, which we know because of the many wicked, unresolved situations at play across the globe—pollution, climate, energy, water, famine, social and economic disparity, and so on. If science is so great, why do these problems persist—doesn't it say something about the limitations of science? In this context, efforts with colleagues have been to understand if can we counter the serious challenges of wicked situations in the world by using cybernetics as a tool. This brings me to a syllogism about the necessity of cybernetics in the context of design (Dubberly & Pangaro 2016):

a **If design, then systems**—by which we mean, if you're doing design, and you're doing design in the complexity of the world as it exists today, including wicked problems, then you must incorporate a systems view. I think this is neither contested nor even controversial. Surely digital technology, web and Internet of Things, and the fact that design in general has shifted from giving form to creating systems to support effective human interaction—for all these reasons, designers need to have literacy around systems, because we need to be able to 'read' (understand) and 'write' (design / edit / modify) complex systems (Dubberly 2014).

b **If systems, then cybernetics**—because the interactions and complexity of systems involve humans, we must incorporate goals, feedback, and information, because we are driven by these things. And these are what cybernetics is all about.

c **If cybernetics, then second-order cybernetics**—because wicked problems are not about finding the solution or expressing the truth of an objective world, they are about establishing effective language for arguing for a framing a worldview that enables effective action. Because of the subjective nature of this framing, we must be responsible for our actions in terms of our values and viewpoints. This, in turn, requires that we are transparent about those values and viewpoints. This is where second-order cybernetics comes in. It's about knowing that when we 'see', we do so from the frame of our language and beliefs and values. Rather than a stance of objectivity, our stance comes from interacting with the world and creating meaning, that is, 'making sense of a world.' This is pure second-order cybernetics.

d **If second-order cybernetics, then conversation**—because design is grounded in argumentation, and therefore requires conversation, so that participants may understand, agree, and collaborate, all toward effective action. Not so that we can say, 'Wow, we know what's going on!' but rather so that we might say, 'Wow, we're getting somewhere, we're improving things!' We are seeing more and acting better.

These are my comments, which I hope are useful as foundation for a brief conversation between Kristian Kloeckl, Liss C. Werner, Omar Kahn, and me:

Kloeckl: Thank you, Paul, for this comprehensive overview. You began with a view of the origins and early history of cybernetics. What has changed since then? Why does it make sense to talk about cybernetics today and how do you suggest we move forward from here?

Pangaro: In terms of what's changed since the start of cybernetics, there has been a huge shift, in that a system's view of the world is no longer new or shocking. The world is more full of systems thinkers and disciplines that are systems-oriented. I think the vast problems on a rampage in the world are showing that, as Joi Ito says, essentially, science isn't cutting it (my crude paraphrase), so that we need something else. His idea that a solution may lie in second-order cybernetics + design is a very viable and brilliant proposal.[17] I think the world is better prepared, and we as a systems community are better prepared, and as so many in the world see things are not working, there is a better opening than ever before for second-order cybernetics—which still requires at least one and probably two moves from mere systems. But this mind-shift toward systems and antidisciplinarity of the last few generations has been a transformation. No longer are individuals so tied up in their individual disciplines from which they derived power and satisfaction and a sense of progress, at least within the narrow confines of carving up smaller and smaller parts of the world about which they can say more and more.

This mind-shift toward systems and antidisciplinarity of the last few generations has been a transformation.

So I think it's a new time and we have to be hopeful that the world is better prepared for a systems view and second-order conversations. What is that cliché—when the student is ready, the teacher will come? The world—including perhaps the scientists, formerly in the business of carving up the universe into smaller parts—is / are students of systems much more now than ever before. There has been a transformation from an old guard tied up in the silo-ed disciplines, and fiercely committed to those. The individuals from the Macy Meetings were part of a generation where dividing up the world made sense for the times—even while Macy attendees saw far beyond that. But in the decades since, we've more than embraced inter-disciplinarity, cross-discipline conversations, and even have a hierarchy for it: meta-disciplinary, inter-disciplinary, and trans-disciplinary.[18] I believe strongly that we must operate at the trans-disciplinary level. I hope that the world is better prepared not just for a systems view, but for a cybernetic view, and not just a cybernetic view but a second-order cybernetic view, and ultimately for a conversation age (Pangaro 2011). Our world is one in which we grow up and access our worlds [sic] on the phone, and have access to data at least, and we move that into information in our interpretations and our worldview and our needs and goals. Every individual in this vast, intractable flux of complexity needs both rational tools, namely systems science, as well as emotional tools, namely learning to be more comfortable in embracing uncertainty and unknowability as foundational to existence.

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Here is another answer to why it makes sense to continue with cybernetics: I've seen this transition to systems thinking in the students of the last 18 or so years, in my efforts to teach successive student cohorts the same concepts of cybernetics for design—namely, first-order loops, requisite variety, second-order loops, conversation, and biocost (Dubberly & Pangaro 2007). Over that timespan I've seen a more immediate intuitive uptake for the systemic views in these models. Students today are more natural systems thinkers, they're much more able to start with a diagram of something rather than just a verbal explanation. What we should expect from an iterative approach is greater traction with the models of second-order and conversational systems. If these fail, we need to assess what variety is missing from the design conversation, and change the design of that conversation.

Students today are more natural systems thinkers, they're much more able to start with a diagram of something rather than just a verbal explanation.

Beyond these, I don't have a way of saying what we should now all go out and do, what the action should be. But a conversation about the meta-process would be something I could join. What was close by in the conversations with Joi Ito, but I don't know that I made quite clear enough, is the idea of variety from Ashby, and that we have to have the right people in the conversation, and we can create a cadence of conversations over time such that the unfolding conversations encompass the necessary (requisite) variety and the scope of potential action is more powerful (Pangaro 2006). I know at least that we must design conversations for the variety that we learn along the way is what we need to make progress. Convening a space in which we can ask each other about situations and therein find meaningful questions, a focusing question. Paying attention to the conversations needed for design is a work of collaboration for some years with Hugh Dubberly (Dubberly & Pangaro 2009 and 2016). Designers need to create conditions under which we can define the difficult focusing questions. Focusing questions should be narrow enough to make progress and yet powerful enough to be useful—to apply to the larger problem space—if we crack it. For example, with climate change: Can we produce an artificial photosynthesis that eats the CO^2 in the atmosphere and produces oxygen as a result? This casts CO^2 as a surplus, as a wealth-creation opportunity—which is simply a matter of reframing. Who should be in the conversation? This is analogous to conversations to build the first atomic bomb in the Manhattan Project, when they knew from a theory that they could unleash vast amounts of power by converting matter to energy. From that starting frame, it was a matter of 'increasing the variety in the room', and iterating conceptually and ultimately experimentally, until something practical could be made. (This is an horrific example, however.) So, convening those conversations, and having the meta-process idea in mind—designing the conversations toward requisite variety for solving a focusing problem—is as far as I can get to an answer.

I know at least that we must design the conversation for the variety that we need in order to make progress.

Kloeckl: You point to the concept of variety and you mention the smart phone. I want to consider these two together: having easy access to time and location specific data and information on one hand and your pointing to variety in it on the other. Not too long ago an article in the New York Times pointed out how the increasingly detailed and timely information available about neighborhood demographics – age, language, education, ethnicity, income, etc.

–appears to contribute at a new level to a dynamic where people purchase homes close to people that are like themselves. It is somewhat a Yelp-syndrome if you will, a very effective system that helps you find likeminded places and people. We often think of the access to information as a contribution to discover novelty and to increase variety. But here we see a trend towards sameness rather than variety based on the way the system is set up.

It is somewhat a Yelp-syndrome if you will, a very effective system that helps you find likeminded places and people.

Pangaro: Well, all we need is Gordon Pask, because so many of the machines he built were about increasing the variety in a conversation in a way that stayed connected to the context of the participants (Haque 2007). He understood that effective conversation was an exchange that increased novelty, within limits, and thereby stimulated continued engagement in the conversation. These interactions were about understanding where an individual was specifically starting from, not from 'big data' or machine-learning (a.k.a. statistical averaging, a.k.a. smudging). Rather his whole approach was to start from this individual, right now: Where I am. From understanding that, you know that information taking me in one particular direction is redundant and repetitive and boring, and information at some opposite extreme is far too new and will be cognitively disconnected and possibly disconcerting if it too much contradicts what I already know and believe—if I can even comprehend it. So Pask's conversational machines hunted for a place in the middle which is novel enough to engage me but not so novel as to repel me. And, as he famously said, human beings are prone to seek novelty and having found it, to try to control it (Pask 1970). As a consequence of our evolution, we seek novelty and we want to engage with things that are somehow new. Of course, the 'filter bubble' may be at play[19,] which we can contravene by bringing these Paskian mechanisms into our designs. These services could seek to increase measures of engagement that track novelty, rather than raw numbers of 'eyeballs' or impressions, which lack indicator of value.

Well, all we need is Gordon Pask, because so many of the machines he built were about increasing the variety in a conversation in a way that stayed connected to the context of the participants (Haque 2007).

I want to add that his mechanisms are much more fine-tuned than those based on serendipity or randomness. The response of the machine in the conversation is calculated specifically from a cognitive point of view that relates to the individual participant's knowledge, interests, context, anything you like in available data that is specific to this person. This contrasts with today's machine-learning systems that aggregate vast collections of data into a form of 'lowest common denominator' person. This is one of the flaws of these heuristics. By being Paskians we can have a system's interaction operate between the fuzzy calculations of the machine heuristics—doing the best it can, not overwhelming but rather harnessing the intuition of the human—and an individual's curiosity, and knowledge and interests, in a beautiful pairing that's completely consistent with our human need for novelty.

By being Paskians we can have a system's interaction between the fuzzy calculations of the machine heuristics, doing the best it can, not overwhelming and rather harnessing the intuition of the human.

Werner: There are issues here about scale and issues of variety versus sameness, their differences in distinctions. The deeper you go into the system the more differences you find along scales; I would like to refer to Heinz von Foerster's description of what happens when you keep on zooming into a system. So, let's consider that diving deeper and deeper gives us the opportunity to distinguish the things we find. Some of them we do mark as relevant or influential or other. I would like to suggest that they are marked spaces or paradigms—in the sense of George Spencer Brown's '*Laws of Form'*—that keep moving, developing, overlapping and changing constantly. Thus, marked and unmarked spaces do differentiate between each other and in themselves. They are never the same. I would want to disagree that the sameness we are working into—when differentiating marked and unmarked spaces -is of the same detail that for instance an entailment mesh is; an entailment mesh like Gordon Pask invented and created 'as a gift' for us. If you take this though and look at a system from the point of view of variety a system may not even be about sameness but more about how you—or in fact each individual observer—differentiates. I guess this is the very issue that we have been talking about today and in the last five to ten years within the associations of cybernetics, systems, and complexity: I think we yet need to find out what cybernetics means. Is it a science or is it a tool, is it a protocol or do we define it through instruments like the *Law of Requisite Variety* in first- or second-order cybernetics or the

I would like to suggest that they are marked spaces or paradigms that keep moving, developing, overlapping and changing constantly. Thus, marked and unmarked spaces do differentiate between each other and in themselves.

Viable System Model, which could be seen as crossing the border from first- to second-order cybernetics? We are increasingly favoring second-order cybernetics; however, I regard first-order cybernetics as not such a bad thing, in fact it can be very useful. If we understand entailment meshes as representations of temporary structural coupling, Humberto Maturana's notion of self-organization and hence the subject of complexity also becomes highly relevant for the debate. It—observing and engaging in ever-changing entailment meshes—does become very complex, indeed. This is the point where I wonder and where I do have a question about designing conversations (in a way, thought-experiments of entailment meshes), what if you can't find participants with the right variety, what agency becomes responsible for moving ahead, who governs the process of debate? This may open up a can of worms.

Pangaro: That's what cyberneticians like, to begin with complex problems in the form of a can of worms, and then to reframe. These are beautiful points, Liss, and they bring to mind the idea of a self-governing system that functions somehow to let the best ideas arise. So I'm hand waving a bit but I'm trying to say that the system may govern itself, or to put it better in your terms, the agency of action is the system as a whole not any given individual.

So I'm hand waving a bit but I'm trying to say that the system may govern itself, or to put it better in your terms, the agency of action is the system as a whole not any given individual.

Kahn: I love this idea of the resuscitation of second-order cybernetics, and the reconstruction of these Paskian machines. I think, as I said in my talk earlier, where is this to be housed? We have a fundamental problem in our institutions—I work very closely with engineering and there's not a single person who would even utter the word cybernetics, which has become an embarrassment in America. And so, where I think cybernetics really has to be housed is in architecture. I'm becoming more and more convinced of this. It is interesting to consider the MIT Media Lab, where I was for a period of time studying, which has an interest in design. I think it is a very interesting topic to contemplate if you're going to adopt this post-disciplinary, anti-disciplinary position. How do we now begin to construct the space, an invitational space in which this can take

And so, where I think Cybernetics really has to be housed is in architecture. I'm becoming more and more convinced of this.

place? Paul is at an art and design school, I am at an art and design school, this conference is taking place at an architecture school, this is all suggesting the location for it. But how does one influence design? How do we get to frame these problems is fascinating and it's very nice to see we're moving in the right direction of it.

Endnotes

1 For further definitions of cybernetics, see http://www.asc-cybernetics.org/foundations/definitions.htm or http://www.pangaro.com/definition-cybernetics.html.

2 See later in the text for the sense intended by 'wicked' in throughout.

3 First 'feed-back` and then 'feedback', the term rose sharply in popularity as a result of cybernetics. One need only run the Google Ngram Viewer on both terms to see the timing that corresponds to the appearance and popularity of cybernetics.

4 System Dynamics has been undergoing a resurgence recently, for good reasons. Cybernetics is different in that it forefronts goals as directing system behavior and therefore goals are construed as a kind of agency. However, System Dynamics is only one of many alternative 'systems' frameworks that can be usefully contrasted with cybernetics.

5 The first copy of Wiener's cybernetics that ever saw was brought home by my eldest brother, an engineering and architecture student at Rensselaer Polytechnic Institute in the late 1960s. He bought it because it was part of the zeitgeist of that era, and despite the fact that he, like so many including myself, could not understand the serious mathematics that makes up the majority of the work.

6 One of the many great teachers of the second-generation of cybernetics was Jerome Y. Lettvin, who made this point in person often (Lettvin 1995).

7 At a dinner arranged by Gordon Pask's research company in the 1980s, Elizabeth Pask intentionally sat me next to Eduardo R. Caianiello, the Italian physicist and cybernetician, because I was of Italian extraction. Caianiello told me that he knew Wiener especially well because Wiener loved Capri and they spent time there together in the summers. After some cordial conversation and some easy silences, Caianiello turned to me and said matter-of-factly, "You know, Wiener was very bitter at MIT." He explained that Wiener felt exploited by the MIT public-relations machine—which frequently piggy-backed on references to him as "MIT's Norbert Wiener".This was very much the case when I arrived to MIT in 1969, 5 years after Wiener's death. But Wiener also felt that MIT didn't sufficiently respect him or his students or his work. I take this characterization by Caianiello to be highly reliable. Notwithstanding the plausible contribution of Wiener's difficult personality traits to this situation (Conway & Siegelman 2009), it seems reasonable to assume that MIT's treatment of Wiener also contributed to the limits of the flowering of cybernetics at MIT and therefore limits to its influence elsewhere as well.

8 The term 'paradigm' was made globally famous by Thomas Kuhn (1962) but Heinz von Foerster illuminated it best by reminding that 'paradigm' by definition means you are limited in your thinking and you don't know it (von Foerster 2000).

9 A litany of offshoots and tools that derive from cybernetics—to apply cybernetics to problem-forming—is an entire paper on its own and would retell a significant portion of the history of engineering from the 1940s. For a very modest list of highly pragmatic models used from personal experiences in teaching design, consider these: first-order feedback, nested feedback, conversation. Methods emerge by applying models to principles: requisite variety, creating new language. See Dubberly & Pangaro 2007 for an explication of these examples.

10 If not already familiar with the work, readers may wish to refer to Rittel & Webber 1973 to understand the nuance and depth to the term 'wicked problem' in its original formulation by those authors. There are too many such attributes that permeate wicked problems to be explained here.

11 This statement is not universally agreed, for example, Peter Cariani believes that the anti-objectivity formulation of second-order cybernetics arose only after conventional funding dried up, that is, in the 1970s (Cariani 2017).

12 Stuart Umpleby and I have exchanged emails about the timing of this, he feels it was in the early 1970s, which would be compatible with the decline of BCL from that time.

13 Ito himself is an unusual choice to run an MIT laboratory, given lack of academic degree or research chops. I recommend to read his piece in Design + Science also because the cybernetics community should have a response to Ito's views on design and cybernetics, and because the whole point of the publishing platform that it's on, pubpub.org, is to enable immediate publishing and also commentary online and thereby to diminish the influence of journal editors, publishers, and the peer-review process.

14 My answer was, if anyone can, you and the Media Lab can. However, from the later conversation it was clear that the faculty was not in favor and it was never pursued, though perhaps for additional reasons not known to me.

15 For example, he collapses second-order cybernetics to layers of complex first-order systems, not mentioning constructivism, framing, language, or subjectivity.

16 Ito speaks about antidisciplinarity as the white space between points on a page, where the points are the disciplines and their limited and silo-ed vocabularies. Andy Pickering, whose work I can't recommend highly enough, has written eloquently about the concept of antidisciplinarity, a term he likely coined in Pickering (2013). He has also advocated for holding a new set of Macy meetings, founded on the idea of this antidisciplinarity, an idea I floated to Ito in our third conversation (Ackermann, Felde, Ito, Pangaro, et al 2016).

17 However, as noted above, it is not being taken up by Ito's lab at this time.

18 I owe it to Albert Müller for calling attention to Erich Jantsch (Jantsch 1972) who defined multi-disciplinarity as the maintaining of individual languages in a conversation with participants from multiple disciplines; inter-disciplinarily as the juxtaposition of existing languages in such a conversation; and trans-disciplinarily as the creation of new language—in cybernetic terms, wholly new framing. For more on creation of new language, see Geoghegan, Dubberly, Pangaro, and Esmonde 2002.

[19] The concept of filter bubble is that today's internet services such as Facebook and others will tend to bring us content that matches our pre-existing interests and that of our friends, who also tend to be like us. This places us in a metaphorical bubble that is massively filtered, the result of which is that we rarely see anything that is different from our existing knowledge and prejudices. The concept became widespread with Eli Pariser's book, The Filter Bubble (Pariser 2012).

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Cybernetic Argument for Democratic Governance: Cybersyn and Cyberfolk

Raùl Espejo

Cybersyn was a utopia of democratic governance. It was beyond our experience of democratic governance in current capitalist societies. Cybersyn's vision was that of a world of communications and information in real time, a world of conversation spaces to balance the short and long term. It offered a utopian form of governance aimed at an egalitarian and non-bureaucratic society. It wanted participation, democracy, and accountability. It was a utopia for democratic viability rather than for democratic capitalism. After almost half a century we can reflect upon its meaning taking into account social, economic and technological developments since then.

Keywords: Cybersyn, Cyberfolk, Viable System Model, VIPLAN Method, Viable Democracy, Requisite Variety, Liberty Machine

Chile

In the Chile of the 1970s, during its two years of implementation, the organisational and technological conditions of the country were highly constrained. Its culture was of dependency to a capitalist, hierarchical and bureaucratic world. Not only the available technology in Chile was limited but furthermore, globally, the network and digital societies were decades away. Political infights and backward institutions restricted reality far from the world that Stafford Beer had envisaged (Beer 1972, 1975a, 1975b, 1979, 1981). His imagination was running ahead of the resources and competencies available in the country. Despite those limitation *Cybersyn* offered an extraordinary utopia. The cybernetics of the social situation was weak; we were living in a world of fragmented, bureaucratic organisations, focused on the short term trying to solve immediate problems, with significant social and political conflicts. The utopia of an egalitarian society, with high expectations of solidarity and respect for the less privileged, was no more than a dream. I have published about *Cybersyn´s* design and its methodological and epistemological weaknesses (Espejo 1980,

Cybersyn offered an extraordinary utopia.

1992, 2014). In this contribution, I want to highlight its conceptual strengths and vision: Beer's *Viable System Model* was a major conceptual contribution and the technological and practical insights of its implementation, Beer's *Liberty Machine*, were visionary. What kind of society Chile would have become if the *1973 Coup* had not succeeded and Chile had had the chance of developing like an advanced socialist democracy? In answering this question two aspects come to my mind; first, the path would have been painful and much social and individual learning would have been needed to overcome a history of conflicts, dependency, and oppression and second, Chile's society would have emerged as a much more equal and powerful democracy. In this contribution, I highlight *Cybersyn´s* systemic underpinnings and its intended management of social complexity.

Which type of society allows for the idea of Cybersyn?
What does it mean to be a society with good cybernetics?

At a global level, I argue that *Cybersyn's* vision was of autonomy and social collaboration. At a detailed level, I argue *Cybersyn* was about managing social complexity. Far from being a recipe for anarchy, it was an attempt to develop a cohesive and responsible society. The *Viable System Model* (VSM) supports the encounter of bottom up self-organising forces and imaginative proposals for long-term development. It is in these encounters that a wide range of recursive organisational systems emerge and create the context for people's social inclusion and the space for a cohesive society. Along these lines the chapter offers, as an initial reference, introductory words to the *VSM* as I use it today, and to the performance measurement system as used in Chile in the 1970s. Then it explores, first, the communications required for people's inclusion in a viable, recursive, democracy; second the performative requirements for social systems to maintain viability in a complex environment; third, the communication requirements for an open and cohesive society and finally, all these aspects come together in what Beer called the *Liberty Machine*.

The Viable System Model and Performance Measurement

Beer arrived to Chile with the manuscript of his book the '*Brain of the Firm*', the first of four about the *VSM* (Beer, 1972, 1979, 1981, 1985). This manuscript was used by the *Cybersyn* team to model the industrial economy. It took some time to learn about it. Its application required multiple clarifications. To understand that the model´s *System One* was constituted by resources producing the products and services of the industrial economy, and not by resources responsible for either regulation or research and development or policy making, required much debate about methodological issues. Equally we had debates about relationships between the different systemic functions of the model and most importantly about the meaning of structural recursion. Early in the project Beer had hypothesised plants, enterprises, industrial sectors, and industry as the primary activities of the recursive structure of the industrial economy. How was that different to a hierarchical structure? However, beyond the learning of those days, it took several decades to clarify important methodological aspects of the VSM. Among other developments, my work developing the *VIPLAN* Method (Espejo, Bowling et al. 1999; Espejo and Reyes 2011) helped facilitating its application not only to firms and enterprises but also to multi institutional set ups like energy, climate change, transportation, education, social services, consultancy, health and many more, in which the organisational systems encompasses often multiple institutional resources. Today, these methodological and related epistemological developments are helping us to see the social relevance of ideas such as structural recursion and the management of complexity in the application of the VSM. These developments are languaging the utopia of the early 1970s into a practice for new social relationships and most importantly for opening possibilities to visualise fairer societies.

Equally we had debates about relationships between the different systemic functions of the model and most importantly about the meaning of structural recursion.

Indeed, for complex policy issues, multiple institutional resources are likely to be focused on their creation, regulation, and production. Often these resources are fragmented, however, one way or the other, through self-organization, over time, they interact, constituting, if the policy proves viable, an organizational system. If we use the example of transportation as an issue, and apply structural recursion, guided self-organisation (Espejo 2015) may imply resources in each town or city to create, regulate and produce their transportation policies. A larger, embedding system could serve as the system for regional transportation with capacity to create, regulate and produce regional policies. Equally, within each local system we may expect to find self-organising teams creating and producing specific products/ services for the community (e.g. country roads management, bus services, traffic management, etc.) and together producing the local policy. These local and regional systems are the implementing units of the national transportation system, that is, the *primary activities* constituting the 'doing' of the hypothesized organization for this policy issue. This *unfolding* strategy assists collectives to cope creatively with chunks of their environmental complexity. Observing recursive levels in this *Unfolding of Complexity*, or cascading structure, consisting of autonomous units within autonomous units (figure 1), is a way to check the coherence of an organisational system.

Unfolding of complexity consisting of [...] autonomous units within autonomous units.

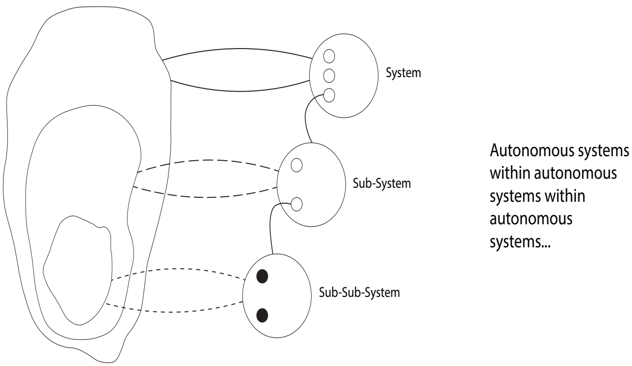

fig. 1: Unfolding of Complexity, Espejo, 2003

This proposition could be easily falsified if it is observed, for instance, that the local transportation policy is defined at the regional level and therefore that there is no such thing as the local transportation autonomous system.

The hypothesis is that each unit is an autonomous unit, in the sense that they can sustain themselves in time despite unexpected environmental disturbances; structurally they must develop ultrastability, that is, capacity to absorb all kinds of environmental disturbances and maintain identity. Autonomy in this context means systems accepting responsibility for their own affairs and situating themselves within the framework of larger systems, such as the national transportation system. This devolving is largely a self-organising strategy to cope with environmental disturbances, which for socially required performance triggers as many structural levels as are necessary to produce desirable services (social goods). This 'Russian dolls' description is useful to visualise a tidy architecture of complex social systems; however, society is far less tidy. Not only we may expect bottom-up and top-down structuring of social systems but also, we may expect multiple forms of embedding and relationships within autonomous units contributing to several autonomous units and a wide range of possibilities of belonging (figure 2).

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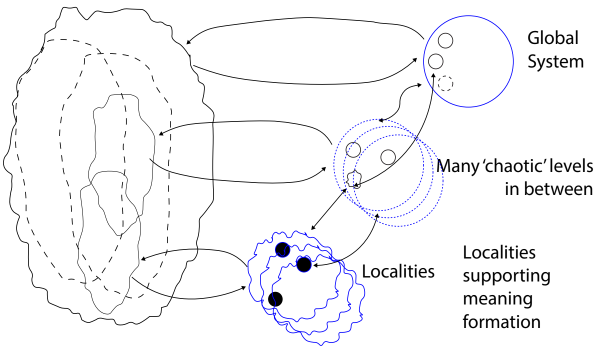

fig. 2: chaos, meanings and levels of meaningful debates, Espejo 2013

In fact, in social situations the political will to pursue a policy may trigger connectivity of so far unconnected autonomous institutions under the umbrella of this policy, thus producing a larger system of which they become, one way or the other, autonomous parts. The variety of possible organizational forms, that is, of possible unfoldings vis-à-vis a wide range of catalysts, e.g. policies, innovations, serendipity, and so forth, can be very large. We may expect that each primary activity (i.e. solid circle in figure 3), to a greater or lesser degree, develops a discourse of its own, norms its own actions -for which it must be prepared to redeem whatever legitimacy it claims - and maintains an autonomous existence in its relevant environment - for which it must be prepared to give proofs of authenticity and competence.

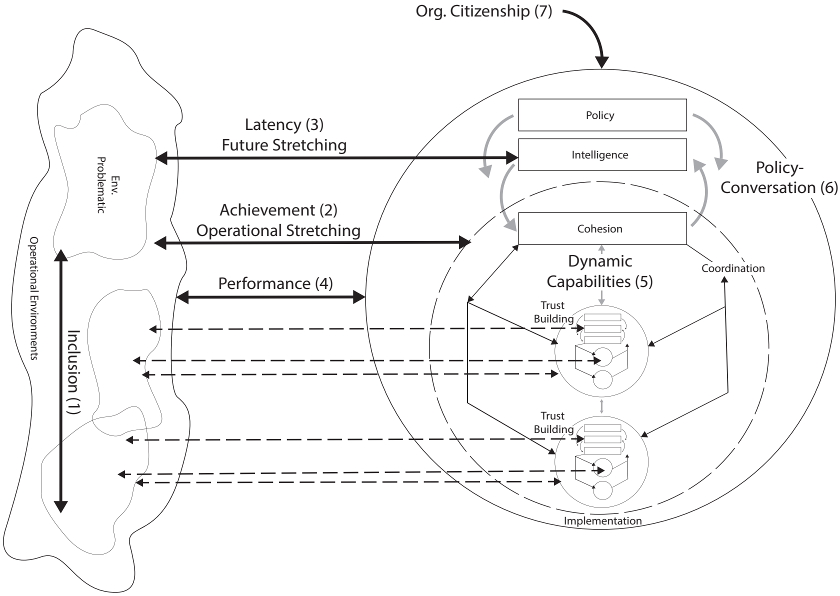

fig. 3: 'the viable system model', Espejo 2008 (adaption from Beer 1985)

All this requires functional capacity (Wene and Espejo 1999) and in a viable system this capacity is given by five systemic functions; Policy, Intelligence, Cohesion, Coordination, and Implementation (Espejo 2003), which together create, regulate, and produce its products and services (figure 3). The system's primary activities produce the policy. Policy, intelligence, and cohesion, largely emerging from self-organisation, constitute an adaptation mechanism that creates policies and supports adaptation to environmental changes. Policy gives closure to their communications; it manages interactions to use intelligence and cohesion resources to the best of their abilities in

The cohesion function, the fulcrum of the organisation, keeps together primary activities and balances the global with the local interests.

This is Beer's concept of structural recursion, i.e. that the same structure for viability recurs in all primary activities, at different structural levels.

the collective benefit. The Intelligence function is concerned with the outside and then the organization's *problematic environment* in the future. This is the functional capacity that maintains conversations with those external agents that may influence the policy's long term consequences. The *cohesion function*, the fulcrum of the organisation, keeps together primary activities and balances the global with the local interests. The *cohesion function*, together with the co-ordination function, allocate resources and regulate the implementation function (i.e. the primary activities). Together cohesion, coordination and implementation constitute the cohesion mechanism. The *cohesion function* is concerned with the balancing the autonomy of embedded primary activities with the cohesion of an encompassing viable system. The same five systemic functions recur in all embedding and embedded primary activities (see this recurrence of functions and relations in the graphical patterns of figure 3), as requirements for their viability. This is Beer's concept of *structural recursion*, i.e. that the same structure for viability recurs in all primary activities, at different structural levels. This model was a cornerstone of *Cybersyn*. Together with the *Viable System Model*, Beer proposed, as another cornerstone of *Cybersyn*, a system of indices to measure performance (figure 4).

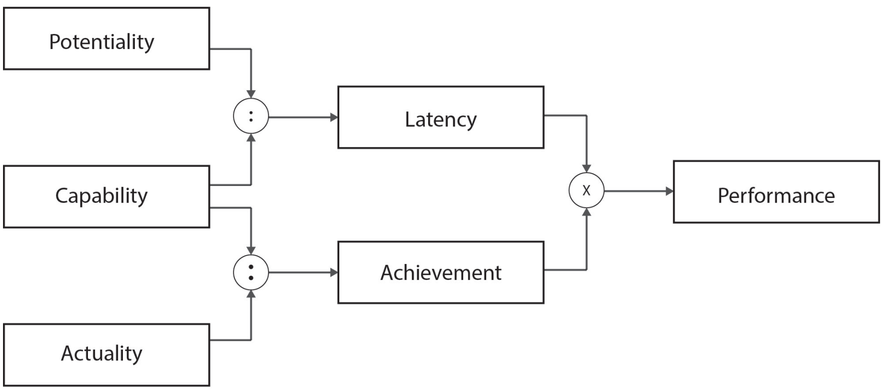

fig. 4: indices for performance measurement, Espejo 1992 (adapted from Beer 1981)

Their design was at the core of the project. For each plant, enterprise, industrial sector, and the total industry, recursively, *Cybersyn* proposed designing a set of indices to measure the performance of plants, enterprises, industrial sectors and the total industry in their environment. The design of these indices and of the software – Cyberstride's temporary and permanent suites - were conceived to support information in real time, informing managers about significant changes in their behaviour. This design was perhaps one of the revolutionary aspects of *Cybersyn*.

In practice the implementation of indices and software were the most resource consuming aspects of the project. They were central to *Cybersyn's* vision. From figures 3 and 4 it is possible to appreciate the intertwining of the recursive structure of the industrial economy with the proposed indices of performance. The co-development of primary activities in interactions with their environments make apparent relationships of *achievement* and *latency*. The *operational stretching* of the environment is responsible for the achievement of primary activities. This *operational stretching* is an important communication channel (channels 2 in figure 3) between the operational environment and the primary activities of the organisational system at all levels of recursion. And, these channels, as I argue later, are central to the functioning of democracy. Equally, the *stretching* that agents of the problematic environment make over the intelligence function, at all levels of recursion, is a communication channel at the core of the organisational system's adaptation and change. This relationship helps visualising the emerging latencies of the organisational system's interactions with agents in its problematic environment. This *communication channel* (channels 3 in figure 3) contributes to the inclusion of the people to democratic processes in society. I will explore this communication in more depth later. In this measurement system, latency and achievement together allow us to measure the *performance* of organisational systems, from the local to the global. This was a distributed measurement system common to all the primary activities of the industrial economy in Chile and was a distributed system common to all primary activities of society in general. What is of significance is that the above description offers

Cybersyn proposed designing a set of indices to measure the performance of plants, enterprises, industrial sectors and the total industry in their environment.

It shows society's variety engineering, in a society overwhelmed by big data. Its relevance is huge as it allows to account for the interactions of local people with global policy makers.

a paradigm to improve society today. It offers a heuristic guide to society's self-organisation and makes Beer's vision more meaningful and approachable. It shows society's variety engineering[1], in a society overwhelmed by big data. Its relevance is huge as it allows to account for the interactions of local people with global policy makers.

Relationship of Inclusion: communications required for people´s democratic inclusion

Allende's insight was that the repositories of the Nation´s governance were the people.

During Beer's first visit to Chile, as he was explaining the VSM to President Allende, he was prepared to say "and here is you Sr. President" when he reached the Policy function (see top of figure 03); Allende in anticipation said "finally the People"[2]. This was a deep insight which greatly influenced our work. Allende's insight was that the repositories of the Nation´s governance were the people. This insight is as necessary today, when discussing democracy and the role of the people in policy processes, as it was in the early 1970s. *Cybersyn's* offshoot, *Project Cyberfolk* (see figure 5), helps explaining this insight. *Cyberfolk* was proposed to support the interactions of the people and policy makers. Clarifying these interactions is gaining currency in today's post truth societies. Politicians can lie without shame. The challenge is how to reduce the chances of unrestricted manipulation of the 'truth'? The nature of these relationships today is very different to the one we experienced in the Chile of the early 1970s. In those days, while politicians could reach the people through the media on a daily basis, the people had more difficulty expressing their satisfaction or lack thereof about what they received from the politicians (see inclusion relationship 1 in figure 3). Representative democracy was slow and the technologies underpinning social networks were very limited.. Elections and polls were few and far between. Contrary to those days, today the situation is highly dynamic and responses to policies can be instantaneous through social media; Cyberfolk's algedonic loop (people's satisfaction/dissatisfaction) works in real time and people's responses are conveyed instantly. People can say whatever they think, and in democracies these channels transmit big data in real

Cyberfolk's algedonic loop (satisfaction/ dissatisfaction) works in real time and people's responses are conveyed instantly.

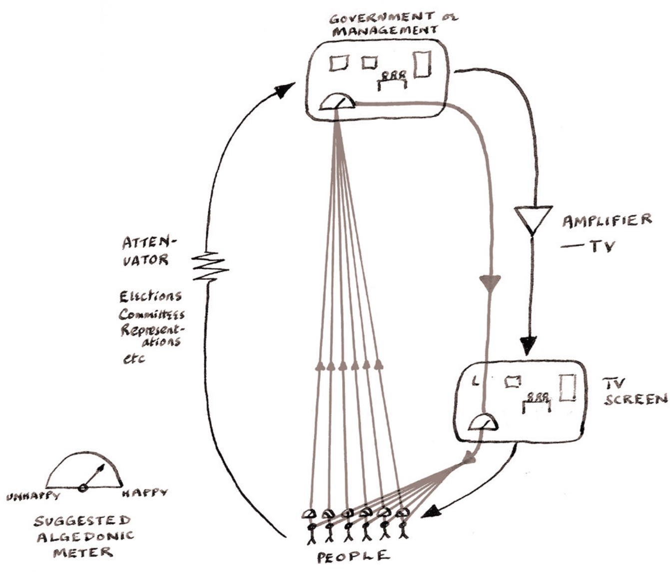

fig 5: 'project cyberfolk': a tool to balance power in an inclusive society power, Beer 1997 in 'Corporacio de Fomento de la Produccion Chile'

time. However, we also live in echo chambers and in surveillance societies that instil self-reference and insecurity. This loop is indeed complex and needs to be reformulated to reduce arbitrariness and misinformation. *Cyberfolk* offered a vision of environmental communications that, today with internet and other communication forms, are transforming people's influence in policy processes. Conversations to clarify information and truth debates are possible and necessary but there are limitations to how much society can rely on them. It is apparent that there is no requisite variety for unrestricted debates. Huge number of unsubstantiated and idiosyncratic meanings can be constructed from big data, algorithms, and social networks. Extracting clear meanings from debates, where the best arguments prevail, is often not possible. These debates require time and resources that seldom are available. The challenge is clarifying meanings in these situations, but how? This is a taxing exercise in a democracy. Alignment of people's and politician's purposes requires more than representation, participation, and deliberation; most significantly, it

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requires systemically sustainable requisite variety in the interactions between them (figure 6). It shows two parts, a) politicians -the low variety side in the interaction and b) citizens -the high variety side- extracting shared, but not necessarily the same meanings through their interactions. We are talking about a very large number of social homeostats requiring attention and possibly design. How to design regulation? A heuristic for this purpose is the *VSM*, which helps to model a network of homeostats, and the design can be supported by the *VIPLAN* Method (Espejo et al 1999; Espejo and Reyes 2011).

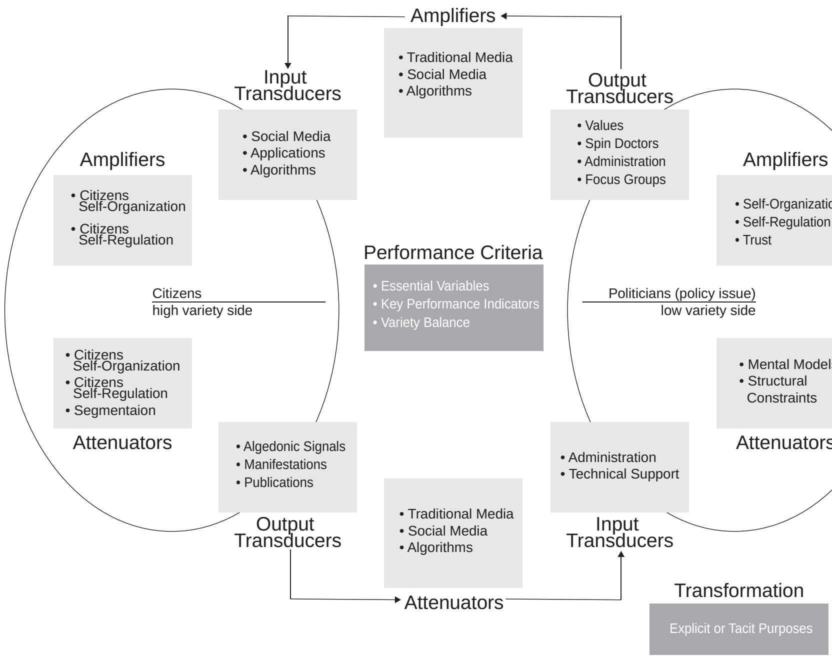

fig 6: variety engineering, Espejo and Reyes 2011 (adapted and developed from Beer 1985)

I argue that the significance of Allende's insight about inclusion rests with structural recursion in the communications between environmental agents and organisational actors. Particularly for those policies that affect people's daily lives, can anyone challenge that local people know better local issues than those distant politicians? They have a holistic experience of the local. At the same time politicians have a fragmented, but much more detailed, understanding of policies.

Why should policy formulation be left mainly in politicians' hands? Is it not that the risks and unintended consequences of these policies will affect principally the people? And, perhaps controversially, is it not that their judgments about the holistic nature of local issues are likely to be more meaningful than those of distant politicians? Improving policy processes needs to add this local dimension to global policies. This is, cybernetically, the meaning of people constituting society´s policy function. Beyond *Cyberfolk, Cybersyn's* vision, and in particular the VSM's vision, is to improve social communications between politicians and citizens through actors in recursive organisations. This is the performative dimension of the *VSM*. Designing the co-production of local services, such as health, social services, education, police and so forth (Espejo and Mendiwelso-Bendek, 2011), is a means of improving people's achievements in their environment. But beyond improving the homeostats between the organisation and its operational environment (i.e. achievement channel 2 in figure 3;); the challenge is improving the 'vertical' communications between the structural recursions producing these services in the organisation (channels 5 and 6 in figure 3). This is necessary to include people's local views in policy processes through and throughout the organisation. To achieve this vertical integration (channels 5 and 6 in figure 3) we need to consider the following issues:

Why should policy formulation be left mainly in politicians' hands? Is it not that the risks and unintended consequences of these policies will affect principally the people?

1. Balancing power between the local and global levels

In a democracy, anything that gives global actors an unchecked control over their decisions is likely to backfire in the long run. Eventually people will question their legitimacy and the quality of their decisions. On the other hand, from the view of global actors, anything that gives local stakeholders the chance to block decisions unilaterally, without proper participation and attention to the global interests, is holding society to ransom and making decisions less effective. To overcome this situation orthogonal communications are necessary. While people's values and interests are paramount in policy processes, in a democracy elected politicians are the ones responsible for policies. Their judgments are supported not only by their personal abilities but also by the institutions and related bureaucracies underpinning their decisions. Here is where the organisational system plays a fundamental role; if experts and bureaucracies are well in touch with local people through recursive structures their contribution to policy making is likely to be more responsive to actual *achievements* (channels 2 in figure 3). An effective engagement of local people, that is, their effective participation in a policy issue, requires good recursive communications throughout society, and these are, as I have already argued, effective recursive communications between actors within the organisational system and between them and global agents in the environmental, but between actors and agents throughout this system (channels 4, in figure 3). This proposition is a tall order but it offers a heuristic to improve social communications. Autonomous systems require articulating mechanisms of cohesion within primary activities at successive recursion levels. What is common to all these communications is a complexity mismatch; policy makers and those supporting them have more diciplinary knowledge of policy issues than local people; and the people have more knowledge of their local situations. These are not one to one communications; these are many to one and one to many communications.

Communicative competence requires the legitimacy, authenticity, and competency of participants.

To balance their views, they depend on *orthogonal communications,* that is, they cannot rely in the possibility of both sides seeing the same complexity; their communications will depend, among other aspects, on trust and P2P (peer-to-peer) coordination (relationship 5 in figure 3). All these are aspects balancing complexities in situations inherently out of balance. Communicative competence requires the legitimacy, authenticity, and competency of participants (Habermas, 1979; Wene and Espejo, 1999); aspects like authenticity and respectful corroboration of facts help to build responsible trust between them, beyond impossible attempts to deal one to one with the complexity of each other. Beer´s vision of *variety engineering* (figure 6), as proposed by him in *Cybersyn,* is now being unravelled.

2. Conversations among and with the people

In a democracy, communications of organisational actors with the people require far more than isolated consultations and dialogues. However visionary *Cyberfolk* was, it just offered a glimpse of the complexity implied by people's inclusion in policy processes (channel 1 in figure 3). *Cyberfolk and Cybersyn* together offer a heuristic for inclusion. On the one hand, it is necessary to consider the hugely chaotic interactions of people throughout society, going from people with local interests to people politically motivated, stretching institutions at the global level in a variety of policy issues like nuclear policy, poverty, migration, agriculture, water resources and so forth. These are social communications in the environment, represented by channel 1 in figure 3, which, one way or the other, badly or not, are chaining operational and problematic environments through several recursive levels. On the other hand, and this is the concern of our next section, it is necessary to consider the often hugely chaotic interactions of actors within institutions, chaining, one way or the other, their activities recursively, producing societal services by means of global organisational systems constituted by a myriad of embedded primary activities.

There is a huge variety gap between people's daily experiences and the global problems they are confronted with. In these circumstances politicians can get away with lies and people with uncorroborated views. Seldom we find structural chaining of meaning formation activities; the cohesion mechanisms linking recursively local and the global processes are in general very weak or totally in the hands of politicians. Trust-creation and coordination processes are weak; chains of meaning formation are weak. In the digital era, in a society of freedom of speech, you can have all kinds of ludicrous proposition (such as there was no holocaust). How do we reduce the negative impact of these extremes? How far is regulation necessary? At the other end, we have global policies that need local attention, like for instance the UK's referendum to stay or not in the Eupean Union. How do we reduce the chances of post-truth in this case? The arguments of Cybersyn and Cyberfolk suggest the need to design effective means of managing imbalances of complexity.

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This implies designing homeostats (figure 6). These propositions are still in their infancy, but Beer's vision of the 1970s opens an avenue to improve communications and transform the utopia of those days in a reality for the future.

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3. Performative requirements for social systems to develop viability and cohesion

Cybersyn anticipated a cybernetic argument that its time had to come. Today, with current technological, methodological, and epistemological developments this time is closer; it is an argument about the management of social complexity from the local to the global and vice versa. *Cybersyn* proposed to make variety, or the number of possible states of a situation, the measurement of the complexity of interactions. Today big data, if well managed, allows us to measure situational states and performance beyond anything that was possible in the 1970s. It is possible to measure the performance of the organisational system and of its embedded primary activities (figures 3 and 4) making possible and meaningful the chaining of the local with the global. Today decisions often fail to acknowledge the complexity of the organisational systems underpinning their decisions. The metrics of money and financial accountancy, fail to recognise the countless number of possible states embodied by people's interactions and decision making. In our capitalist economies, money and the market measure the implications of decisions with limited attention to people and organisation. The emphasis of *Cyberfolk* was the interactions between citizens and politicians; how is it possible to have citizens at the core of the policy process? The emphasis of *Cybersyn* was the chaining of the local to the global through a measurement system and structural recursion. Yes, this chaining is extremely untidy; however, it happens, in one form or another, with different levels of success through processes of self-organisation and self-regulation - the Viable System Model offers a powerful heuristic to improve them. The interactions driving these processes are between actors making things happen and actors creating and regulating policies (relationships 5 and 6 in figure 3). Organisational systems, with different degrees of effectiveness,

The emphasis of Cyberfolk was the interactions between citizens and politicians.

emerge from these self-organising processes. Eventually, when policies are created and implemented more or less effective cohesive organisational systems underpin them.

Whether society evolves as an effective organisational system is another matter. People clarify their purposes- a wide range of possible purposes- which are the driving forces to make things happen. Many efforts of collaboration are unsuccessful; others compete for their viability. The successful alignment of people along particular purposes may produce the organisational systems we recognise operating in our world. As this happens people become actors of organisational systems in environments constituted by stretching agents; in figure 3 we recognize that operational interactions, the ones producing the products and services implied by actors's purposes, constitute the achievement interactions between actors and agents (relationship 2). What the *VSM* tells us is that for sustainable achievements, actors need to work out what is possible in their environment (potentialities), and develop relationships of latency with agents in their problematic environments (relationship 3); these latency interactions are engines for social innovation and development, at all recursion levels for aligned purposes (i.e. policy issues). We cannot anticipate which primary actives and which recursion levels will succeed and over time will be constituted as organizational systems. This is an outcome of their performance relationship (4 in figure 3); if actors and agents, as they achieve particular outcomes and learn how to modify these outcomes to match problematic situations successfully, then we may expect that their chances for viability will increase. These arguments apply to enterprise of all kinds. Beyond the organizational systems, from a societal perspective, a question is which are the *autonomous nodes* with capacity to contribute to the emergence of a social system, such as a nation/state. Is it meaningful to think about a nation as a viable system striving for shared purposes and values? Or, isn't it that in democracies people strive for varied values through elections and other forms of participatory, deliberative, and inclusive democracy? It can be argued that nations strive for their viability and therefore that the *Viable System Model* can help designing viable nations.

Organisational systems, with different degrees of effectiveness, emerge from these self-organising processes.

What the VSM tells us is that for sustainable achievements, actors need to work out what is possible in their environment (potentialities), and develop relationships of latency with agents in their problematic environments.

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Discussing this use of the *VSM* goes beyond the possibilities of this chapter[3]. Cybernetically, if a society increases the number of its autonomous nodes it risks increasing its regulatory problems; it risks becoming more anarchic and potentially unmanageable. Increasing people's freedom naturally increases viewpoints and most likely increases social richness but also increases potential conflicts. The control strategy of dictatorships is reducing *active nodes* in society, and by forcing the alignment of their purposes and values with those of the dominant groups, they may increase the chances for economic development. This model overvalues the economy in detriment of social and ecological aspects. Paradoxically, because of the conflation of the social and the economic, in a dictatorship it is possible to think, albeit only for the time it is in power, about society as a viable system. While in a more chaotic situation, we may be thinking about conflicts between varied ideologies and possibly between varied projects for social viability. Even in more benign situations, such as those of liberal and social democracies, where politicians espouse inclusivity, politicians and oligarchs are likely to overwhelm the views of the most. Dominant ideologies attenuate hugely the variety of our societies (Beer 1993), impose their values and measurement systems over the majorities (Espejo 1994) reinforcing power imbalances. From a social perspective, regardless of having well structured or poorly structured organisational systems, some societies build up solidarity and responsible trust among autonomous nodes at the same time of enabling peer-to-peer coordination of actions, thus reducing the chances of social inequalities; others do not. These can be seen as social mechanisms for cohesion (relationship 5 in figure 3). These behaviours are less likely to hinder freedom and the emergence of alternative ideologies and increase the chances for a fairer distribution of resources. This is what I relate to a cohesive society. What happens in these situations is something that runs beyond the economic system. By operating a centralised decision-making system, governments constrain the variety generation capacity of the people, reducing their contribution to global social interests. This is the discussion of the cybernetics of society beyond the cybernetics of the industrial economy. *Cybersyn's* scope was of a project for the industrial economy, however, *Cyberfolk* opened the opportunities to think about communications in a free society. Chaotic societies risk moving in the direction of anarchy. To counter this risk, dominant ideologies threaten society with undesirable constrains.

> *"Step by step, the landscape of freedoms and liberties – which been the source of so much pride for the English people – is being dismantled. Yet recent research shows that 73% of British respondents think this is a price worth paying in this dark game."*
> (Zygmunt Bauman in an interview to Open Democracy 2005)

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Centralised governments in an increasingly complex world, with changing environments, most likely will lack requisite variety to support democratic processes. Usually they exacerbate the situation by reinforcing their commanding culture as situations become more uncertain. Among other aspects, they fail to enable societal recursion and cohesion. Recursion is the most powerful strategy to distribute complexity, as autonomous units take responsibility for larger chunks of the environmental complexity. Effective cohesion, enabled by the self-regulation of peer-to-peer coordination, increases the complexity, that is, the response capacity, of the autonomous nodes (i.e. primary activities). Indeed, peer-to-peer (P2P) interactions hugely increase the variety of primary activities. This is a huge change that the digital society is making possible beyond anything that could be dreamt about in the days of *Cybersyn*. Developing effective recursive and cohesive structures increase the chances of chaining the local and the global (making more aligned the circles in figure 2). In cybernetic terms the key issue is that social complexity in general is not managed well. For instance, British policy makers were concerned with the death of a child in one of the country´s local authorities.[4] The issue had become a global policy issue through the amplification of the media, social media, pressure groups and so forth. These high variety communication channels were hitting politicians. The good cybernetics challenge for them was having organisational actors managing big data through a recursive organisational system that attenuated social variety in such a way that they got the benefit

Effective cohesion, enabled by the self-regulation of peer-to-peer coordination, increases the complexity, that is, the response capacity, of the autonomous nodes.

of their distributed knowledge and their local action capacity. The child's death in the hands of her mother was a case of bad cybernetics (Mendiwelso and Espejo 2015). Normally this situation should have been beyond the attention of Westminster politicians, however in 2008 it reached them, the most global level of decision making in Britain. These are instances of weak variety management starting at the local level; if those responsible for *achieving child* care locally fail, and the structures in between them and the global are weak, we may expect *algedonic signals* (see figure 5) jumping from the local to the global, where policy makers may find themselves pressed to make decisions beyond their response capacity. The complexity of the situation is beyond them. On the one hand, the inclusion channel (1) was overloading policy makers; on the other the *performance* channels (relationships 4 in figure 3) of the responsible lacal team, and of social services and the related local authority -two structural recursions above the local level- were not managing complexity effectively, as was made apparent by the tragic death of the child. In this situation, the achievement (2) and latency (3) channels, at two levels of recursion, were failing to attenuate the systemic variety of the child care situation, increasing the chances that local information would reach global politicians. The cohesion mechanisms of all recursions failed. The accounting of their complexity failed. In parallel to *Cyberfolk*, *Cybersyn* through structural design offers a heuristic to manage this vertical variety.

4. Beer's Liberty Machine

Bob Hughes (Hughes 2016) reminds us, that the Canadian author and activist Naomi Klein, in her 2007 book '*The Shock Doctrine*', dates the start of the global shift away from utopia as the 11 September 1973, in Santiago, Chile. Indeed, the *Military* Coup destroyed the hopes for a democratically elected socialist government to evolve towards a more equal society. Inequality remains as a key challenge for our world today. Unfortunately, our world today remains as much, as it was 45 years ago, a hierarchical world, dominated by the low variety ideologies of those political classes in positions of power, that maintain inequality and constrain the freedom of the people. Beer, in his paper *'A World in Torment'* (Beer 1993) argues forcefully against the triaging of societal structures produced by the dominant ideologies, which attenuate the variety and creativity of those who happen not to share them. However, even when people are free to express their views, their operational capabilities may be restricted by an establishment that validates certain distinctions at the expense of those of the majorities. The informational domain of those holding these ideologies, such as those expressed by their traditions, procedures, management practices, accounting procedures and many more, constrain the operational domain of the most (Espejo 1994). More than changes in the economic system the problem is building up new societal and organisational forms that make possible the alignment of recursions and the strengthening of cohesion in all primary activities. Unfortunately, despite the fact that the digital society is allowing heterarchies today, that is, peer-to-peer communications and coordination of actions, it is not proving enough to counter today´s social and economic inequalities. Social conservatism[5] is still constraining people's effective use of these evolving technologies. Social scientists, like Hughes (op. cit.) and economists such as Wolfgang Streeck (2016) are arguing for new societal forms and new economic relationships. Streeck argues for new institution in a world that is witnessing the failure of the Capitalist system. The societies of the 1970s were dominated by conflicts between capitalism and communism. The cold war remained virulent until the end of the 1980s. At that point, with the collapse of the Soviet Union, capitalism appeared to emerge as the dominant system without a counterpart. In the 70s, Beer's utopia in Chile appeared as a puny alternative to the much more significant prevailing proposals for an ideological socialist democracy. The question is whether Beer's organisational cybernetics offers now a language aligned with the technological developments of this century and offers an avenue for further developments. His proposed *Liberty Machine,* as summarised in the *Operations Room* (figure 7, Medina 2006 and 2011), is an iconic offering in the direction of constructing a better future. The situation today, beyond 1989, and after the 2008 economic crisis, is indeed difficult. Geoffrey Hodgson (2001) has argued that capitalism

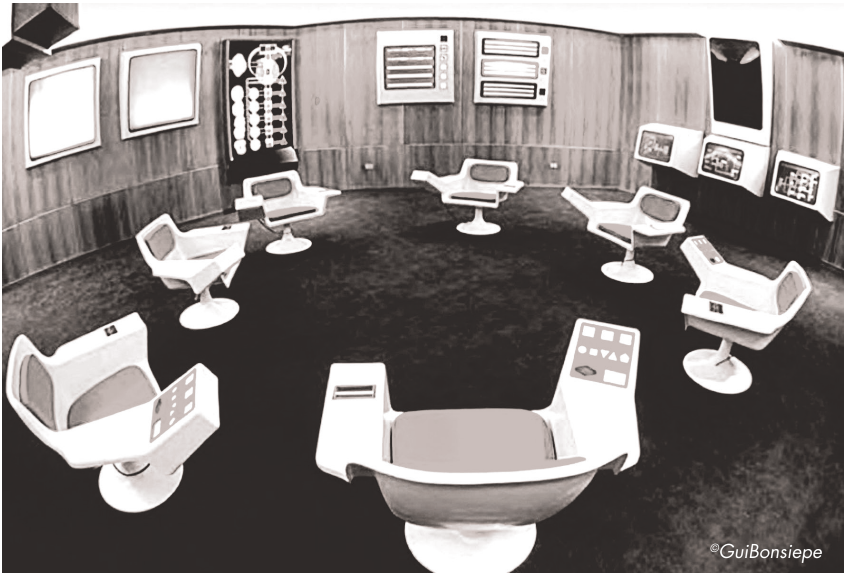

fig 7: Beer's 'Liberty Machine', Beer 1972-73 and Bonsiepe. Opsroom with displays for presentation and simulation of economocal data and. Design: Group of Product Development at INTEC, Institute for technological Research, Santiago de Chile, headed by Gui Bonsiepe. Published Bonsiepe, 2009.

can survive only as long as it is not completely capitalist, i.e. unchallenged - as it has not yet rid itself, or the society in which it resides, of 'necessary impurities'. Streeck (2016) in his book '*How Will Capitalism End: Essays on a Failing System*' quotes Hodgson "Every socio-economic system must rely on at least one structurally dissimilar subsystem to function. There must always be a coexistent plurality of modes of production, so that the social formation as a whole has the requisite structural variety to cope with change" (Hodgson 2001), he adds "For a less functionalist formulation of the same idea see the concept of 'beneficial constraint' (Streeck 1997). Streecks reflections about the demise of capitalism (Streeck 2016) as well as the work of several other authors point at limitations of the current capitalist system (Piketty 2014; Chang 2010; Mulgan 2013; Acemoglu and Robinson 2012). They raise awareness about the need to have an alternative to traditional socialism and capitalism. This is the challenge for organisational cybernetics and in particular for the utopia of *Cybersyn* and *Cyberfolk*. Streeck's diagnosis of the current situation of capitalism and his proposition of five systemic disorders in our current societies offer a connecting language of economics to cybernetics. He argues three points underlying capitalist decline:

> *"The first is a persistent decline in the rate of economic growth, recently aggravated by the events of 2008 [..] The second, associated with the first, is an equally persistent rise in overall indebtedness in leading capitalist states, where governments, private households and nonfinancial as well as financial firms have, over forty years, continued to pile up financial obligations for the future […] Third, economic inequality, of both income and wealth, has been on the ascent for several decades now [..]"*
>
> Streeck 2016

If lower rates of economic growth in western economies are the case, if higher inequalities and increasing rise in debt are not indefinitely sustainable, where is democratic capitalism heading to? This is a world in torment.

Endnotes

1 And compliance with Ashby's law of requisite variety

2 Account of Cybersyn by Beer in Beer, 1981. Conversation took place in Santiago, November, 1972

3 People in society through their interactions may constitute themselves as roles of several organisational systems, such as schools, enterprises, voluntary organisations and so forth. But with reference to society, as nodes of society, whether they are autonomous nodes or not depends of the kind of society they belong to. Some societies, like dictatorships, may be highly restrictive, others like anarchic societies, may be highly permissive. In either extreme people may fail to constitute themselves as autonomous nodes of society. To become autonomous nodes, society must allow them to become primary activities of an ideal organisational system, which succeeds aligning their purposes. In dictatorships their variety is constrained to the point that their own purposes are denied; in anarchies they are independent, to the point that they may have their own purposes but may fail sharing purposes with others and forming a cohesive society. This is a complex issue that in this paper I will simplify to facilitate the systemic argument of cohesion.

4 Referred in Espejo and Mendiwelso 2015

5 Social Conservatism denotes an attitude that tends to favour beliefs seen as traditional, retreived 24.08.2017 from https://en.wikipedia.org/wiki/Social_conservatism

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CYBERNETIFICATION I:
Cybernetics Feedback Netgraft in Architecture

Liss C. Werner

During the last decades, architecture has changed its role from fetishizing and fertilizing objectification and objects alike towards glamorising the processing of relations, observations and materialization of the objectile[1]. Steering the design process in contemporary computational architecture through and with a variety of dynamic, interconnecting agents affords re-framing, re-viewing, and re-designing prescribed patterns of creating architecture. It critically encourages to examine the concept of feedback beyond the beloved evolutionary algorithm, which presents a technical rather than architectural cultural calculus. ‚CYBERNETICS FEEDBACK NETGRAFT' proposes cybernetic principles as blueprint or genotype for computational architecture. Such principles allow for a systemic continuation of re-programming the architectural culture currently at stake. The forthcoming observation hovers between theories and meta-models. It argues that the possibilities for design increase through digitization and digitalization[2]. In this respect, the chapter refers to Ross Ashby's *Law of Requisite Variety* (Ashby 1957) on one hand and to emergence through digital self-organization on the other. (DeLanda 2011; Johnson 2001). The text offers a critic of the bio-digital and too fantastic (Werner 2014, pp.229-230). I am starting to suggest an 'architectural laboratorium of and for computational theory' built on a systemic approach to emergence and the unforeseen - nourished by cybernetic principles: a cybernetification that eventually can govern and feed back into practice and the art of architecture.

Keywords: feedback, cybernetification, network, Anthropocene, ecology, architecture

Cybernetification

CYBERNETIFICATION© has been inspired by the 'growth' of *entailment meshes* and the possibility for grafting them as developed by Gordon Pask (Pask 1975; 1976[3]; Werner, forthcoming). The term *cybernetification* appeared first in conjunction with the Cyberneticon, a construct, a virtual cybernetic driver, enabling concepts such as recursive circularity and learning through constant observation and error-control (Werner 2015, pp.38-78). Essentially it is a *Turing Machine* necessary for feedforward through feedback. Cybernetification is enabled through the technical possibilities the Internet with its generous infrastructure offers; leaving aside the critical view towards cyber-hacking, the Internet as money-making-machine or the ecological impact of large data-centers in the desert Nevada and other places. In the abstract I am referring to a CYBERNETIFICATION© that eventually can govern and feed back into practice and the art of architecture. One obstacle for resolving this suggestion, desire, hope or simply process lies in the fact that architecture – design and theory - globally is in a time of crisis. We are not sure how to define architecture, and certainly we are not sure about what the practice of architecture actually does or how to educate our architecture students - contemporary and in future. Alberto Pérez Gómez discusses the 'loss of architecture' by reflecting on the influence of the first industrial revolution on strict architectural and geometrical orders. He brings to life the perturbative aspect of sciences in the evolution of architecture (Pérez-Gómez 1983). In more recent times, Antoine Picon, Professor of the History of Architecture and Technology at Harvard GSD, has been engaging with the feeding back of a digital architectural culture into the architectural culture of material practice through a number of lectures on 'Digital Culture in Architecture' at HGSD, or *'Architecture, Matter and Language in the Digital Age'* at SciArc and his book '*Ornament: The Politics of Architecture and Subjectivity'* (Picon 2013). Alberto Pérez Gómez, Antoine Picon, Mario Carpo and a large number of others offer valuable analyses and advice for us architects to find our way through the forest of code and robotic operations back home or rather towards to an architecture where object-focused geometric notions Vitruvian and Corbusier'an architectural principles can merge with code, new materialism and what I call *Netgraft*[4]. The concept of *netgrafting* describes designing with and through digital conversation, learning algorithms and a trans-cultural approach: in a way assisted or governed self-designing architecture enabled through the Internet, open-source tools and above all a new understanding of ownership,

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that emerged with the emergence of the digital natives, born around the 1990s. The theoretical and academic paradigm through which Pérez Gómez, Picon and Mario Carpo develop their thoughts may be seen critical from the perspective of a practicing architect (which is understandable), it may also be seen as visionary and utopian through the eyes of an architect planning and constructing in less wealthy countries. Thoughts of constructing material ornament through algorithms are distant from the possible urgent necessity to install a sewage system for a school complex in Nepal; however, the facts that our architectural culture is

a) transforming, specifically digitalizing
b) increasingly influenced by direct and indirect digital feedback – in addition to analogue human feedback
c) a product of 'collective' and designed coding, on a communication level, an engineering level and a geometric aesthetic level
d) investigating material intelligence as design driver

indicates that architecture as a discipline is undergoing a process of cybernetification.

Context

CYBERNETICS FEEDBACK NETGRAFT is part of a research focusing on the evolution and development of architectural ecologies in an age of digitization and digitalization, informed by complex political, economic and climatic interdependencies.

CYBERNETICS FEEDBACK NETGRAFT is part of a research focusing on the evolution and development of architectural ecologies in an age of digitization and digitalization, informed by complex political, economic and climatic interdependencies. Research, starting in 2002 with a more intense iteration beginning around 2010, is first of all engaging with cybernetics and architecture as variety system[5]. Work is primarily driven by the research and cybernetic concepts developed by Gordon Pask '*Conversation Theory*' (Pask 1976), Margaret Mead '*Cybernetics of Cybernetics*' (Mead 1968), Heinz von Foerster '*eigen-behavior*' (Heinz von Foerster 1981) and Ranulph Glanville '*Cybernetics and Design*' (Glanville 2009; 2014). It is spinned by an increasing techno-fication and bit-fication of the 'natural' human paired with a humanization of the (mainly digital) technological; all influenced or let's say seasoned by selected perturbing subjects, such as post-ecology, Anthropocene, man-machine co-evolution or what I call involuntary architecture.

It is a process of transformation from a state X to a dynamic state of operation of which it is known that the state is fully based on active and passive feedback, partly governable, partly influencing the system to involuntary operations. This book chapter is the first of a series of the CYBERNETIFICATION© TEXTS[6]. It begins discussing the relationship and influence of cybernetics on humans, machines, our habitual environment and constantly transforming relationship to architecture and the material world. One could locate the writings within the discourse of the socio-technical ecology, written through the lens of digitalization and extend the ecological paradigm of architecture from purely shelter via urban planning to an interconnected organizational design and cultural evolution in a *Technosphere milieu*; an extended ecology where nature and technology seem interchangeable and not differentiable. Gilbert Simondon's description of the 'associated milieu' describes such an "environment, which is at the same time natural and technical […]". In '*The Mode of Existence in Technical Objects*', originally published in 1958[7] (Simondon 1980) p.61. Simondon, ahead of his time, understands 'Technical Objects' as "at the same time natural and technical." It is notable that he prefers and uses specifically the term 'technical' rather than 'artificial'; a term popularized since artificial intelligence has visibly infiltrated human culture. CYBERNETICS FEEDBACK NETGRAFT in architecture was conceived through a series of lectures that focused on digitalization and alien control enabled through the Internet enhancing communication – conversation – between humans (and humans and machines) to generate or optimize form, collectively, touching on conversation between intelligent humanoid or virtual machines, humans and other systems. The latter is a subject perpetuating machinic (Deleuze and Guattari 1987; Werner 2014b) as ecology to be discussed in future CYBERNETIFICATION©TEXT. At this stage, I will discuss CYBERNETICS FEEDBACK NETGRAFT through the lens of a cybernetic architect. The discussion embeds itself within the geological and political context of the Anthropocene and settles on the foundations of Katherine Hayles '*How we became post-human*' (Hayles 1999), Nicholas Negropontes '*Being Digital*' (Negroponte

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1995), Arthur C. Clarke's '*Neuromancer*' (Gibson 1986) paired with a) the contemporary socio-cultural discourse of algorithmically steered self-organization and b) the architectural discourse of the second digital turn[8], even if the chapter does not refer directly to the above mentioned framework. Cybernetics[9] had its high and lows, its heydays and its falls. Throughout the decades of the 20th century it was nourished, treated well and raised from a tool for controlling electric circuits, navigation or warfare to a magic wand for regulating the complex and the unknown[10]. Cybernetics, the study of systems based on circularity, decoding and encoding of information, now, in the beginning of the 21st century "rises from the ashes" (see ch. 01 by Paul Pangaro, 'Cybernetics as Phoenix: Why Ashes, What new Life') as black box encapsulating the DNA of feedback and a foundational tool-kit for mastering the art of the unpredictable. I provide the reader with one definition of what cybernetics can be. However, this is not the one-and-only-text-book definition on which the text builds up upon, instead I integrated an explanation, or rather explanations, in the paragraphs themselves. The cybernetic principle does not allow for ONE definition of cybernetics, since every observer has his or her own reality and epistemological treasure chest of wisdom, which influences the definition. This is one of the magic aspects of cybernetics.

The cybernetic principle does not allow for one definition of cybernetics, since every observer has his or her own reality and epistemological treasure chest of wisdom.

> *"CYBERNETICS is a young discipline which, like applied mathematics, cuts across the entrenched departments of natural science; the sky, the earth, the animals and the plants. Its interdisciplinary character emerges when it considers economy not as an economist, biology not as a biologist, engines not as an engineer. In each case its theme remains the same, namely, how systems regulate themselves, reproduce themselves, evolve and learn. Its high spot is the question of how they organize themselves."*
>
> Pask, 1961

Feedback

Feedback according to the cybernetician and radical constructivist Ernst von Glasersfeld is "something that is produced by a machine or organism is led back to modify the process of production."

(Glasersfeld 2002). Feedback (negative feedback and positive feedback / feed forward) as a concept can be defined as the process of routing back an output as input to the same processing / producing 'machine'. The process of feedback is a tool for regulating a system in order for it to traverse towards its goal or 'advising' a system to adjust, change or even replace its goal. It allows for communication between a sensor and a regulator, which is the one that instructs a system to 'react'. It has been defined slightly differently over the decades and in accordance to the definition source. I think we can say that overall is an indicator of cause-and-effect relationships, which may be assessed differently in controlled environments than in uncontrolled environments; despite that the underlying behavioral rules may be the same. The difference is that an uncontrolled environment can evolve and mutate according to the individual agent's or actor's possibilities and a controlled environment can only act according to a controlling 'force' or limiting circumstance. Systems in uncontrolled environments may also be more resilient than systems in other environments. A controlled environment could be a classroom, a family, a political system or a biological milieu where a certain species of bacteria resides, live and evolve. An uncontrolled environment is the Internet. Now, almost 30 years after its conception, known societal instruments, such as respect, laws, codes of communication conduct or legal regulation, steering functioning social systems (a people, a village, a family or simply a small group of friends) are disappearing. The uncontrolled Internet, including the milieu of the Darknet, has grown a scale of complexity based on feedback loops, nourished by societal change and learning algorithms that is simply unsteerable and to interwoven to comprehend. The once controlled Apranet (Advanced Research Project Agency Network) which was conceived and brought online as the first switching network in 1969 applied TPCs (Transmission Control Protocols) and IPs (Internet Protocols), the foundations of our Internet, opened to the world in 1991. Feedback as motor for digital growth and tool for qualitative optimization is a relatively new understanding. In the 1940s and decades after, Norbert Wiener in *'The Human use of Human Beings: Cybernetics and Society'*, first

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published in 1950, considers the quantitative application of feedback, as used in machine performance. He states

> *"This control of a machine on the basis of its actual performance rather than its expected performance is known as feedback, and involves sensory members which are actuated by motor members and perform the function of tell-tales or monitors – that is, of elements which indicate a performance."*
>
> Wiener, 1989 p.25

explaining feedback functions of an elevator or a gun and regards those as 'feedback' and 'reflex' before considering – and this is the core of his book- feedback as an operation for human and societal evolution and optimization.

Wiener continues explaining feedback functions of an elevator or a gun and regards those as 'feedback' and 'reflex' before considering – and this is the core of his book- feedback as an operation for human and societal evolution and optimization. At this stage, he redefines an at that time already obsolete understanding of feedback. In light of the differentiation between first (information transport and observer exclusion) and second-order cybernetics (feedback, learning and observer integration) I would like to quote one of the relevant sections of the chapter 'Progress and Entropy' (Wiener, 1989 pp.28-47):

> *"Feedback may be as simple as that of the common reflex, or it may be a higher order feedback, in which past experience is used not only to regulate specific movements, but also whole policies of behaviour. Such a policy-feedback may, and often does, appear to be what we know under one aspect as a conditioned reflex, and under another as learning."*
>
> Wiener, 1989 p.33

The notion, concept, process or tool that we call feedback entered a new territory through Norbert Wiener on one hand, but also through the Macy Conferences, held between 1946 and 1953, funded by the Josiah Macy Foundation. Cybernetics was a young field, not yet established in any way beyond the hard sciences, navigation, mechanization, thermodynamics (physics), hence conference titles changed throughout the years. The sixth Macy Conference, held 24th and 25th March 1949 in New York, received the title 'Cybernetics

– Circular Causal, and Feedback Mechanisms in Biological and Social Systems', initiated by Heinz von Foerster, to exactly discuss this subject between different disciplines ranging from computer sciences to anthropology and philosophy. The group of scientists included Claude E. Shannon, Norbert Wiener, Gregory Bateson, Margaret Mead, Warren McCullough and others. At that stage Wiener, according to his first book 'Cybernetics: Communication and Control in the Animal and the Machine', suggested that "today [in 1949] "Cybernetics" has ultimately come to stand for the science of regulation in the most general sense." (Foerster 2003 p.192). In the 21st century, the Anthropocene, the time where most humans - and an increasing number of 'intelligent', 'smart' machines - are connected and 'controlled' by digital 'artificial' algorithms more than our human instincts (technically also based on algorithms), the process of feedback is common practice. Digital feedback, often invisible, has undergone a naturalization process, similar to the existence of technologies such as running water, the telephone or a pencil – the generation of the digital natives is the first truly embodying cyberspace. Increasing and complex interconnectedness feature trans-communicational tools, uncountable coding languages and multi-parametric design requirements and nourishes some designers desire, urgent necessity and quest for suitable design strategies and design models.

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Netgraft

In my lectures and writings I emphasize that "The architect is no longer a designer of discrete objects, matter and space, but a designer of systems with complex components and multi-layered relationships." (Werner 2014; 2014a). At this moment in time I would like expand the statement and suggest that the architect, in fact, all designers are designers of relationship. Depending on how a relationship is designed the system will test and establish systemic operational and behavioural rules, including rules for feedback; which essentially is the systematic behind 'negrafting', hence cybernetification. The term 'netgrafting' stands for a networked ‚graftsmanship'. It is a hybrid between the 'net' and 'graft'. The 'net' can be any net, from

Thus 'netgrafting' is the action of directed collective design, the 'styling', the development of stabile or permanent or temporary conversational systems.

Open source platforms describe such sub-regions, which can change in shape and size where parts / variables interconnect, create relationships.

very small closed systems, such as a pencil and a designer, to very large complex such as the Internet. In light of the current debate on digitalization of the architectural culture and the rise of novel design strategies embracing emergence, 'net' refers to the latter. The term 'graft' or 'grafting' means to "insert a shoot from one tree into another" and relates to regulated forming of plants, etymologically 'graft' stems from the Latin graphium meaning 'stylus' and the Greek equivalent grapheion meaning 'to write'. Thus 'netgrafting' is the action of directed collective design, the 'styling', the development of stabile or permanent or temporary conversational systems. Architects and designers of all disciplines – including creatives in astrophysics, quantum mechanics, economy, computer sciences, anthropology, material sciences or digital humanities, biology – are facing a similar challenge in the sea of information overload. Namely to find a tool and a tool-maker for creating a filtering device that would regard or (temporarily) leave behind unnecessary, obsolete bits and bytes in a design process of any kind. In contrast to the linear suitable in and for a straight and predictable environment we are now longing for tools that can craft and graft dynamic self-organizing systems for meta-environments, able to adjust their goals and subsequently behavior in response to perturbations[11]. One way of designing or generating those tools is to work collectively rather than individual and exclusive. Knowledge-sharing and collective problem solving has experienced a full start over the last decade. We, Internet users, have been building a strong network in and through cyberspace; a large metasystem, an expanding field with smaller netgrafted sub-regions[12]. Open source platforms describe such sub-regions, which can change in shape and size where parts / variables interconnect, create relationships. The application of collective intelligence to solve technical design problems takes place in such systems, which we may recognize as open systems. Open systems can be accessed from the outside, agents or parts located inside the system can also access the outside, hence they are different to closed systems since they. Information-flow and conversation between inside and outside is enabled. The open system can underlie principles of 'dynamic equilibrium', however this is not a requirement. In contrast to processes carried out in closed systems, processes in open systems are irreversible and cannot be undone (Bertalanffy 1968 pp.30-52)[13]. Once the system is made of a group of parts, it underlies basic principles of complex systems, with interconnected parts (agents or actors). Communication about a given problem is possible through the infrastructure of the Internet. Feedback is essential for the complex open system to 'work', to be viable and resistant.

Thoughts on Foundations of Netgrafting Form

To understand the logic of how an architectural form (a form-giving algorithm or a script to operate a robot arm) is grafted by 'graftsmen' around the globe we need to analyze the complexity system as a whole and the 'make-up' of its parts in order. According to Ashby, this becomes difficult in system with high complexity: "when there are only two parts joined so that each affects the other, the properties of the feedback give important and useful information about the properties of the whole. But when the parts rise to even as few as four, if everyone affects the other three, then twenty circuits can be traced through them; and knowing the properties of all the twenty circuits does not give complete information about the system. Such complex systems cannot be treated as an interlaced set of more or less independent feedback circuits, but only as a whole." (Ashby, 1957 p.54).

Ashby's understanding of the complex system as a whole is visible in crowd-behavior of any kind where, let's say, parts in a colony communicate with each other, including schools of fish, swarms of birds, connected IoT-devices, algorithms, bots, ants and also humans. In intelligent brain-like network structure allows the parts to regulate the whole's survival strategy. The mentioned examples are all resilient living systems – some of them biological and organic, some not. Resilient systems found in nature, biology and physics have developed techniques (scripts) that behold a large number of possibilities of reaction in case of danger. A strategy based on knowledge (information embedded in the systems and in the parts) guarantees development and evolution through error control. Error control implies that the effectors of a certain error are known to the

Error control implies that the effectors of a certain error are known to the system, that the system has sufficient information in order to 'sense' an error.

system, that the system has sufficient information in order to 'sense' an error. In cybernetics terms, such systems or organizations are equipped with requisite variety. The Law of Requisite Variety, known as the first law of cybernetics, was developed by Ross Ashby and first published in '*An Introduction to Cybernetics'* in 1957. The law states that the number of actions available to control a system must be equal or larger than the variety of perturbations (Ashby 1957). Thus the number of elements and its material behavior determines the degree of complexity of the system, while the relationship between degree of complexity and resilience – or comprehension of information - is isomorph.

We could argue that only if the designer of a system understands each element he or she can steer/graft the design process of the system.

We could argue that only if the designer of a system understands each element he or she can steer/graft the design process of the system. Since it is impossible to fully understand each part in a complex system, an abstraction of the part's attributes is applied. This manifests in the temporary coupling with a small number of parts in the system. In our case of computational architecture, the knowledge (information embedded in the systems and in the parts) mentioned above does not imply or even guarantee a clear vision of the formal outcome, but an idea of behavioral patterns and possible consequences of relationships between the elements. According to Ashby a set of distinguishable elements in a system enabling a distinguishable number of actions gives the system its number of variety and its number of behavioral patterns – internal and external. Architecturally speaking, each behavioral pattern has the potential to give birth to one or more typologies of form - more or less complex[14]. Both terms, 'form' and 'pattern', are long established in architecture. Wentworth D'Arcy Thompson (Thompson 1961)[15], Christopher Alexander (Alexander 1971), Nicholas Negroponte (Negroponte 1975) have primed several generations of architects. John Frazer's *'Evolutionary Architecture'* (Frazer 1995), and Greg Lynn's *'Animate Form'* (Lynn 1999) gave way to exploring the feedback, the novel tools and the digital offered. "In addition to the aesthetic and material consequences of computer-generated forms, computer software […] offers capabilities as a conceptual and organizational tool." (Lynn 1999).

Ranulph Glanville gave ground to a cybernetics and design and reflecting disciplines (Glanville 2009). In architecture, especially since the first digital turn in the 1990s, computer software has offered formal variety and organizational 'skills'. In the 2010s reaching an overwhelming level of complexity between hardware and software, designer and computational design-strategy (multi-agent systems, flocking, DLA, genetics, subdivision, structural optimization), aesthetics and engineering, politics, tectonics and environmental context. The science of complexity has grown into a major field of research in itself in order to shed light on the interwoven processes of the natural and ubiquitous digital world. Continuously improved code, regulates symbiotic relationships between industrial robots and natural spiders, digitized tectonics and augmented reality – and receives feedback. Interacting living processes between seemingly unrelated domains are digitally linked. A life form of organization is driving the second generation of *cybernetics and architecture*. The characteristic of life "[…] does not lie in a distinctiveness of single life processes (Lebensvorgänge), but rather in a certain order among all the processes" (Bertalanffy 1934). Platforms or virtual codelabs such as OpenProcessing and GitHub are nodal points for an order of living organization that has grown to a common good over the last years. They have contributed to the shifting notion – and by now illusion - of singular authorship. Instead a netgrafted systemic design approach is present and applicable to at least some parts or even all parts of a project. Architecture emerges into what we could call a multi-parametric net-verse. A dynamic space inhabited by a growing number of users and designers found in almost all disciplines, formally alien to each other.

A life form of organization is driving the second generation of cybernetics and architecture.

Conclusion

Leaving aside the techniques in form of multitudes of virtualization and digital design and manufacturing methods makes room for understanding architecture form, beauty, aesthetics, tactility based on feedback. Prerequisite for this argument is that architecture has cognitive, hence biological, capabilities. Past and contemporary excursions lead us into the world of the bio-digital and genetic architecture. We the 'creators' of architecture interacting with the mechanics of biological principles such as growth, aggregation or subdivision. Intriguing results lured us into a world of form-fantasm. Still, "we are […] happy to 'borrow', but the advent of the genetic algorithm in architecture, and still limited interdisciplinary exchange bears the risk for bio-digital and genetic architecture to remain as representative, formalist stylistic betrayal; rather than comprehending, and adopting concepts of behavior, information, feedback and biological-cognition as the design-processes leading to form." (Werner 2014). Cybernetics as metasystem offers tools that can create interpolants between the various design-requirements, data sets, parameters, processes, operations and approaches mentioned above. The act and knowledge of defining the projects we work on and with through architectural AND cybernetic terms may assist in distinguishing trails and error from governing design. If we start understanding architecture not as architects, but as cyberneticians we may learn about it as organization, closed or open system, autopoietic ecology, evolutionary or coupling (Varela 1974). Understanding the architecture we create as learning network, as phenomenon constructed out of difference (Bateson 1999, 1971)[16] and distinction (Brown 1972), treating the actors (the scripting architects) and the agents they code as carriers of information for conversation (Pask 1976) may lead us towards a clarification of the new architectural craft we are trying to master. Cybernetics, once understood as *Control and Communication in the Animal and the Machine* (Wiener 1948) is starting to take an effect on design disciplines, as processor as interface as protocol.

If we start understanding architecture not as architects, but as cyberneticians we may learn about it as organization, closed or open system, autopoietic ecology, evolutionary or coupling (Varela 1974).

The questions still to be answered or to be discussed include

a) how can we refer back to our architectural heritage, or should we accept current developments as a stage change, a step in the evolution of architecture, and

b) will the new typologies that are emerging and merging through netgrafting and design processes between humans and machines create new architectural spatial and material values?

Whatever the answer is, there are exciting times to come for architecture and cybernetics.

Endnotes

1 The term ‘objectile’ stems from Deleuze, The Fold p.20: “[…] the object assumes a place in a continuum by variation; where industrial automation or serial machineries replace stamped forms. The new status of the object no longer refers its condition to a spatial mold – in other words, to a relation of form-matter – but to a temporal modulation that implies as much the beginnings of a continuous variation of matter as a continuous development of form.” (G. Deleuze, 2006). In the present ‘objectile’ refers to the iterative design process enabled through programs designed for designing and testing variations according to adjustment of parameters, hence a technological evolution from mechanical industrial automation to digitally ‘generated’ and operated industrial automation of morphology of form.

2 ‘digitization’ refers to the process of transforming / converting information into a digital form, ‘digitalization’ refers to the process of a cultural, hence political, sociological and possibly teleological transformation caused and fed by digitization. The digitization of architectural construction process influences the culture of building inherently. The digitization of generating form (through algorithms in form of code) transforms the culture of form-finding.

3 Gordon Pask used the term pruning, referring to the process of regulating the shape of plants during their future growth process

4 Netgraft is a networked ‚graftsmanship’ related to a ‚neurotecture’, developed as a term and action in ‚Codes in the Clouds: Observing new Design Strategies’, (Werner, 2011)

5 See Ross Ashby’s ‚Laws of Requisite Variety’, introduced in ‘An Introduction to Cybernetics’, 1957. (Ashby, 1957)

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7 Erich Hörl embeds this theory of Gilbert Simondon in his introduction to ‘General Ecology’, (Hörl, 2017) p.11,

8 see Carpo, 2017. (Carpa, 2017)

9 The Greek term ‘cybernetics’ was first used by Plato in the ‘Politea’. It means steersman, ‘cyber’ means steering or governing. Since the 1950s Cybernetics has reached its third iteration, ‘the cybernetics of cybernetics of cybernetics’.

10 The reader may refer to the introduction as well as chapters 01 and 02 of this book

11 See Paul Pangaro and Hugh Dubberly

12 see similarity to Christopher Alexander, chapter ‘The Source of good Fit’. Alexander graphically describes a system of interconnected, interlaced points (variables). In the next diagram, he circumferences two parts of the network with one circle each, showing that “[…] since not all the variables are equally strongly connected (in other words there are not only dependences among the variables, but also independences), there will always be subsystems like those circled below, which in principle, operate fairly independently.” (C. e. a. Alexander, 1977) p.43. Alexander at this point refers to Ashby “For the accumulation of adaptations to be possible, the system must not be fully joined” (Ashby, 1954) p. 155.

13 I recommend a study of ch. 1-2 of ‘The General Systems Theory’, by Ludwig v. Bertalanffy. In the 1st ed., he shows the differences between Ashby’s understanding of (open) systems and his theory of systems. (Bertalanffy, 1968)

14 See 'On Growth and Form', D'Arcy Wentworth Thompson, 1917

15 originally published in 1917

16 "Information is a difference that makes a difference.", Gregory Bateson, (Bateson 1999, 1971) p.459

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Designing designing: Ecology, Systems Thinking, Designing and Second-Order Cybernetics

Michael Hohl

> *"Is there an underlying, universal problem at the root of most short-lived or failed design solutions? Is the real issue our perception of problems and the way we frame them within context? Are we failing to take into consideration the inter-connectedness and interdependencies that are present everywhere?"*
>
> Terry Irwin 2004

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In this chapter I discuss how learning from living systems might provide a new perspective for approaching design problems and the design process. This learning would focus less on visible structures, such as the Lotus effect or aerodynamic shapes, but on relationships between elements, processes and systemic qualities, observed in nature. The latter are less easy to grasp and insights require time to emerge. As an example of principles learned from living systems I will discuss Linda Booth-Sweeney's 'habits of mind of a systems thinker' and discuss these 'habits' from a Second-order cybernetics (SOC) perspective. As a perspective SOC might add another layer of critique, reflection and ethics to the 'habits of mind', perhaps creating a theoretical framework to benefit a design process. This framework - bringing together new habits of acting and learning from nature together with a corrective theory of why and how to act - explicitly considers care, values, ethics, responsibility, and consideration of other positions, beyond mere self-interest. For the benefit of both, the 'habits of mind of a systems thinker' together with SOC might form a theoretical (design) framework to which other disciplines, such as social sciences and philosophy, among others, may contribute. These habits may be applied on different levels of scale and different phases of the design process. The goal here is to design societies, products and services for which the concept of sustainability and care are imperative. This includes, among others, applying a long-term perspective, conscious use of resources, energy, ecology and economy.

Keywords: Ecological literacy, second-order cybernetics, systems thinking, Designing, values, thinking, habits

Designers from various fields have been thinking of how to integrate principles observed in nature to designing. The idea behind this being that nature's principles, those of living systems, having evolved over millions of years in countless iterations, are often efficient, sustainable, elegant, do not waste energy, and as such have stood the test of time. Learning from these principles may allow us to adapt our more systematic arts, crafts and sciences (technologies) to perform as elegant and robust as nature. Learning from nature is not a novel approach and is often associated with biomimetics or biomimicry, "the conscious emulation of life's genius" (Benyus 2002, 2). While Benyus states that biomimicry could potentially change the way we grow food, make materials, harness energy, heal ourselves, store information and conduct business (Benyus 2002, 2), it might be best known for imitating 'hardware', e.g. such as the Lotus Effect and aerodynamic shapes. From hardware, the interest lead to software development, where it informs algorithms for collective behaviours such as swarming, herding, flocking, schooling or similar. Here many individuals display complex behaviours based upon simple rules. These software applications may also be viewed as methods of enquiry for understanding natural principles. So how might we grow food, make materials, harness energy, in a more sustainable and efficient manner? Identifying systems, the relationship between elements and discovering patterns is not a straightforward process. They often are not apparent and do not reveal themselves easily. An example for this might be the symbIoTic relationships between insects, trees and other plants within particular habitats (Hohl 2012). Here, becoming aware of the hidden connections is less straightforward then researching the Lotus effect. Many indigenous societies have learned about these cycles and relationships intuitively through acting and observing in a particular habitat over many generations. However, from a rational and reductionist scientific perspective such knowledge is not regarded as acceptable as it is not the result of a proper scientific research process.

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In the last decades, several lists have been compiled, that transfer interpretations of the workings of living systems to recommendations for human acting. Possibly best known among designers is the above-mentioned biologist Janine Benyus and her 1998 publication '*Biomimicry: Innovations inspired by nature*', which she subsequently inferred into more general "12 sustainable design ideas from nature" (Benyus 2007), for example 'the power of shape' and 'self-assembly'. Related to those is Hugh Dubberly's (Dubberly 2008) observation that design was shifting from a mechanical-object ethos to an organic-systems ethos, and points to emerging similarities between design and biology having become visible through "a focus on information flow, on networks of actors operating at many levels and exchanging the information needed to balance communities of systems". Among those are principles such as 'embracing complexity' or 'self-organising'. Pioneering systems scientist Donella Meadows distinguished nine rather abstract 'leverage points to intervene in a system', which she subsequently adapted into a twelve-point list of 'places to intervene in a system', among those "parameters, stocks, delays, flows, feedback and mindset" (Meadows 2008, 145). Gordon Rowland who based his style of teaching upon Bela Banathy's comprehensive social systems design applies such principles to social systems. In includes principles such as "expanding boundaries; considering interdependencies and interactions with and impact in the larger system; designing with rather than for clients;." among others (Rowland 2014).

Among those are principles such as 'embracing complexity' or 'self-organising'.

Physicist Fritjof Capra distinguished between 'six principles of ecology' which include networks, nested systems, cycles, flows, development (emergence), and dynamic balance (Boehnert 2012). Another concept oriented towards a better understanding of principles of nature is Ecological Literacy. Ecoliteracy is an educational practice that aims to increase human understanding for the principles of how ecosystems work. It emerged from the Center for Ecological Literacy in Berkeley, California, founded in 1995, and is based on ideas of physicist Fritjof Capra (Capra 1996, 2007), environmentalist David Orr (1991, 2002); ecoliteracy has links to Alice Waters' 'Edible Schoolyard' project' (Waters 2008). Developed by educators Michael Stone and Zenobia Barlow, ecoliteracy is not an additional subject added to the curriculum but a perspective through which any topic can be taught. The idea here being that systems

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thinking lead to a particular way of thinking, acting and being in the world which is best adopted at an early age. They also developed the *'Seven lessons for Leaders in Systems Change'* (Stone/Barlow 2011) which I have discussed in more detail at another occasion (Hohl 2015). Designer and educator Terry Irwin (Irwin, 2011), developed a theory around "10 living systems principles", which includes ideas from Capra, Benyus, Meadows and Rittel. Irvin's theory discusses the principles' relevance to Transition Design, a post-graduate design education program offered at Carnegie-Mellon University. The mentioned examples demonstrate that in the past decades there has been a growing interest in learning from living systems and applying these insights to how we think and act as designers. In the next step, I will discuss the relevance of this concept to Second-Order Cybernetics (SOC), which is related to Systems Thinking.

Second-order cybernetics (SOC)

While cybernetics, as defined by Norbert Wiener (1948), as the 'the science of control in the animal and the machine', second-order cybernetics (SOC) aims at the understanding and critique of cybernetics applied to itself. Considering the role of the observer, which traditional sciences rarely include, SOC focusses upon the epistemology, ethics, self-referentiality and emergent properties of complex systems. These systems may include language (Conversation Theory), Autopoiesis (Maturana, Varela), Living Systems Theory, Group Therapy, Organisational Theory, (Russell Ackoff) and Artificial Intelligence, among others. How do systems thinking and SOC reflect each other? Glanville notes that Wieners follow-up volume '*The Human use of Human beings*', published in 1950, should have been published first, as the order led to the misconception that cybernetics was an engineering subject. The second volume, so Glanville, was about a way of thinking, a way of being in the world, which was a different proposition. The difference between systems and cybernetics, so Glanville, was that 'cybernetics' was more abstract while 'systems' tended to be more pragmatic. Glanville and others suggested that it did not matter which word was being used. If there was a difference it was that cybernetics was

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the dynamic complement of systems. For example, typical diagrams connecting boxes with arrows would have systems scholars be interested in the boxes, while cyberneticians were interested in the arrows (Glanville 2014).

As a meta-discipline it philosophizes human knowing, technology and our discussions of systems, networks and the relationships we identified.

SOC creates a layer of deep reflection, a dimension which appears to play a less prominent role in first-order cybernetics, taking into account ethics, values and epistemology. As a meta-discipline it philosophizes human knowing, technology and our discussions of systems, networks and the relationships we identified. While cybernetics could be viewed as designing things right, e.g. building planes that can be operated safely, SOC could be viewed as the ethical dimension, reflecting upon which types of planes to build, or not to build, or designing the right things. Related to this also is Heinz v. Foerster's theorem Number Two, that the 'hard sciences' were successful as they dealt with the 'soft problems', problems for which there was a viable solution, while the 'soft sciences', such as social sciences, were badly off, as they dealt with the 'hard problems', for which there usually were no clear solutions or problem description (Foerster 2003, 191). With SOC re-emerges a layer that may have been customary in some traditional societies, where the effects of human actions upon the environment, resources and following generations were observed and considered deeply, especially within precarious ecosystems such as island habitats. These considerations affect the thinking and acting, language, and, over time, shape a particular mindset, a culture (Hohl 2017).

Above I tried to demonstrate that knowledge inferred from nature is inspiring new ways of thinking and acting in the world, from the 'transition design' curriculum to ecological literacy education. Perhaps some traditional and indigenous knowledge has in the past led to comparable ways of acting, where intimate knowledge of a habitat was linked to distinct values and ethics. However, these ways of knowing were based on a different epistemology than our enlightened scientifically oriented culture would accept as reasonable. Indigenous societies constructed their proper ways around customs we might view as mythical, irrational and superstitious today. The models briefly introduced above however are based upon scientific thinking, and as such have more acceptable origin. How might Second-Order Cybernetics contribute to a society which integrates living-systems knowledge in combination with values and ethics? As an example of linking systems thinking, SOC and designing with a dimension of ethics and values I will discuss Linda Booth-Sweeney's '12 habits of mind of a systems thinker' (Booth-Sweeney, Meadows 1995).

12 habits of mind (of a systems thinker) by Linda Booth-Sweeney

Linda Booth-Sweeney's 'habits of mind' were derived from Donella Meadows' "Systems principles" (Meadows 2008, 188-191) and Arthur Costa's 'Habits of Mind' (Costa 2008), the latter beginning with the individual and expanding out to the entire community. The 'habits' emerged from the field of systems thinking but also have links to organisational learning, systems dynamics and mental models. They are viewed as an open framework that is likely to expand as new habits are added to the list. Below I will continue to discuss the "12 habits of mind of a systems thinker", relating them to design education and a SOC perspective.

1. Sees the Whole: sees the world in terms of interrelated "wholes" or systems, rather than as single events, or snapshots;

Seeing the whole, compared to a constrained perspective, applies to different phases of the design process. (If we structure the cyclical process as: Problem identification, analysis, defining solution, ideation, selection of solution, realisation, evaluation (with feedback loops between the different phases)). In the earliest phase, which often consists of identifying the problem, it reminds the designer to look at the situation from a larger, birds-eye perspective. How are the problems connected to larger, intractable problems? Some design processes are open-ended and can be viewed as a research process where the solution is not known in the initial stage. Other design processes, especially those existing in a professional setting clearly outline the desired solution. If the initially stated goal is the design of an office chair, the result will be an office chair. However, in a 'seeing the whole' approach, it might be novel working styles and

Some design processes are open-ended and can be viewed as a research process where the solution is not known in the initial stage.

conditions or back-pain that might be considered. Then working on tables with adjustable heights, working while standing, or working from home, begin to play a role. During the ideation and selection of solution stages designers might consider how their idea integrates into existing contexts and how it might affect those. Or viewed through Capra's principles: How does it affect ecology, community, sustainability? From a SOC perspective a 'system' also is 'a way of looking at the world'. This 'system' does not exist independent of the observer out there in the world, but the distinct elements and the relationship that they have with one another are distinguished by an observer. They may or may not exist. While some of the elements that constitute said system might be observed, others are not. The true complexity of the connections between all elements of a system may never be fully understood. As such we could view a system as another model we have of the world. As we can never know the world fully, we may want to be careful and tentative in making decisions, and take responsibility for our actions.

From a SOC perspective a 'system' also is 'a way of looking at the world'.

2. Looks for Connections: assumes that nothing stands in isolation; and so tends to look for connections among nature, ourselves, people, problems, and events;

Here a designer will consider how the design connects to the problem it tries to solve, how it is connected to ecology, community, and sustainability. This may also link to Rittel's 'wicked problems' (Rittel and Weber 1984), where design problems often are symptoms of larger, systemic problems for which there is may be no satisfying description and solution. How will the design solution affect the existing context? What will it make obsolete? What new connections might emerge? How will the system change? Then we might design with these considerations in mind. At present discussions around these issues are being held around automation and Industry 4.0.

This may also link to Rittel's 'wicked problems' (Rittel and Weber, 1984), where design problems often are symptoms of larger, systemic problems for which there is may be no satisfying description and solution.

3. Pays Attention to Boundaries: "goes wide" (uses peripheral vision) to check the boundaries drawn around problems, knowing that systems are nested and how you define the system is critical to what you consider and don't consider;

Again, in view of SOC, boundaries are perceived boundaries by an observer. Another observer might distinguish different boundaries. A psychologist, an economist or a physicist have different perspectives and might distinguish different boundaries around the perceived problem. In conversations, different stakeholders may agree upon a shared perspective upon boundaries. In recent years, this has been acknowledged in the design process. While in the past a more 'heroic' expert design approach was present, this has given way to design methods which view the stakeholders as experts for their problems. Especially through User-Experience Design, Participatory Design methods, co-design or design thinking, other perspectives have played an increasing role in the initial design process. Also, testing and designing in different iterations have become standard.

4. Changes Perspective: changes perspective to increase understanding, knowing that what we see depends on where we are in the system;

As described above with the boundaries of problems, designers are aware of the benefits of changes in perspective. They consult or even involve different stakeholder to develop a comprehensive view of the problem's context. They also consult experts and conduct interviews. How will the proposed solution affect different stakeholders, such as cleaning staff, the ecology, what if everyone was using one, how does it affect the manufacturer, the workers making it? How will it be used? What might other, unintended ways of using it be? How will it affect the ecology? Will it last?

5. Looks for Stocks: knows that hidden accumulations (of knowledge, carbon dioxide, debt, and so on) can create delays and inertia;

Stocks have been described by Meadows as 'the memory of the history of changing flows' (Meadows 2008, 188). This might also include old ways of thinking or habits which might affect openness for a new proposition. Who might be interested in leaving things as they are? Who benefits from the current situation? May it be used in conventional settings, or does it establish new norms? From a SOC perspective this might be viewed as 'old paragims' or ways of thinking that must be taking into account.

6. Challenges Mental Models: challenges one's own assumptions about how the world works (our mental models) — and looks for how they may limit thinking;

Mental models are perspectives we hold, often without being consciously aware of them. They include values, deeply held beliefs, stories and scenarios (Booth-Sweeney 1995). From a SOC perspective this requires an openness to challenge own thinking, to question those values and beliefs, to try new methods and perhaps strive against the impulse to repeat what worked well in the past. This might result in new learning experiences and new insights. For example, the designer might view himself as an enabler and facilitator. Also, from a SOC perspective a designer enables while disabling simultaneously. By deciding what and how a design facilitates or mediates particular actions, inadvertently other actions will be excluded which might be desirable to aid usability or simplicity. An example might be the ability to make one's own tools, or rely on the tools made for us by others. How does a design solution empower users within its constraints?

Mental models are perspectives we hold, often without being consciously aware of them.

A designer enables while disabling simultaneously.

7. Anticipates Unintended Consequences: anticipates unintended consequences by tracing loops of cause and effect and always asking "what happens next?"

How will it affect the users in the long term? How will it affect the producers? How will it affect the ecology? For the designer, this might include to conceive two solutions. A traditional one among a more radical and compelling one. Often design changes how we interact with one another. At another occasion, I wrote that travelling by train twenty years ago it could be considered impolite not to strike up a conversation with the fellow passengers on the train. Today the opposite might be true, as travellers are busy handling their mobile devices. To an observer, it might look as if the design brief had been to stop citizens talking to one another. To provide them with headphones and small screens filled with moving images. Yet most likely the designers of mobile technologies intended to connect people and provide compelling experiences. If we begin considering the long term it becomes clear that it is very hard or perhaps impossible to imagine unintended consequences. Working with scenarios, testing a design with a small group of people might give helpful evidence. Another solution might be to keep studying the effects of a design after it has established itself. This idea leads us to the next habit. From a SOC perspective the idea of feedback is an essential part. Distinguishing between negative feedback (for example a thermostat controlling a heater) or positive feedback (a process amplifying itself as in the feedback-loop between a microphone and a loudspeaker). One is in a state of equilibrium, the other has run out of control. Here it also might affect the habits and behaviours of users with long term effects.

Most likely the designers of mobile technologies intended to connect people and provide compelling experiences.

8. Looks for Change over Time: sees today's events as a result of past trends and a harbinger of future ones;

From a design perspective this may concern the initial problem definition, the design process itself, as well as the final goal or solution. What is the problems relation to time? Perhaps the problem only shows up under certain conditions? Central to design and SOC are the concepts of a) recursion and b) iteration. Every design process begins with a particular idea and a prototype will be tested in multiple iterations until the results are satisfying. The design process is a learning process. From a recursive perspective, the design process also might continue after the initial goals have been achieved in order to improve quality; an approach especially seen in today's software applications. Often a beta-version is made publicly accessible, it is being tested and feedback is provided be the testers in order to improve the product. This process might go on continuously. So many non-critical applications might be viewed as being in beta. The application changes over time.

Every design process begins with a particular idea and a prototype will be tested in multiple iterations until the results are satisfying.

9. Sees Self as Part of the System: looks for influences from within the system, focusing less on blame and more on how the structure (or set of interrelationships) may be influencing behavior;

Designers take into account not only the design process itself, but a different view upon framing the initial design problem, adopting a larger perspective, seeing how a design solution might be part of a larger wicked problem on another level. We could interpret this as that to change the world by designing begins with oneself in the personal environment, through acting, responsibility and conscious decisions - not only striving to change policy. Designing for sustainability begins in thinking and acting local. Design might be a life project and begin in one's own home. How do you wish to live? For example, in your own kitchen. How do you cook? What do you eat?

Designers take into account not only the design process itself, but a different view upon framing the initial design problem, adopting a larger perspective.

Local produce, local materials, what does a sustainable life, a sustainable breakfast look like here in your hometown? Where do materials and produce come from? From a SOC perspective this is an important concept, that the observer is part of the system she observes. Heinz v. Foerster writing that objectivity was the delusion that observing could be done without an observer (Poerksen 2004).

10. Embraces Ambiguity: holds the tension of paradox and ambiguity, without trying to resolve it quickly;

Usually we strive for clarity, avoiding ambiguity and paradox. Possibly this is a cultural trait that encourages a dualistic either/or perspective. However, if we permit ambiguity we might learn something new. This is very much a position in the spirit of SOC, which is aware that each person has their own way of viewing the world, and that we need openness and generosity in order to understand one another. The contradictions we are observing might not be contradictions for another observer. Returning to the metaphor of feedback and the thermostat avoiding rapid oscillation between on and off states due to two switching points, it shows an inherent trait of SOC, of appreciating an equilibrium between two distinct states, "not of single causes and effects, but rather of equilibria between constraints"1 (Glasersfeld 2000).

11. Finds Leverage: knows that solutions may be far away from problems and looks for areas of leverage, where a small change can have a large impact on the whole system;

Defining the leverage and developing a convincing, rational argument around it is central do designing.

Imagining how small interventions or improvisations might change a situation is an essential part of designing, especially in problem-based approaches where designers try not to jump to quick conclusions but instead try to stay open for developing new insights. Sometimes a video might solve a problem, at other occasions a leaflet will be more useful. Defining the leverage and developing a convincing, rational argument around it is central do designing. This might be developed further into improvised workarounds, and playful speculations about the possible causes or alternative solutions for problems.

12. Watches for Win/Lose Attitudes: is wary of "win/lose" mindsets, knowing they usually makes matters worse in situations of high interdependence;

Here we touch upon the beliefs and values mindsets and mental models. Again, these can pertain to different phases of the design process and levels of interaction, be it team members, clients, users, stakeholders, or partners of a project development team. Avoiding a win/lose attitude will result in more conscious interactions, reflection and critique. From a SOC perspective this encourages us to create an awareness for different mindsets, foster discussions and making them explicit. This reflective process also encourages to take responsibility for our actions and to care. To be aware that other stakeholders might have different perspectives. The goal here might be to create a shared mindset which all stakeholders can identify with, avoiding a Win/Lose Attitude.

Discussion and Conclusion

Above I have discussed how the '12 habits of mind of a systems thinker' may be relevant to designing, while framing these through ethical and value based thinking provided by SOC. I think what has emerged is that systems thinking and SOC have an intrinsic relationship. They appear to investigate the very same phenomena, however, from different perspectives. One perhaps viewing systems thinking more in view of concrete application, while the other is more interested in abstractions and theory. At the same time the intertwined relationship between designing and cybernetics has become clearer. This has been addressed by Glanville, who reminds us that "[C]ybernetics is the theory of design and design is the action of cybernetics" (Glanville 2007). In that sense SOC, Systems Thinking and Designing could be viewed as a triangle of a theory of knowing, applicable acting, informed by ethics and values. All of which feeding back to one another in a continuous process of change and learning. In this model theory is emerging through

SOC, Systems Thinking and Designing could be viewed as a triangle of a theory of knowing, applicable acting, informed by ethics and values.

practice, in a subsequent iteration theory is being applied to practice, the resulting experience in return shaping values and ethics, and vice versa. By viewing design problems and the design process from a perspective informed by systems thinking, this reveals at least two distinct dimensions. One informing why and what we design, the other how we go about designing. Why and what we design will involve considering values, ethics, future generations, durability, sustainability. But how might it affect how we go about actually designing? This might be where the more pragmatic systems thinking approach of the '12 habits' come into play, completing the triangle of ethics, theory and application. In design research contexts, this may allow new theories to emerge. It is here where I see great potential for new ways of designing in at least two ways. First it encourages learning from nature beyond biomimicry and adopting a perspective of systems thinking. This might involve conceiving innovative design ideas observed in nature (of which biomimetics may only be one), a deeper understanding of bottom-up development in multiple iterations, the value of reflection and perhaps sharing this knowledge through clear communication. All these may become habitual and benefit the entire design process on multiple levels. As in SOC, this opens up the design process for other perspectives and new ways of thinking. The model also encourages self-organisation and networks, inviting novelty and change. Disappointments can be viewed as learning opportunities. Ideally designers being educated in these systems thinking principles may expand these insight into a cybernetic way of life, a way of continuous learning, questioning and openness for change. The design process becoming a research process and a learning process.

Disappointments can be viewed as learning opportunities.

Endnotes

1 Quote: *"It leads us to think in terms, not of single causes and effects, but rather of equilibria between constraints. This helps to avoid the widespread illusion that we could gather "information" concerning a reality supposed to be causing our experience; and it therefore focuses attention on managing in the experiential world we do get to know."*

2 von Glasersfeld E. 2000, 'Reflections on cybernetics', *Cybernetics & Human Knowing* 7(1), pp. 93–95.

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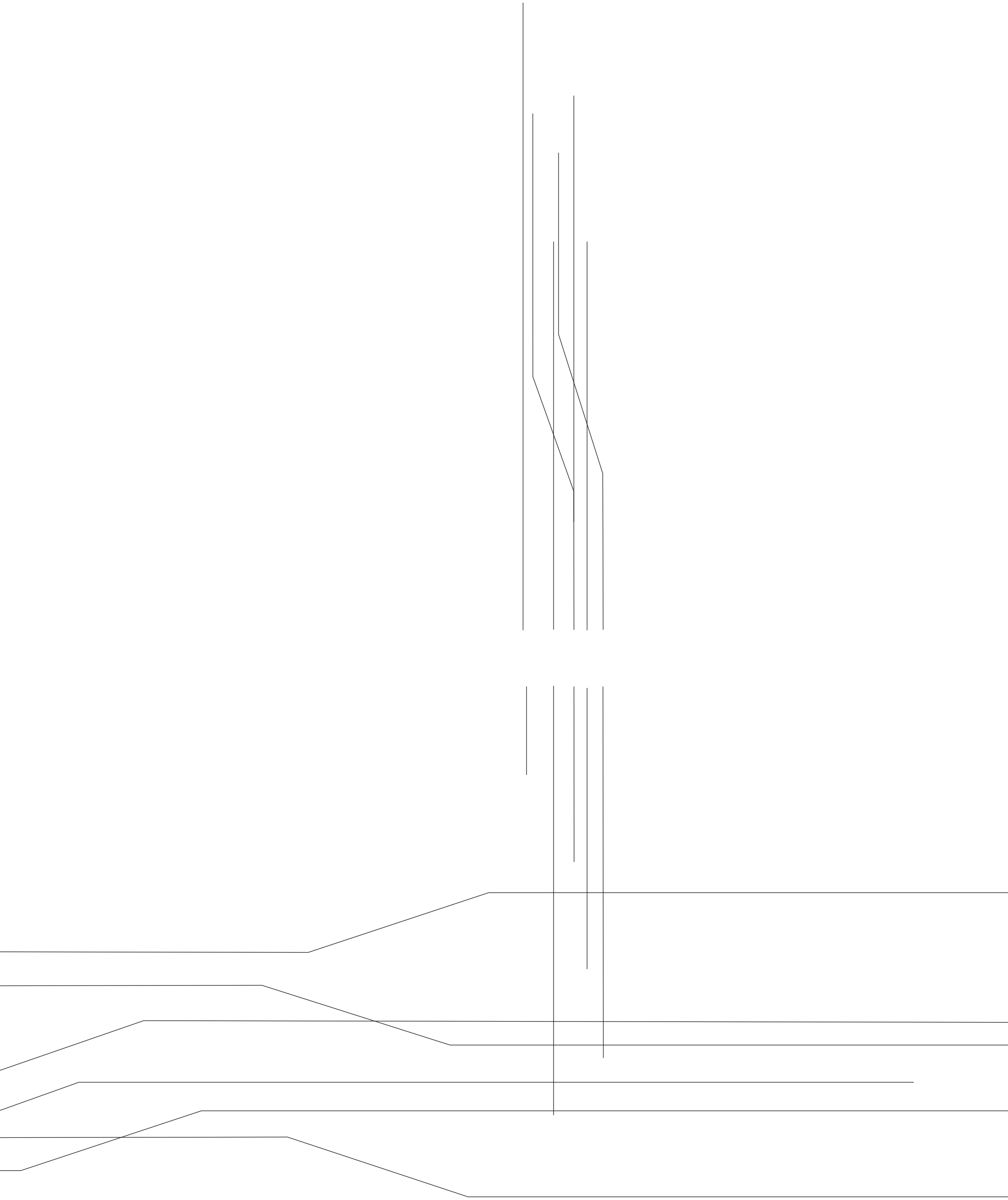

PART 2

SYSTEM 5

The second Skin: From Cybernetics to Conscious City

Raoul Bunschoten

What is the *Conscious City*, how do we plan and construct it, and what are its historical and conceptual foundations? Why is cybernetics important for the understanding of both its emergence as well as for its use as a theoretical framework and as practical tool? The shift in the balance from First Skin to Second Skin, at least as perceived or constructed through the human consciousness, happened some time during the 20th Century when our scientific knowledge of climate change affirmed the radical nature of the Anthropocene, with rapid temperature increases certain to happen, and the global topology of digital networks, data and the internet becoming a form and presence distinct form he First Skin. The Anthropocene is the era in which homo sapiens became the first species that has had an effect on the global ecosystem, according to Yuval Noah Harari in his book Homo Deus. Instead of the Holocene era following the Pleistocene, scientists use the word Anthropocene to describe the current geologic era. During the last 70.000 years, but especially since the Industrial Revolution or as Harari calls it the age of humanism, in which human life, happiness and well being are the focus of human society. Humans have started to influence global ecologies to such an extent that not only their relationship with animals and plants have changed radically, humans have also changed the dynamics of the atmosphere.

Keywords: Second Skin, Conscious City, Smart City, Urban Gallery, prototyping

The First Skin is a dynamic environment, but humans have affected the speed and directions of its dynamics. This is what climate change has come to mean. I am writing this on the island of Stromboli, an active volcano which is perhaps closest to a kind of primal nature, with no influence of human beings whatsoever determining its dynamic behavior. You can come close to the fire, but it is something very different, untouchable, and a very powerful expression of the dynamics of what constitutes the First Skin, and what lies below this skin. The core of the earth, its enormous volume of magma, is something which we know very little about and cannot influence in any way possible, and yet, that fire, in addition to that of the sun, supports our life and evolution. The First Skin of the Earth - nature as we know it through history, culture, science and direct experience - has enabled life to emerge and evolve for billions of years, and very recently enabled sentient beings to inhabit the Second Skin, and homo sapiens to go through a process of domestication. This domestication of the homo sapiens, through the formation of urban civilisations, social and political transformations and the recent industrial revolutions, has been culminating in the digital revolution and the possibility of machines as sentient beings, sharing a consciousness and purpose that forms the Second Skin of the Earth. In my six lessons of the Smart City, published as part of the Smart City to Conscious City article in urban design magazine of TsingHua University, Beijing China, I wrote about the need to move from mere intelligent systems as the new urban planning tools to recognizing that these systems will eventually behave, will need to operate collectively and will join up their intelligence and will need new tools and will need new tools and modes of operation, as well as clear goals and visions. In this chapter I am aiming at sketching out a manifesto for a new way of urban thinking, and create a brief for an exhibition which brings together the work of CHORA with many other projects, theories, historical events and ongoing projects. The main aim of the text is to introduce the theme Conscious City. In order to do that I needed an overall concept which places the Conscious City in the context of the history of humankind and the global habitat it has domesticated, or within which it has itself domesticated. The concept is the Second Skin, which I introduced in the book *'Urban Flotsam'*. The structure of this book was an architecture I called the *Urban Gallery.* This architecture, in the '*Urban Flotsam'* mainly a way to organize the development of a body of thought and projects, became gradually the core structure for the planning support tool which now forms the core of our *Conscious City Lab*, formerly the *BrainBox*. This planning support tool is in fact a contemporary cybernetics tool. It is a tool which combines learning with the generation of a kind of collective intelligence, and standardization of urban complexity with the formation of narratives,

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creative coding with the algorithms of emotions. The need for such tools comes out of the challenges new technologies pose, as well as the effects on society and global ecosystems. The First Skin is perhaps an unavoidable reality, or a utopia. Either way, we need to think big and test the visionary scenarios offered to us by science, industry and culture.

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Conscious City

The Conscious City is physically formed by the places where humans live, work, produce, play. These places are predominantly cities and the networks and systems that extend from cities into space. They tie humans to these all these places of work, leisure and coming together and link the places to each other and both humans and places to the First Skin of the Earth.

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Since the digital revolution data is used to convey information through networks that further link humans, systems and nature together. Data are used to generate information flows, and models that use these information flows to evolve according to the dynamics of nature and society, to create real time representations and simulations of the complex dynamics of both nature and human society. When these models and systems are instructed to make interpretations and decisions based on such models, a machine intelligence is created (the 'smart' adjective added currently to many objects, systems, cities, even people).

Human intelligence emerges from neural activities in the brain, and consciousness is a product of this intelligence once it is combined with feelings, memory, perception, and an awareness of oneself. Culture expands that into a collective intelligence. Cities and their places and systems are formed by this human consciousness, and are physical extensions of both the body – streets, squares, buildings are still measured by a 'human scale' - as well as the cultural context of collective consciousness. The intelligence of urban systems, developed through a combination of data, sensors, connective networks and processing power, enables humans to increase their health, comfort, wealth, and make more efficient use of natural resources. In other words, the intelligence of emergent technologies and the systems humans create based on these emergent technologies and intelligence enable humans to negotiate the challenges of poverty, inequality, and climate change mitigation and adaptation. The Conscious City indicates an awareness of the challenges and the opportunities. Human capacity to generate narratives through which they interact, negotiate, create narratives of coexistence, the future, survival, but also the beauty of life and imagination. One could say that his intelligence becomes an extension of human consciousness, a deposition of being aware of the world a being able to give it form through models, analysis, understanding and decisions. Secondarily it makes the urban space and its systems into a sentient being, the city into the Second Skin of the Earth as an intelligent structure.

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The city is a network spanning around the globe, even apparent wilderness, rural territories, the oceans, belong to this network of economic, political, observed (Nasa, Landsat, Copernicus) and cultural relationships and infrastructures, and the more these systems are like the systems in the human brain, and generate consciousness, the more the city is like a brain, and human culture and domestication a kind of second nature. Brain science, neural network sciences are evolving as fast as the other sciences creating machine-learning, artificial intelligence and computer brain interfaces. Scans of the human brain are becoming extremely detailed, process is made in studies on memory, perception, consciousness. Brain science and urbanism become intertwined themes by experts measuring the stress levels of urban life and looking at the effects in the brain, and its potential to cause illnesses. But if we see the Smart City as a positive development, and not as some do a pure branding exercise by companies and cities alike, in using digital technologies to enhance quality of life and a mediation of the effects of humans of the global ecosystems, or the Anthropocene and human induced climate change, then we need to at least play with the thought of urban systems as extensions of the human systems, both physical, muscular as well as nervous and the Second Skin as a kind of sentient being. Much has been written about this in science fiction, for example in the novel *'Solaris'* by Stanislaus Lam, but the reality is closer than we think or may wish for.

Urban Curation

If the Conscious City is defined more by its cognitive and emotive properties, its abilities to be aware and behave, then we have to treat planning and managing it more like we treat the city as a society of beings which pursue well being and happiness. The tools with which to plan and run the Conscious City are curatorial tools. These are educational tools, games, learning methods, visualization processes, as well as the current trends of co-working and co-creation. The word *Cura* relates to care, or care taking, such as in healing or the prevention of illnesses. But today the words curation and curator refer more to the curatorial practices that have emerged in Europe since the Renaissance in art. The arts included scientific knowledge and the poetic imagination, the art of governance or politics as well as the art of healing. Today's intelligence embedded in healing tools, creative coding art projects, driverless cars, and renewable energy systems contain all digital components, data processing capabilities. The Internet of Things (IoT) will increase this and make digital processing a basic component of space, and will start to define the fabric of the Second Skin. It will form a kind of second Nature, especially if this capability will either act as an extension of the human body and mind, or create enhanced awareness and an upgraded body. Or this fabric will reach a critical mass of intelligence and attain a kind of consciousness different from that of humo sapiens. Planning, designing and constructing the city will demand an unknown degree of responsibility, craft, knowledge and negotiation skill. But which are the systems that contribute the best to the well being of humans, to the prosperity of communities? Who decides which are the priorities? Which visions, utopias show us what could be, or what alternatives we have to what we are already building? Today there is an amassing of power through knowledge based on collective data mining, as well as through scientific research commissioned finance not only through government grants but increasingly through he new financial power of global companies that have used the exponential growth potential enabled by the Internet. They probe a reshaping of evolution such as eternal health and life, painless and effortless existence, which raise issues of priorities and meaning. When

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technologies empower new organisations, industries rather than states with the power of knowledge given through the use of their services and infrastructures of most of the earth's population, issues such as individual happiness, longevity etc. should be balanced with the well being of all, starting with the reduction of poverty and illness, but also ensuring a balanced co existence with nature and the global ecosystems form the First Skin. In other words, this power of awareness, and new consciousness created through the intelligence of digital systems or enhance bio structures, comes with responsibilities that should be negotiated through curatorial processes and innovative decision making methods. Consequently, democracy itself will need to be reassessed, or refreshed, or even remade and reinvented.

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Cities, and the Second Skin as a continuous city web spanning the earth, consist of a thin layer of complex dynamic processes, and have continuous feed back loops between the fluidity of these processes and built things, houses, streets, infrastructures, objects etc. Making decisions in this skin of complex dynamics means aiming at moving targets, and requires continuous updating while things along the pathway of a decision move, change and evolve all the time. A practice that has been emerging recently everywhere in city development is that of urban curator. This is a practice that tries to capture something of the underlying currents in the complex dynamics of an evolving Second Skin, formulate trends, structures, connections, and put these findings out for observation, appropriation, and as material for negotiation between different actors active in the city. This can include planners, designers, system specialists, managers of utilities, data analysts, but also those using the city to trade, move to or through, to be entertained in, to live, love, dream and come together in cultural events.

The tools of these curators are manifold. They usually contain forms of gamification, but also standardization. This involves collecting and categorization of existing things and processes, but they also involve analysis, visualisation, and making places to get together for exchange, negotiation, and ultimately of participation and political action. Over the years CHORA has developed different versions of gamification tools, as well as a tool for visualising urban performance and scenarios interacting with this performance. The Urban Gallery is such a tool, it is a negotiation game and planning tool in one. It is based on a standardisation of elements of the city, of its processes, dynamics, fixed things and the drivers of change, the proto urban conditions often unseen or unknown. The standardisation is achieved with simple cards, which are grouped into four categories: action plan, actors, prototypes and the basic database of necessary knowledge. Some cards have subsets, such as the subset in the database group that are used to describe basic dynamics. This subset has itself four elements erasure, origination, transformation, migration, arranged in a linear structure with a progressive movement describing a kind of basic growth or evolution process borrowed from the First Skin. This subset of cards acts as a driver for a narrative. If we visualize this narrative as a core, and if four players sitting around a table create an ongoing development of this core by playing in turns following a circular motion, with the steps of E, O, T and M repeating themselves, and we add a timeline as a vertical axis to this motion, we create a narrative helix. This helix describes some kind of expected or imagined reality. The other cards, the main cards of the Urban Gallery, are attached to a second narrative helix, that of a projected reality. On a kind of musical score template these cards appear as constellations. During a negotiation process about the direction a project should take these constellations are changed, iterations based on feedback loops are created showing alternative pathways through the double helix. This double-helix forms some kind of DNA of a project. Perhaps more precisely these constellations become algorithms prescribing developments, planning stages, solutions.

The Urban Gallery is one component of the predecessor of the Conscious City Lab, the BrainBox. The BrainBox is a prototype for a control room for intelligent urban systems, while it is at the same time a participatory space where interaction with the controlled systems is enabled through gamification interfaces such as the Urban Gallery. In 2014-2016 we developed several versions of the BrainBox, which were presented by TU Berlin CHORA during the Long Night of Sciences and the Metropolitan Solutions

Expo during those years. The BrainBox posed the questions of ‘who controls?’ and ‘who shares?’ by creating a kind of Pop-up Agora of both negotiation tool and urban dynamics visualization. This then became the Conscious City Lab (since 2017), the latter being the peripatetic version of an otherwise experimental City Lab based at the Institute of Architecture (IFA) at the TU Berlin. The CCL is in fact a prototype for an Intelligent Operations Centre (IOC), a typology which is emerging around the world in different versions, for example the Intelligent Urban Centre in London, or the City Lab in Berlin, the IOC in Taichung and the Smart City control rooms in Hangzhou. The BrainBox or Conscious City Agora is in fact a cybernetics instrument and an immersive negotiation environment. It is a space where the observer observes, but is part of what he or she observes by being, at least in part, in control of the systems that are like the neural networks of a city. This feedback mechanism creates a new form of consciousness, which will need to be redefined in terms of governance, of rule by representation, through participation. It is a space of democratic reform and evolution. The curatorial instruments of a Conscious City use basic algorithmic structures to generate narratives, but link these to the sensing power and emergent intelligent decision making pathways of the Internet of Things, while using access to other kinds of data flows to create models These models are in effect version of a micro cosmos which allow, when accessed through dash boards or other interfaces, the user to play with the factors of life.

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City Making - prototyping the architecture of the Second Skin

How do we build the Conscious City? Obviously much of the city exists, and some say the main project for at least the European city is deep retrofitting, meaning upgrading the fabric of the existing building stock, improving the urban infrastructure, adding more resource efficient systems for the water, energy and gas supplies. Into this fabric a host of smart object appears, sensors sneak in with electric appliances, microwave masts appear on housing tops and where possible fibre optic cables snake through available underground channels. Citizens are armed with smart phones, often several, which currently contain a powerful computer and at least 57 sensors to sense movement, light, heat, sound, the magnetic North etc. This arsenal of communication devices generates flows of information, creates webs of community interaction, sends images and texts, and receives a continuous flow of information from across the globe. The contemporary Smart City is both an ideal of interactive, hyper efficient intelligent support systems enhancing life, politics, economics, social structures, culture and overall prosperity, as well as a parasitic layer which preys upon its host, or even a virus which becomes ever more powerful, a plague nearly impossible to evade, an invasion of privacy, of public spaces, an explosive corruption of the urban civilisation which has slowly emerged over several thousands of years. When we teach the basics of urban design what do we teach? And if we sketch out the future of cities and the life of its citizens which contain practically all of homo sapiens – basically the interconnecting web of satellites, fibre optic cables, microwave signals, as well as all the physical modes of mobility form a complete mantle of the earth which forms the habitat for humanity whether they be slums in Caracas, Kampungs in Sumatra, polar science stations or new housing blocks in Berlin – what do we sketch?

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The industry making the commodities that we need for life, or that enhance it, are already employing the digital technologies on a massive scale to make cheap, flexible, customised objects. It uses digitally managed robots to replace human labour leading to higher volumes of production, greater efficiency and accuracy, and reducing hard labour, accidents, and unhealthy working environments. Industry 4.0 has created not only better value chains, but also interaction between suppliers and the production process, and between the various stages and components of the production line. Internet trading and internet based knowledge industries such as Facebook and Google have created new economic phenomena, far outscaling in terms of customer base and turnover the physical manufacturing industries such as Bosch, VW or Siemens. Citizens using their smart phones, or even just moving through the streets of a city, generate data that form part of the economy of these new industries. Citizens are more aware of trends, of alternatives routes through a city, of the state of the global economy, while the new industries are aware of what the citizens do, look for, need, or could desire. Smart systems, armed with data flows linked to databases, anticipate the behavior of citizens and prepare the apartment, regulate traffic signals, tell farms to produce more of certain foodstuffs. But many people in conferences, professorial evening meetings in universities, journalists and blog writers ask: “What do the people, the same citizens, actually want and how do they choose their destiny?” It appears to some that a robotic world is emerging which shackles the freedom of humans, rather than enhancing it. We need to create a design process for cities, with no difference if that means deep retro fitting, slum upgrading, or newly built cities and infrastructures, which both uses the capabilities of digital technologies as well as enabling citizens to apply curatorial planning procedures to shape the habitats, life styles and environments they would like to inhabit. Take as an example Berlin. In 2016 the new government of the state of Berlin a Left, Green and Social Democrat coalition created a coalition contract. In this contract the new Green Senator for housing postulated that all new housing projects should be preceded, or accompanied by a process of participation. This in itself is neither an outcome of the digitalisation of society, nor a symptom of the emergent digital technologies enhancing communication processes. It is an expression of the need for more human feed back processes in a market driven by the profit margins of the construction industry and project developers. Parallel to this decision and apparently unrelated is the phenomenal growth of cities such as Berlin, at least for European standards, and the need for a yearly delivery of housing units far outstripping the supply. Taken together, these two issues, enhanced by similar but much larger trends in Asia and Africa, give rise to the question of what the building blocks are of this Second Skin, in which digital webs are global and becoming increasingly dense, and the physical fabric of cities are pushed to extremes in terms of population density and intensity of system use. The participation demanded by the Berlin government is a policy which requires increased awareness, the creation of a new social and cultural consciousness, and the growth of the physical city increases the need for industrial production of

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building stock. Both processes require the intelligence of urban systems, the one for narratives and human feedback in the construction process, the other for feedback in the construction process of urban building kits and the creation of intelligent and responsive production methods and building kit components to enhance life and enable more resource efficient habitats. The pressure for new housing, for deep and wide spread retrofitting, and for the improvement and new development of infrastructure requires massive production of city components, structures, systems is a chance, an opportunity. Current developments in the digitalization of industry, called Industry 4.0 in some countries, or China 2025 in China, and the concomitant automatisation of production processes leads to the unleashing of enormous powers that can improve the living conditions of billions of people, but also can help alleviate the impact on climate change, including the increasing rise of global temperatures.

With advances in digital technologies, data processing, interface design and robotic innovations, come challenges: job losses, loss of private identity, whole generations left behind in the avalanche of online communications, management, financial services, etc. as well as the empowerment of the collective mind of human sapiens through machine-learning, artificial intelligence, and new forms of social actions and the creation of radically new cultural identities. We have recently been working on bringing Industry 4.0 closer together with the building industry. Current construction practice is slow, inefficient, wasteful, and doesn’t incorporate many of the innovations in technology which generate so many new products, services and capabilities elsewhere. Increased digitalisation of the construction industry enables both an intelligence in the production process itself, it also creates a greater feedback ability between inhabitants and other urban actors which have specific needs, as well as greater flexibility towards ecological cycles, energy efficiency etc. The creation of city building kits enables not only the production of city structures at a higher, and more sustainable way, but also enables the integration of intelligent systems in the building kit components. These components make city structures more responsive, ‘smart’, and flexible. The skin of city structures can be more akin to the skin of human beings, sensing, exchanging essential substances, as well as enclosing organs which enhance life and ensure a future.

Foundations: Cybernetics, Digitalisation and IoT

The foundations of cities are increasingly formed by the intelligent systems with which steer all other systems. The infrastructure that enables information flows of data that power the algorithms that generate the intelligence of the urban systems is a new kind of foundation. We are used to foundations made of stone, bricks, sometimes even wood such as in Amsterdam or Venice, and we are used to the tunnels, pipes and caverns that lace these foundations to transport our waste, water, energy, goods, ourselves, and since the last century with the webs of mostly copper cables also our voices, files and signals. This kind of foundation remains mostly in place. It is that which roots us in the First Skin. But there is another foundation that links the city to the global web that embeds the individual place of a city into the global topography of the Second Skin. If digitalisation is defining the future the way it seems now, if it defines the Anthropocene and a new kind of intelligent organism emerging from through human's technological advances, then this new foundation takes precedence over the original one made of stone and clay. This assumption will be the focus of much debate and disagreement, as is the postulation that the city's intelligent systems are like, or even an extension of the brain. What is clear is that we need new forms of governance, of management to steer this intelligence and give it direction.

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The steering of the city's flows and dynamics, their governance, is the subject of new trans-disciplinary sciences, of new curricula, but have been foreseen in various forms by the scientists and entrepreneurs, among others, that developed cybernetics. This kind of 'steering' or directing, an extension follows up the practice of urban curation and is at the core of the planning practices and expertise we are currently developing at universities, in city departments, in international agencies are and in dire need of. cybernetics and at its core the concept of 'cyber' (from kyber) ancient Greek for steering, like a steersman of a boat but also meaning a Governor, a political steersman) has lived on in the margins of culture after causing some excitement in the 60's and seventies with as perhaps its most public highpoint the exhibition 'Cybernetic Serendipity' curated by Jasia Reichardt and held at the Institute of Contemporary Arts in London in the 1960s. But its essence and terminology spread through human consciousness and is always linked to the digital space or technologies, such as in the words cyberwar, cyberspace, and ultimately the cyborg, a man-machine hybrid.

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The concept of a Smart City is in principle that of a cyborg, a machine, or robot, or robotic systems, merging with or extending from a human body and mind. This is where the question of consciousness arises. This new avatar of a concept has created a new aura, an aura of live game performances, of people living in a world of hyper-reality, of stories made through coded visualisations, but also into a world of hackers and cyber attacks on state organisations like the UK's NHS, some GermanmMinistries, and as an attempt to influence the US election. This trend and the power of the internet has both produced the largest ever companies such as Facebook, Amazon, Alphabet (Google) and Microsoft, but also a massive games industry that has overtaken the film industry as economic driver. Games create alternative realities, and an ever increasing percentage of humans spend much of their time creating or living in these alternative realities.

New scientific work pushes the speed, power and versatility of these alternative realities, or tools with which we alter the physical reality as we know it. Web science, and the related subjects of machine-learning and the Internet of Things, empowers systems and objects to define new spaces, new relationships. IoT shapes new military theatres, with for example swarms of drones poised to monitor enemy movements in Afghanistan, weapon systems poised to attack and steered through a control room based in Nebraska or California. This sighting of and aiming for a moving target from a distance was the legendary start of the cybernetics movement, with gunner's sights in 1940's London tracking bombers of the Luftwaffe and trying to anticipate their movement, while the bomber's intentions were to avoid the gunners' actions. Actually, its history goes much deeper and starts with the first stirrings of machine-learning, the calculating machines of Leibniz, Babbage, and the programming experiments of Lovelace, and of innovations in electricity and electronics in the 19th and 20th century. The invention and making of the first computer has become a source of national pride for different nations, competing with different legacies of machine-learning in their virtual Halls of Fame. These continuous feedback loops practiced by the gunners, and developed by cybernetics pioneers such as Pask and Ashby in their learning machines and homeostats, was a trend that eventually led to the world's first national economic planning control room, the Cybersyn room developed by Stafford Beer during the presidency of Salvador Allende. This room can be considered to be the first IOC, or Intelligent Operations centre - Beer called it the Opsroom – which was a prototype for all the Smart City control rooms that are now emerging in various forms, usually as mobility control centres, but as in the case of Rio the Janeiro, the COR, as control centre to react to any emergencies caused by extreme weather and unrest by sectiosn of the population. The *Cybersyn* or *Opsroom*, and the COR of Operations Room in Rio. The curatorial tools and the gamification mentioned above are cybernetic tools.

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Our BrainBox, Urban Gallery method and the tools of many other urban agencies as well as the emergent market of interactive video games in which you can construct your own natrratives, play with hosts of others through online connections, as well as the control and employment of drone swarms in warfare as is now emerging all are cybernetic outcomes. The development of a project for driverless tricycles by an expert in MIT has a core of feedback loops, learning behavior and modeling capability to allow it to balance out the distribution across a territory is a cybernetic project. At some point Gordon Pask was working with a mathematician on a project for the development of armbands, apparently a commission by for a national airport somewhere in Scandinavia, which all travellers and visitors would be asked to wear, and which would sense the heartbeat or perhaps more enhanced emotional states and through some software would allow the authorities be able to detect terrorists intent on creating an attack. A project such as this is suddenly again relevant following the waves of attacks by ISIS fighters or sympathisers. Of course it also raises the ethical questions if you can equip every citizen entering a public space with similar equipment to prevent the kinds of car attacks now favoured by terrorists, or even knife attacks with kitchen knives. Many such attacks could not be prevents since the perpetrators managed to stay 'off line', could not be digitally detected. What is the balance between public safety and all put control of people's moods and emotions?

What is the balance between public safety and all put control of people's moods and emotions?

The relisation of cyberspace as a constituent substance of the Second Skin, and a foundation of the new city planning practices is a complex theme of which we see the first development, but cannot tell the future yet. The Internet of Things is certainly an indication of where this future may go. But visiting the CEBIT this year, and all the various IoT systems companies show, showed the nerd for a cultural assessment of IoT as part of the new urban Foundation It needs the frame of poetic imagination to read the potential cultural meaning of embedding a Consciousness in all made objects through IoT, investing an intelligence in an inanimate world created by humans.

The theme *City Making* touched already on the issue of sensing, and objects sensing and communicating information generated by sensors with each other, as well as with humans. This sensing capability forms the creation of data and knowledge but needs a visionary vehicle, we need utopian narratives describing its potential. The closest we have so far as a purely symbolic image of a cyborgian existence with a mind extending through different places of the Second Skin is found in first line of Shakespeare's Sonnet 44 'if the dullest substance of my flesh were thought', then he could reach his distant lover. If the Sonnet is indeed a love poem, then he can reach his lover where ever he is. This in part the basis of a cyber-being, a being that can extend its physical structure through the virtual web of data, and the Internet as the primary architecture of the Second Skin, an architecture whose foundations are made of the infrastructure of the Internet, its optical cables, server centres, its satellites and beamed signals, and even the so called Dark Internet, where another kind of trading, hacking, probing, and even war fare is emerging similar to the magna flows circulating below the slightly shifting tectonic plates of the First Skin, erupting occasionally with an other worldly sound through the calderas of volcanoes and other cracks in the skin. The interior of the earth and its original crust is really much more like the rest of the universe, than the very thin Second Skin homo sapiens has constructed and is now remoulding through new technologies and an expanding intelligence and consciousness.

Sonnet 44

If the dull substance of my flesh were thought,
Injurious distance should not stop my way;
For then, despite of space, I would be brought,
From limits far remote, where thou dost stay.
No matter then although my foot did stand
Upon the farthest earth remov'd from thee;
For nimble thought can jump both sea and land,
As soon as think the place where he would be.
But, ah, thought kills me, that I am not thought,
To leap large lengths of miles when thou art gone,
But that, so much of earth and water wrought,
I must attend time's leisure with my moan;
Receiving nought by elements so slow
But heavy tears, badges of either's woe.

W. Shakespeare

As always, he imagined worlds we now inhabit or human traits we still aspire to.

Managing (with) the Unmanageable City

Timothy Jachna

This chapter articulates some aspects of a cybernetic approach to understanding and intervening in contemporary cities. It discusses precedents in the application of cybernetic principles to urban contexts and argues for the appropriateness of a second-order cybernetic perspective in engaging 'unmanageable' systems like cities. The implications of this perspective on pedagogy are demonstrated by way of an exposition on a short intensive studio conducted in the context of a Master program in urbanism in a design school in Hong Kong, taking a risk-based approach to *urban futuring* and seeing the city in terms of learning processes rather than master plans. It concludes by reflecting on the shifts in approaches to the city rehearsed in this exercise.

Keywords: Urbanism; second-order cybernetics, conversation theory, risk society, Pearl River Delta, urban futuring

Control and Conversation

A pivotal principle of cybernetics is the framing of such systems in terms of iterative feedback loops, through which systems sense and react to external and internal conditions, and monitor the results.

The founding of the field of cybernetics is generally traced back to Norbert Wiener's (1948) work in pursuit of a generalized understanding of mechanisms of communication and control in complex systems, unifying biological, social, electromechanical and other types of systems in one theoretical perspective. A pivotal principle of cybernetics is the framing of such systems in terms of iterative feedback loops, through which systems sense and react to external and internal conditions, and monitor the results. While the initial, so-called 'first-order' understanding of cybernetics tended to take a somewhat one-directional understanding of control as something imposed on a system from an external controlling entity, 'second-order cybernetics' recognizes that the observer/researcher/designer of such systems must also account for themselves as a component of the system, and that they are (or should be) changed by their engagement with this system, even as they seek to steer change in the system, in a cyclical relation. Gordon Pask's *Conversation Theory*, an essential concept of second-order cybernetics, posits that all learning happens through conversations (Pask 1975). Conversation denotes a process of meaning production between at least two participants, who compare their understandings of a concept through an iterative process of expressing their understanding, listening to other conversation participants' expressions of their understanding, and comparing their original understanding with (their understanding of) the other's expression, in order to approach an impression of a shared understanding. While the process is by nature communal, meaning can only ever be constructed by each participant, for themselves. This approach is rooted in the radical constructivist view (Glasersfeld 1987) that knowledge is always constructed by the observer and not constituted by simple reading of objective facts that exist in the world (c.f. Eco's (1989) *opera aperta* ('open work')). The idea of *between-ness* is essential to second-order cybernetic understandings of both control and conversation, neither of which is seen in terms of an enactment of influence by one actor upon another, nor as a quality of one actor or another, but as a cyclical process of interaction and mutual adaptation that exists in between the participating entities. Control is an important concept in the literature of cybernetics and related fields. In first-order cybernetics, this term has been defined as the choosing of inputs to a system so as to make the state or outputs change in (or close to) some desired way, or as a relation between two systems in which the behavior of one system determines that of the other. Second-order cybernetics sees the control relationship as not linear (one entity exerting influence on another entity), but as cyclical, with each system in a control relation controlling the other.

This approach is rooted in the radical constructivist view (Glasersfeld 1987) that knowledge is always constructed by the observer and not constituted by simple reading of objective facts that exist in the world.

Ross Ashby's *Law of Requisite Variety* states that a controlling system must have a degree of variety at least as high as that of the system it controls (Ashby 1956). A common control strategy is to forcibly reduce the complexity of the controlled system to that of the controlling system (Glanville 1994). Robinson (1979) remarks on classroom control, in which control is maintained by rules that suppress the individuality of students in order to reduce the complexity of the collective minds of the (controlled) class to that of the single mind of the (controlling) teacher.

Glanville (2000) writes of 'unmanageable' systems, whose degree of variety exceeds that of any possible controlling system and suggests that such systems challenge us to accept unmanageability and relinquish the desire to control. He goes on to propose that such systems are the rule rather than the exception, necessitating that we address such systems not by attempting to wrangle them into submission but by accepting their unmanageability and committing to an open-ended process of adaptation and learning in our relationships with them. Cities are prime examples of unmanageable systems or, more precisely, as assemblages within which multiple superimposed unmanageable systems overlap, superimpose and interact. Despite their inherent unmanageability, cities cannot conscionably be left unmanaged, as they are the environments within which the majority of humanity lives in the contemporary world. The academic exercise described and explored in the remainder of this chapter constitutes an attempt to rehearse the type of thinking required to envision and enact strategies and tactics of engagement with cities that can help move them towards desirable and sustainable futures, given their intrinsically 'unmanageable' character.

Cybernetics and the City

As apparent manifestations of complex human-made socio-cultural and material systems, cities have been the subject of cybernetic analysis from the relatively early days of the discipline. Notably, Forrester (1969) and Brown (1969) proposed cybernetic descriptions of urban dynamics. While both of these scholars essentially took a primarily command-and-control (first-order cybernetic) perspective on urban governance, they both also acknowledged that decisions and actions taken in cities ultimately rely on the goals and values of individual actors, making many of the behaviors of the component processes of the city essentially unpredictable and beyond control.

The field of urban studies takes as its subject the city, as the crucial context within which critical issues of the constitution of human societies – such as sustainability, social integration, the public realm and societal governance – come to a crux, but this field is also rife with writings relentlessly problematizing the very notion of the city as an inherited concept (Appadurai 2002; Koolhaas & Mau 1997; Lerup 2000; Soja 2001). It is precisely the tension between fervently sustaining the idea of the city as a social and material construct while at the same time subjecting it to intensive critique that makes urban discourse a valuable model for examining the intensively interlinked systems of people, things and ideas.

It is difficult to circumscribe the city as a discreet subject of analysis.

It is difficult to circumscribe the city as a discreet subject of analysis. That is to say, it is nigh impossible to delineate the boundaries and constitutive physical, bIoTic, spatial, political, cultural, informational and societal elements that make up a city – characterized, as it must be, by its heterogeneity, openness and state of continuous change. At its broadest, this construct subsumes all of the material, energy, human (and other-than-human) actants, and information processes in the urban area. At the same time, the boundaries of any urban area are also ill-defined, as all cities are linked with their surroundings and, indeed, with the global economic, cultural and political milieu and the totality of the physical environment of the earth. Accordingly, urbanism as a field of study encompasses a rich repertoire of concepts and approaches to understanding an immensely complex, dynamic and multifaceted system that subsume numerous material, spatial, cultural and social artefacts and processes, requiring what might be called an 'ecological' understanding of the city.

An important touchstone in the development of the ecological perspective on the city is Reyner Banham's *'Four Ecologies'* treatise (Banham 1971), in which the British architectural theorist and historian demonstrated an analytical angle on the built environment of Los Angeles that deviated radically from conventional architectural approaches that saw cities as collections of built objects. As a counterpoint, Banham extracted four typical 'ecologies' of that particular city – the beach, the freeways, the flatlands and the foothills – that demonstrated ways in which people come together with places, and with each other, in this city. This approach saw society, culture, objects, built structures, geography, climate and topography as entangled in the environments that make up a city. This represents a shift in the way of thinking about the built environment, shifting away from a focus on monuments and

This perspective forms the foundation of current discourse on ecological urbanism, that expands from Banham's concentration on environments within cities, to encompass the macro-urban systems that characterize cities and urban regions as complex wholes.

objects, towards a focus on environments, 'performativity' and social construction. This perspective forms the foundation of current discourse on *ecological urbanism*, that expands from Banham's concentration on environments within cities, to encompass the macro-urban systems that characterize cities and urban regions as complex contexts, and seeks to understand cities as complex heterogeneous systems that are in constant interaction with natural ecosystems, as well as to act upon this knowledge to promote sustainable urban futures (Mostafavi & Doherty 2010). As the Anthropocene perspective teaches, it is impossible to extricate the human-made from the purportedly 'natural' elements of our global environment (Crutzen & Stoermer 2000).

Proposition and Context

A workshop, *'Urban Strategies for the Pearl River Delta'*, was conducted in April, 2015, co-led by the author of this chapter and the design theorist and philosopher Tony Fry, Principal of the Studio at the Edge of the World. This was a six-day intensive exercise within the subject *Urban Systems and Strategies* in the MDes (Urban Environments Design) program, at the School of Design of the Hong Kong Polytechnic University. The participants were twenty-one students in a design-centered urbanism Masters – nineteen from mainland China and one each from the USA and New Zealand, holding undergraduate degrees in diverse spatial design fields (architecture, landscape, urban planning, interior design, installation art). The Pearl River Delta (PRD) refers to a region in China's southeast, around the eponymous waterway as it flows into the South China Sea. This region of nearly 40,000 square kilometers contains nine major cities, including two of China's ten largest metropolises, Guangzhou (population 14 million) and Shenzhen (12 million), as well as the Special Administrative Regions of Hong Kong and Macao and five other urban settlements of substantial size. The PRD is the most economically productive area of China and the area that, in recent decades, has undergone the most rapid and large-scale process of urban expansion and industrial development in human history. The project drew on the notion of the Global Risk Society

The Pearl River Delta (PRD) refers to a region in China's southeast, around the eponymous waterway as it flows into the South China Sea.

(*Risikogesellschaft*), a term coined by the German sociologist Ulrich Beck to express the ways in which politics and economics are increasingly influenced by decision processes based on the mitigation of anticipated risks. Beck claims that societies and organizations are increasingly concerned with the anticipation and mitigation of risks to their assets, structures and values, and that this preoccupation affects the ways in which societies organize themselves, allocate resources, and structure their imagination of their futures (Beck 1986). Anthony Giddens, another important figure in this stream of thought, has stated that globalization, advances in economies, technology and communication bring a "high opportunity, high risk society" (Giddens 2014).

Beck claims that societies and organizations are increasingly concerned with the anticipation and mitigation of risks to their assets, structures and values.

The workshop began with the premise of a risk-based approach to structuring ways of thinking about the future of the Pearl River Delta (and also eventually tried to transcend the limitations of this approach), and to consider interventions in the future evolution of the urban region in anticipation of these risks. The class was divided into six groups of students, each of which adopted one of six perspectives (*social*, *experiential*, *economic*, *infrastructural*, *geographical*, or *cultural-historical*) as a point of access to understanding the existing situation. Each group began by considering the value(s) implicit in the tangible and intangible assets, relations, actors and patterns of exchange and interaction in the Pearl River Delta urban region, and the systems in which these elements are embedded. Then, based on this understanding, each group considered the dimensions of risk posed to these systems and relations by anticipated macro-scale changes. The central element of risk considered in this exercise was that of anticipated sea level rise associated with global warming. A rise in sea levels is not merely a possibility but a surety, that cannot be reversed by any actions that may be taken now or in the future. The question is not whether this will occur but how rapidly and to what extent. This is an example of what Peter Drucker has called "the future that has already happened," an element of the future that is beyond the control of the agent or organization in question to control or substantively influence, and which must therefore be incorporated into any future visions or plans

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as a given factor of the environment, not a problem that can be solved (Drucker 1998). The Pearl River Delta is one of the areas of the world most under threat from the projected rising of ocean levels in the coming decades, due to the concentration of built infrastructure, population and economic activity in relatively low-lying coastal and riparian areas, and the contribution of rampant industrialization and urbanization to localized climatic, topographical and ecosystem change (He & Yang 2011).

Workshop Structure

The workshop began with a series of quick cartographic exercises, in which students mapped the geographical distribution of assets within the PRD area, each of the six groups concentrating on its designated angle of focus. For instance, the *infrastructure* team looked at the distribution of urbanized areas, transport and utilities systems, industrial production facilities, the relative intensiveness and nature of land use, whereas the *economy* team investigated the geographical loci of the investments in assets and developments, the economic value of these investments, and the flows of inward, outward and intra-regional monetary flow in the region, and the *social* team concentrated on the socio-cultural elements of communities and interconnections between groups and places. Each team also considered the resilience of these assets, patterns, etc. in the face of the anticipated risks (considering issues such as to what extent they could be moved, reconfigured, replaced) (see figure 1).

This mapping of assets was paralleled with a mapping of the geography of the risk associated with sea level rise, including identifying the extent of seawater inundation of land that would be expected, as well as the territory that would be affected by increased salinization of the water table, higher incidences of river flooding and other knock-on effects of the rising of the ocean surface. An obvious early step in visualizing the cartography of risk was to superimpose these maps onto the mappings of the distribution of assets produced by the six groups. This produced a clear indication of the interference patterns between risks and assets (see figure 2). In the course of this step of analysis, a high degree of isomorphism

fig. 1: One of many mappings of existing at-risk built assets and relationships in the Pearl River Delta

Fig. 2: Mapping of areas most endangered by sea level rise superimposed with areas of most concentrated industrial development, to reveal a geography of risk

between different distribution patterns was revealed. The areas of densest settlement, unsurprisingly, tended to correspond with areas of greatest levels of investment, highest concentration of cultural heritage assets, etc. These also were precisely the areas with the highest degree of historical influence from non-Asian cultures, lying as they do along the waterways by which Western traders, troops and missionaries first penetrated into the Chinese mainland.

These zones along the Pearl River and its navigable tributaries logically also correspond to the areas most at risk from sea level rise and flooding. From these visualizations of the geography of risk in the Pearl River Delta, the six groups were then asked to develop strategies for responding to the risks revealed by this exercise. The groups' initial reactions were characterized by three types of strategic approaches. The first impulse was to develop technical approaches of *fortifying* assets against inundation, usually by the construction of technological infrastructure such as sea walls. The second was characterized by attempts to preserve as many of the existing assets as possible by physically *redistributing* them out of harm's way. The third, related, approach was to anticipate the need for *reconfiguring* the existing systems in which these assets are embedded, so that they could continue to function in their accustomed way.

Reframing Risk and Resilience

Many of the suggested moves were bold and resourceful, and generated much lively discussion about value and resilience, in particular in terms of weighing the relative merits of two ways to address resilience: on the one hand strategies of *resistance* (putting in place defensive measures to stave off the local effects of this global phenomenon through immense infrastructural investment to stop the incursion of water into the PRD) and on the other hand strategies of *retreating* (acceding to the changing geography and adapting the distribution of human assets out of the areas under threat) (see figure 3.1 and 3.2). However, the discussion eventually led to more fundamental questions of whether our strategies should be motivated by the desire to preserve what exists at all costs, or whether the necessity of rethinking and reforming this urban

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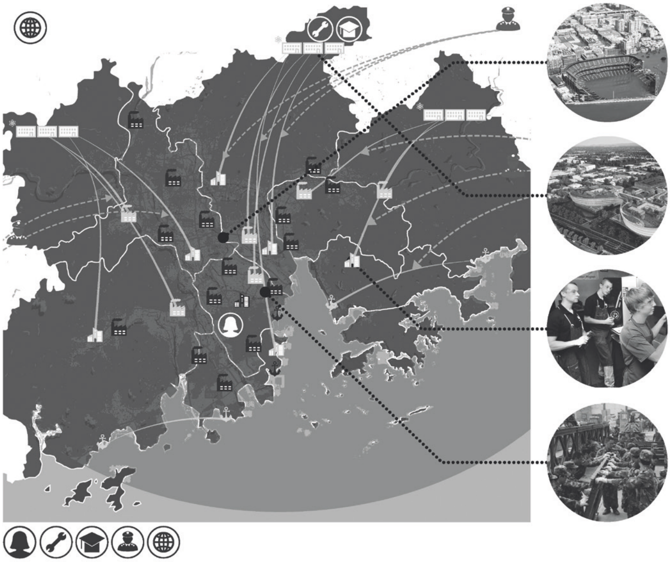


fig 3.1: diagrammatic mapping of potential implications of strategies of resistance

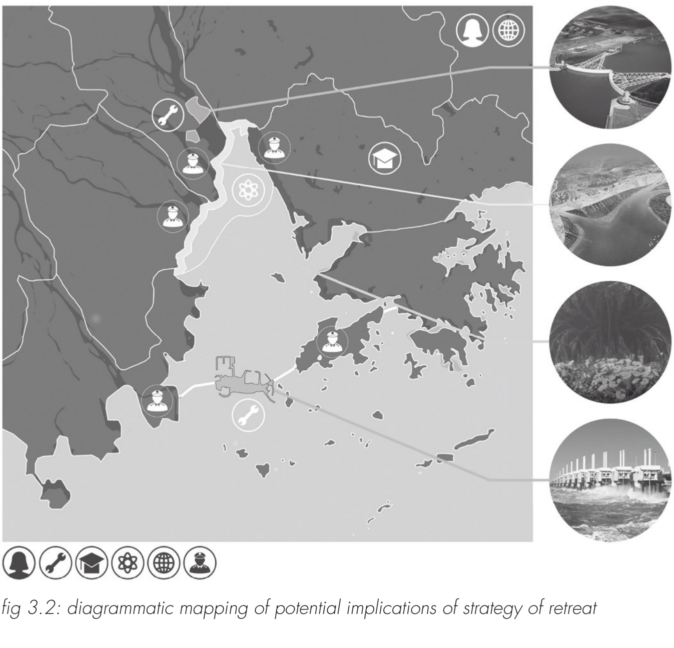


fig 3.2: diagrammatic mapping of potential implications of strategy of retreat

Should strategies of fortifying, redistributing and reconfiguring be augmented, and indeed in many instances superseded, by strategies of reassessing, to address the necessity, possibility and desirability of systemic change in the face of radical changes in context?

region should be taken as an opportunity, indeed a necessity, to fundamentally reconsider alternatives to existing systems, and the values we attach to them. Should strategies of *fortifying*, *redistributing* and *reconfiguring* be augmented, and indeed in many instances superseded, by strategies of reassessing, to address the necessity, possibility and desirability of systemic change in the face of radical changes in context? This stance should not be mistaken as a heroic-modernist Utopian approach of starting from a *tabula rasa* and reinventing society and the city from the ground up. Rather, we proposed an approach in which scenarios for possible desirable futures were constructed based on propositions as to how existing assets, knowledge and values in the urban region could be activated, augmented, reconceived, re-valued and re-contextualized to meet the challenges and the opportunities of the future. Tradition and

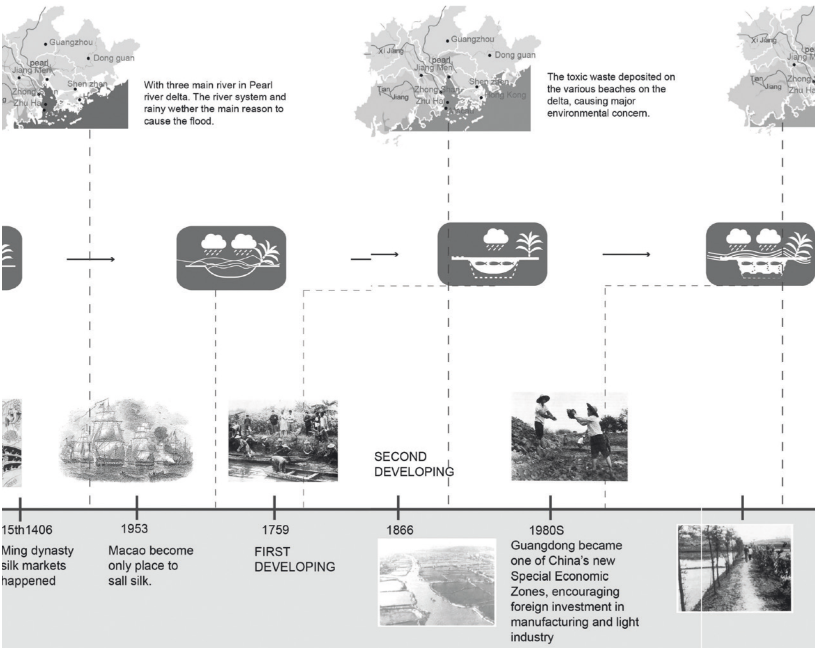
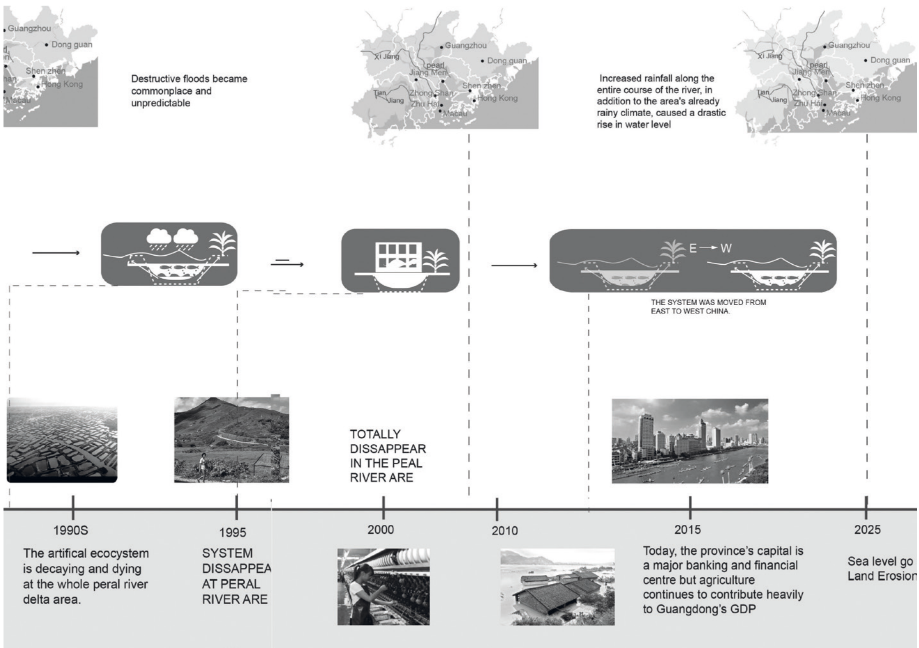


fig 4: Excerpt from a timeline tracking the historical development of the 'co-evolution-ary' relationship between natural and human-made systems in the Pearl River Delta

inheritance were important resources in this sense, not considered as simply habits from the past to justify resistance to change, nor as merely heritage artefacts of the past that should be preserved as if in a museum, but rather as some of the components from which and upon which any future for the region must necessarily be constructed (Fry 2017). Subsequent stages of the workshop appropriated conventions of visualization beyond geographical cartography. For example, timelines were used to visualize local historical narratives of adaptive (and maladaptive) processes and practices, and alternative potential future continuations to these storylines were projected and evaluated (see figure 4). Historical local adaptive practices were re-discovered, in which traditional sustainable systems of land management, horticulture, settlement and societal structuring had co-evolved.



This understanding of the Pearl River Delta region as an ongoing process of interlocked and co-evolving systems allowed for projections of possible positive changes.

These practices were re-engaged and analyzed through various forms of system mapping (see figure 5). This understanding of the Pearl River Delta region as an ongoing process of interlocked and co-evolving systems allowed for projections of possible positive changes. For instance, one group proposed that the de-urbanization of certain areas, and the concomitant urbanization of erstwhile rural areas necessitated by sea level rises could enable the reconfiguration of China's *hukou* (household registration) policy, by which each Chinese citizen is designated as either an urban dweller or a rural dweller, which is currently used to deny rights of residency or access to urban public services such as education and health care to the tens of millions of rural migrant workers to the PRD's cities. In the final stage of the workshop, the maps and scenarios generated by the different groups were pooled to inform a shared vision for the future of the Pearl River Delta urban region. This vision did not revolve around financial, social or land-use planning strategies, but rather around education and learning. *The central guiding question for this phase was: Who needs to learn what, and when, in order that the PRD can continuously evolve to meet future challenges and risks?* As just one indicative facet of the rethinking inspired by this proposition, with most of the region's universities and other institutions of learning under threat of inundation, a re-spatialization of the physical geography of formal education was considered. A new distribution of institutions was proposed, based on an assessment of which locations would be in need of what skills and knowledge in the new socio-geographical context of the post-sea-level-rise PRD (see figure 6), new curricula and areas of study were proposed based on the knowledge that would be essential in addressing the climatic, technological, political and societal problems expected to arise within the scenario at hand, and new architectural and organizational forms for this projected new generation of learning institutions were also explored. Likewise, an inventory and mapping of the tangible and intangible cultural heritage of the PRD, much of which was also concentrated in threatened areas, was on the one hand seen as a store of valued assets requiring strategies for rescuing from impending eradication, and on the other hand was used as a resource from

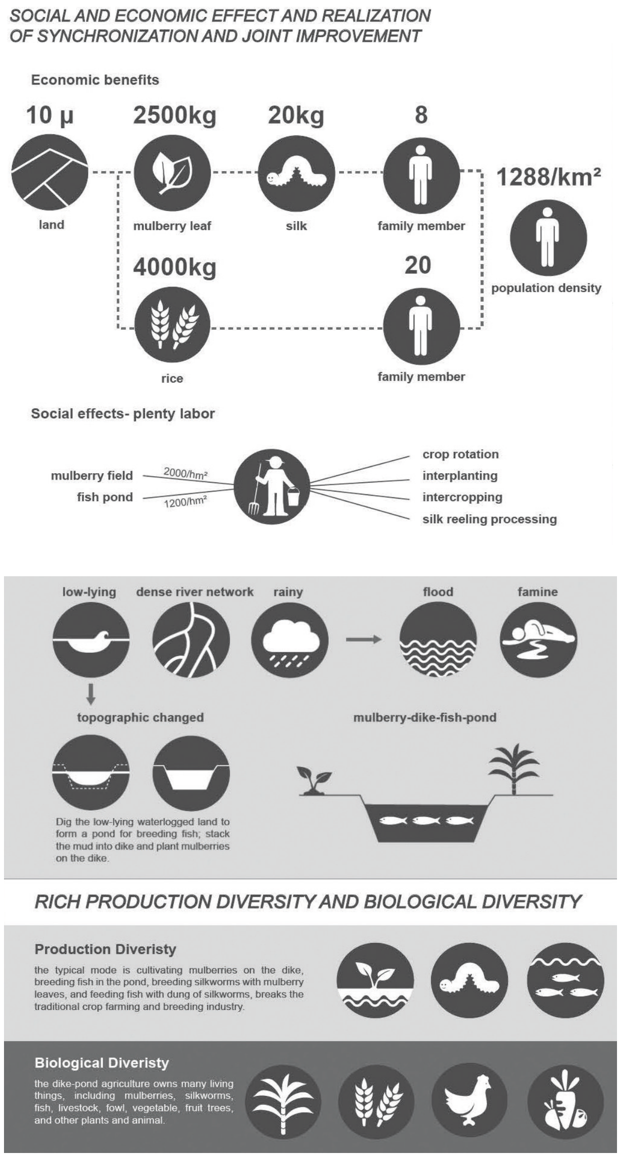


fig 5: Excerpt from a study on traditional local adaptive practices in the Pearl RivervDelta, in which rice growing, fish farming and silkworm raising existed in a symbIoTic relationship that also formed and sustained a resilient amphibious landscape

which students proposed traditional knowledge and skills could be extracted, that could serve in informing future adaptove practices to react to climatic risk. Programs were proposed for the re-activation and dissemination of this knowledge and these skills throughout the regional society and for the concerted further development of this inheritance of wisdom in concert with contemorary technological and organizational knowledge so that is could be mobilized in the service of facing the challenges at hand (see figure 7).

Reflections

If viewed as a problem-solving exercise, this project must be seen as having several limitations, including its extremely short timeframe (six days), the 'quick-and-dirty' approach necessitated by

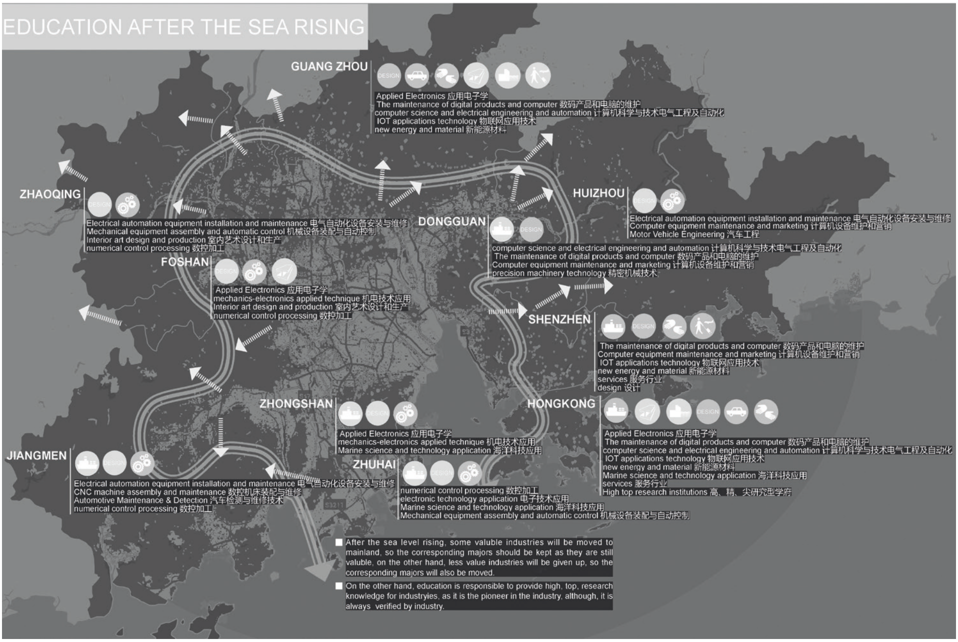


fig. 6: One of the maps developed to explore the implications of the risks and opportunities at hand for the rethinking and reconstitution of the region's education system, both in terms of the spatialization and distribution of learning institutions and in terms of the knowledge, curricula and methods required.

a. this limitation (using only information that was ready at-hand and quickly digestible)
b. the uni-dimensionality of its starting proposition (isolating sea level rise as a single factor without methodical consideration of the interaction of this factor with other dimensions of risk or opportunity)
c. the narrow disciplinary background of participants (all students with backgrounds in the spatial design disciplines, mostly from mainland China)
d. the persistence among students of wanting to frame this as a problem-solving exercise or a project (given their backgrounds as designers)

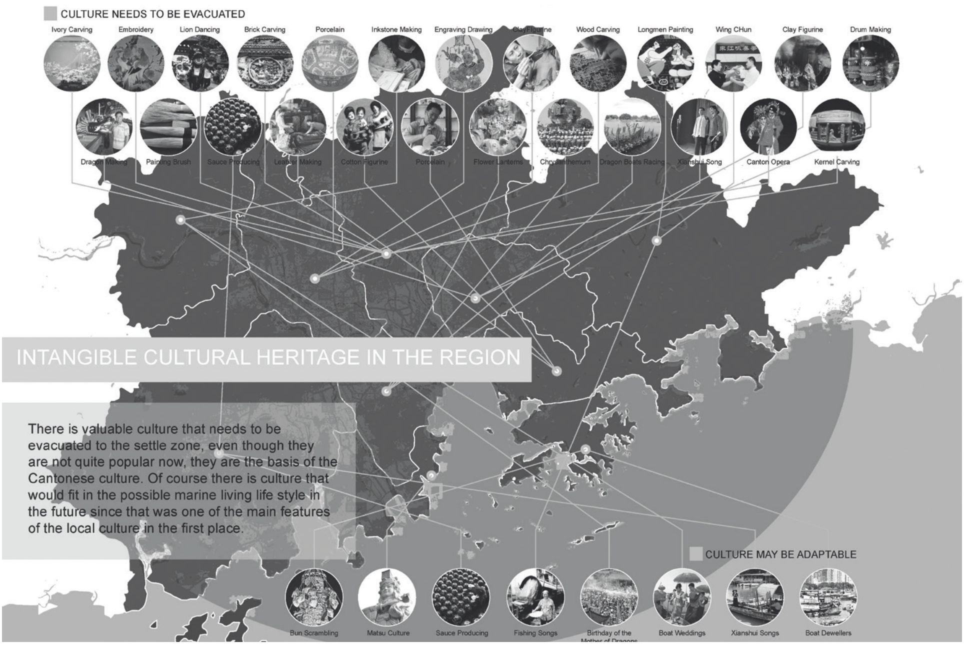


fig. 7: One of a series of maps exploring the role of the region's intangible heritage in the envisioned future, both as a set of at-risk values that need to be protected and as an inheritance of knowledge that could be mobilized in the adaptation to a more risk-prepared culture.

It is clear that a credible approach to seeking implementable strategies for addressing issues of this magnitude would require vast resources and an ongoing engagement with the context over years rather than days. However, as a pedagogical exercise, the value of this exercise was not in the tenability of its outputs, but in the transformation in students' ways of thinking that it engendered. The 'outcomes' were not in arriving at any practicable proposals, but in changing the terms of discussion among the group. This project was intended as a pedagogical exercise, the goal of which was not to develop 'projects' as 'solutions' to the issues being addressed, but rather to spur students to rehearse ways to cognitively engage issues of huge magnitude and intractability..What was achieved was a number of shifts in perspective. Students shifted from an architectural / planning perception of the Pearl River Delta as a site, a physical territory, to an ecological understanding of it as a *situation*, a complex ensemble of interdependent and interacting tangible and intangible, man-made and natural, human and non-human entities. Accordingly, they shifted their understanding of designers' relation to the situation from that of a *project*, a time-bounded relationship with the situation aiming at a final outcome, to engagement, an ongoing and open-ended relationship of observation, intervention and monitoring of a situation. This necessitated a transition from a problem-solving approach to an approach based on *learning* and *adaptation*. Through this process, an initial impulse to perceive risk as a threat to existing assets and ways of doing things gave way to a perception of *risk as an opportunity* to rethink existing practices, value systems and assumptions. This enabled a move from *responding to and mitigating the negative effects of contextual change* to *anticipating and designing with and for contextual change*. Finally, the progression of responses, proposals and discussions throughout this exercise demonstrated a learning journey from an initial impulse to d*efend existing assets, relationships and practices,* to a will to create new assets, relationships and practices, to a recognition that true urban resilience necessitates preparedness to *continuously adapt assets, relationships and practices.*

This necessitated a transition from a problem-solving approach to an approach based on learning and adaptation.

Implications

The academic exercise presented in this chapter provides a counterexample to master planning and strategic planning approaches to urban governance that are based on the formulation of a desired future state of a city and the implementation of control regimes to steer the development of a city - or in this case, an urban region - towards that envisioned future. In contradistinction, the approach practiced and demonstrated in this exercise was based on a consideration of what types of knowledge would be requisite to dealing with the risks, challenges and opportunities at hand, that would enable the constellation of actors in the urban region to perpetuate an ongoing conversation with one another and engagement with the issues faced by the region. Since much of this required knowledge is knowledge that might not yet exist - or that was once known but has been forgotten -, this approach is characterized, first and foremost, not by regimes of control and technological application, but rather by processes of learning and adaptation. I have elsewhere (Jachna 2012) proposed a theorization of the city as a learning process, based on affinities between processes of urban becoming and models of learning and of research.

Thus, second-order cybernetics, while maintaining the first-order cybernetic concern with issues of control in systems, understands the reciprocal nature of the 'steering' relationship between controlling and controlled systems. The process of steering a system's development is understood not only in terms of the application of control and technology to move a system toward desired goals, but also in terms of the nominally 'controlling' system being steered by the supposedly 'controlled' system, in the former having to constantly update and expand its understanding of the controlled system and to continuously adapt its goals and methods accordingly (Bailey 1994). This begins, as in the case of this workshop, with a will to understand the values and history of the system in question (the Pearl River Delta urban region), and to engage in an ongoing conversation with the system in a process of mutual learning and evolution.

Thus, second-order cybernetics, while maintaining the first-order cybernetic concern with issues of control in systems, understands the reciprocal nature of the 'steering" relationship between controlling and controlled systems.

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Uncertainty, Complexity & Urgency: Applied Urban Design

Arun Jain

In an increasingly complex world, growing amounts of information and data make it all the harder to discern what is relevant. Our immediate response is to over-simplify complex conditions. In doing so we lose much of the nuance that is important to solve problems in such settings. This is even more complicated when we are faced with growing uncertainties and an increased sense of urgency, particularly when dealing with urban development. Both, *urban design* and *cybernetics* address complexity differently. The first part of this chapter highlights the conceptual frameworks in which both could work together. It then shares a real planning effort in the form of a 'Decision Support Tool' to demonstrate how both could work in concert to address even our most urgent, and difficult urban development challenges. There is a widening gap between planning theory and practice. This narrative is emphatic in our need to focus on applied, and real world tools to close this gap. Urban development, cities, and the world would benefit immensely from such efforts.

Keywords: Complexity, Decision Support, Urban Design, Planning, Cybernetics, Uncertainty

Introduction

This chapter draws upon my closing keynote presentation entitled: '*Uncertainty, Complexity and Urgency: Applied Urban Design' at the 'Cybernetics: State of the Art*' held at the Technical University of Berlin, on June 9th, 2016. The emphasis of that presentation was to underscore our need for more thoughtful methods to intervene in cities. Cybernetic thinking could help in comprehending complex systems (both man-made and natural). However, for this to happen, a largely theoretical discourse must become more widely applied. This assertion is driven by the conviction that we need faster ways to apply critical thought in a fast moving and increasingly complex urban world. The presentation at '*Cybernetics: state of the art*' shared how a ‘Decision Support Tool’, prepared for the Maryland National Capital Parks and Planning Commission (MNCPPC) in 2013, could be imagined as a practical and applied example containing elements of cybernetic thinking. The intent of that effort was to create an easy-to-understand visual means by which decision making within the planning and allied departments could be improved. It also sought to build widespread and easier stakeholder comprehension of the complex regulatory realities in which county wide planning problems needed to be prioritized and addressed. Although the tool was not implemented, the thought process and outcomes serve as a good lesson on the opportunities and practical challenges of embracing comprehensive, system-sensitive thinking. Urban design and cybernetics are both amorphous terms with multiple connotations. Without getting into the details of the similarities and divergences, it is useful to look at both in terms of their most basic intent.

Urban design and cybernetics are both amorphous terms with multiple connotations.

What is Urban Design?

Urban Design can mean different things depending upon the vantage point of the person using the term. Generally, it is the process of defining and shaping urban settlements and is thus, by definition, more applied in intent. The term implies and requires a multi-disciplinary approach. Traditionally this has meant merging the professional disciplines of architecture, landscape architecture and planning (urban and regional). More contemporaneously, influences from real estate development, urban economics and social theory are often integrated. In my own work, I prefer to go further, embracing not only a full range of systems that comprise of soft (social) and hard (physical) infrastructure, but also, adding the role of technology, cognition and behavior into the mix.

Urban Design can mean different things depending upon the vantage point of the person using the term.

What is Cybernetics?

Wikipedia [1] defines cybernetics as a transdisciplinary approach to explore regulatory systems, their structures, constraints and possibilities. The widely-acknowledged originator of the term ‘cybernetics, Dr. Norbert Wiener [2] [3] (Wiener 1948), formalized the notion of feedback from, between, and within systems (Wiener, 1950). Today, the term is loosely used to imply the control of any system using technology. This however, has caused many cyberneticians to avoid using such references and associations. This is a consequence of a shift away from AI (Artificial Intelligence) around the 1970's, and a move into the world of social sciences. Starting in the 1970's *new cybernetics* [4] saw work in biology particularly in the study of organized systems occurring in nature (i.e. not man-made). Through the 1980's cybernetics oriented itself toward political science and the ways in which social systems build upon themselves[1] (Harries-Jones 1988) [5]. In the 1990's the field viewed information as constructed and reconstructed by how individuals interact with their environment (natural and man-made) rendering it observer dependent[2] (Bailey 1994). Contemporary efforts have looked at how systems communicate and tend to steer each other. Cybernetics continues to look at how systems interact with themselves and externally. Its thinking and research can be found in computer science, biology, engineering, management, mathematics, psychology, sociology, education, art and in earth system science.

Cybernetics continues to look at how systems interact with themselves and externally.

Nexus between Urban Design and Cybernetic thinking

In theory, urban design practice, the processes underlying thoughtlogic and appropriate intervention can be understood and explained in cybernetic terms (Koberg, Bagnall 1974). However, in professional practice, it is extremely rare to find planners and urban designers that might use such system level comprehension as a basis for their work. In my view, contemporary urban design has three dominant conceptual challenges. First, we struggle with the comprehension and framing of the typical urban development problem itself. Often, the problem imagined is not what needs to be addressed. Second, solutions are compromised by a failure to acknowledge that, because most urban development problems are complex or "wicked" [6] (Rittel et al 1973), viable responses to them cannot be binary (i.e. rather than 'right' or 'wrong', they are better thought of as 'better' or 'worse'). Third, we generally underplay the importance of comprehending the full range of the complex forces at play. This means we are prone to over-simplify, and our responses remain in silos that are dominated by a few select areas of focus. Although some of these concerns could be aided by cybernetic thinking, I am not aware of any explicit cybernetic oriented efforts that have positively influenced urban development outcomes.

Complexity

Both urban design and cybernetics address complexity, albeit differently. The complexity of our world is growing, and our struggle to comprehend it promises to get only tougher as we become increasingly data heavy. This is amplified by the demand for faster decision making, which is governed by time and budget constraints that urge responses to stay as simple and fast as possible. Since our world is complex by its very nature, it follows that our success in dealing with these man-made and environmental systems is directly proportional to our ability to comprehend them. Developing better ways to comprehend is critical to understanding both the nature of complex urban problems, and the 'space' in which desired outcomes can be realized.

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Uncertainty and Risk

Uncertainty is a state in which limited knowledge makes it difficult to describe a prevailing condition and have a clear idea of what outcome may emerge from it. For the purposes of this discourse, I will concentrate on 'objective uncertainty'. This is epistemological in its orientation, and solely focused on knowledge guided decision making. This focus is best suited to compensate for a lot of noisy sensory information, which often acts as an impeding fog, particularly when trying to comprehend complex (urban) environments. Risk is the potential of losing something of value. It is an intentional interaction with uncertainty. Risk perception is the subjective judgement we make about the severity or the probability of a risk. It is important to note that often unless we have a personal stake in an outcome, we may not be personally taking any risk at all. This is an important and necessary self-realization for anyone who designs and plans for others.

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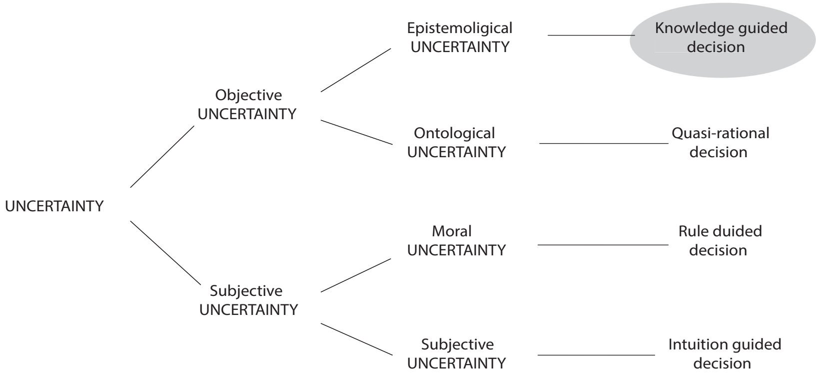

fig. 1: a taxonomy of uncertainty
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Urgency

There is much that can be said about the urgencies that confront us. Our world's complexity is growing faster than we can address it, and it is far from clear what our human and urban trajectory within it is. It is also increasingly apparent that our methods to deal with complex man-made and natural conditions are increasingly inadequate. This is underscored by our persistent struggles and lack of agreement on appropriate responses to climate change, and other large global trends like social and economic inequities. It is unreasonable to assume we can create proper responses to situations requiring complex trade-offs without understanding, or at least appreciating each problem in all its complexity first. The need for better methods to do so is urgent.

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The Growing Gap Between Theory and Practice

I consider urban design to be an applied endeavor in which theory is most helpful when it improves the way in which problems are understood, approached, and how outcomes are implemented and realized. This is not to suggest that urban design theory does not exist, but rather, that there is no one theory that has consensus. In practice, theoretical assertions do not usually aid or influence the decisions of the many stakeholders involved in the normal urban decision making process and implementation.

The Growing Gap Between Theory and Practice

There are many impediments to effective urban development processes. They transcend geography, context and scale and can be briefly stated as follows:

a. the inability to comprehend complexity and the nature of complex problems
b. the failure to understand that responses are better thought of in terms of trade-offs (i.e. better or worse), not right or wrong
c. our inability to transcend siloed thinking
d. our inability to work across different skill sets and competencies to understand the issues
e. our struggle to fully exploit and work with our inherited governance and fiscal constraints the collective inability to look beyond the short term
f. our inability to plan adaptively for uncertain futures (without needing to predict them)
g. our inability to deal with problems that dynamically morph as we attempt to address them

It is important to be sympathetic to the above realities. Most people do not make it their core competency to deal with the long term needs of complex urban situations. It is therefore incumbent upon urban designers and planners to develop methodologies that help every actor in the development process comprehend the realities and issues better. Individualized responses tailored to satisfy a bunch of single issue advocacies do not usually add up to a nuanced, and comprehensive response to a complicated problem (Kahn 1966). As our world becomes more data driven and complex, our responses and systems must be of proportional consideration[3] (Ashby 1956).

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To be adequately strategic, it would be helpful if urban design and planning can be thought of as an act of devising an explainable set of actions to achieve a desirable set of urban development outcomes. This means there must be an adequate mix of thought, technique, creativity and expertise. It also means that everyone involved must

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acknowledge that for complex urban conditions, there cannot be one ideal strategy to achieve desired outcomes. It also means that every 'strategy bundle' will have its own unique mix of risks and uncertainties. Each with its own mix of opportunities and potentials as well. When successful, the resulting strategies may use, or be used to: coordinate public and private efforts, channel civic energy and resources, adapt to new circumstances, create new contexts and settings and finally, integrate. The ongoing dilemmas in accomplishing such robust outcomes are that:

a. it is difficult to bring involved parties together
b. we have inadequate tools to build collective comprehension
c. we have entrenched and difficult governance structures
d. open processes often allow the original purpose of gathering to be hi-jacked
e. it is hard to predict dynamically changing external influences
f. it is tough to give up decision making authority and truly democratize information and related processes

These are not intractable problems, but addressing them does require creativity that vigorously challenges the existing paradigms in which decisions are routinely made. Theory is necessary for us to be more thoughtful, but real world problems in complex conditions are constrained by personalities, governance structures and other operational constraints that require applied approaches. To be truly adaptive and contextually relevant, urban problems cannot blindly rely on theory. In every instance the understanding of, and the approach to the problem must be tested, and made adaptive to its context.

Decision Space

Every problem can be imagined as sitting in a conceptual volume that contains the entirety of its complexity. For complex urban problems, imagine this volume to contain an amorphous cloud in which both the problem and its constraints, and the response potential exist together. This cloud or volume can be thought of as the *decision space* within which all the factors impacting the problem exist. Human factors routinely cause planning issues to be quickly bogged down by the core issues being hijacked by vested interests, competing entities taking over, and the domination of unplanned political agendas. Without early definition of the boundaries within which the problem, its comprehension, and the discussion of the issues is relevant, these disruptive forces are likely to jump in all the sooner. Figure 2 diagrams this conceptual cloud or *decision space* to the extent it is possible to define this conceptual volume of context and stay within it, planning efforts have a better chance of keeping the forces that tend to tear them apart on the periphery of the core aspects of the problem that need to be understood and addressed.

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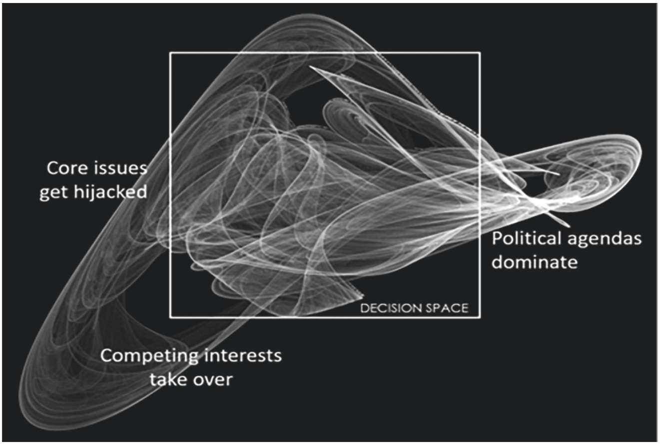

fig.2: decision space, focusing dialogue, Jain 2013

A Decision Support Tool for Planning and Urban Development

So how might we think and do better to address these concerns? The following is a real-world attempt in the US to provide a better basis for planning strategies and activity. The original engagement with the MNCPPC (Maryland National Capital Parks and Planning Commission) was to help their in-house planning teams refine their Montgomery County wide master planning process. The then director felt that the plans being developed by staff were not only poorly conceived, but inconsistent in quality and intent when seen collectively across the entire county. The prevalent and persistent planning approach (common in most settings) was an abiding belief that more entitlements (zoned development permissions) were always better, and that more development would increase revenues and economic activity, which in turn would somehow improve the prospects for paying for public amenities (such as parks, libraries, schools, transit, bike trails etc.). It is an unfortunate reality that this trickle-down approach to obtain all the community needs that fall within the realm of the 'public good' is erratic and uncertain at best. This is most apparent when towns and cities have large skews in the quality and distribution of their public spaces and social services. At the time of this effort there was no collective comprehension of the total permitted development capacity within Montgomery County. Each master plan was independently seeking to add as much development entitlement as possible, without regard of whether it was 'stealing' development potential from an adjacent master plan area, or the entire county. As in many places, master planning in the county was a 'me first' game, with each master plan taking advantage of their timing to formally entitle as much future development as possible. This would likely increase the risk for imbalanced conditions that would skew regional resources and service infrastructure. Clearly a mechanism to understand the larger consequences of local master plan formulation (and entitlement change) was needed. Further, due to budget constraints, the MNCPPC staff could only undertake a limited number of master plans each year. The basis for selecting which areas needed master plans seemed driven more by procedural urgencies, and expediencies rather than from technical comprehension and a broader consensus of both the county's environmental limits (expressed in part as existing regulations) and its development potential (i.e. available capacity). The director's office agreed with this broad assessment and supported the creation of this tool, which is now described.

It is an unfortunate reality that this trickle-down approach to obtain all the community needs that fall within the realm of the 'public good' is erratic and uncertain at best.

Development Management Assessment Tool (DMAT)

Most planning activities in the US take the guidance of an overall policy document that is usually known as the planning jurisdiction's

‘General Plan’ (the actual term may vary). This document is only periodically updated (usually at 5 - 10 year intervals), which means that most ongoing planning activities are mandated to work inside its directives.

Figure 3 shows the relationship of how periodic and ongoing activity interact with each other with only infrequent impacts on the General Plan. The DMAT (Decision Management Assessment Tool) created in this effort was conceived to assist both periodic and ongoing activity. In this specific setting, this tool was designed to spatially map existing regulations relating to both environmental sensitivities and man-made development controls. The intent of DMAT was to create a GIS mapping methodology that would provide spatial insights on what was ‘fixed’ - or regulated -, and identify what was ‘flexible’ (i.e. less constrained) and to do so over the entire county’s land area. The outcomes would easily show which lands had the most unconstrained development potential. Such knowledge could in turn, help clarify internal planning priorities (i.e. within the planning department), and permit more clear discussions with the community, technical experts and decision makers - including elected officials.

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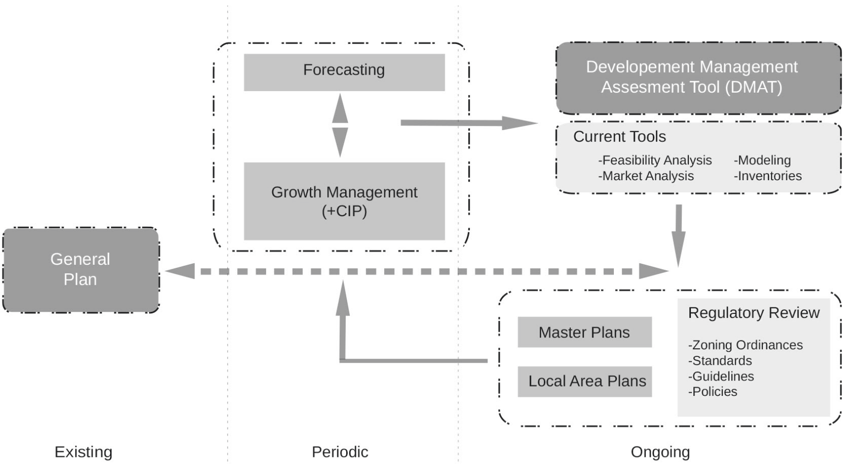

fig.3: role of DMAT in the MNCPPC Planning Process, Jain 2013 (developed for MNCPPC)

DMAT Methodology

To accomplish this, careful decisions were made on the relevant data sets that would best represent the most comprehensive information on environmental and man-made regulations. The GIS representations of these data sets were then consistently represented as land areas colored from dark (regulated area) to light (less, or no regulation for that category). Figure 5 shows how these layers were assembled. A third category of 'qualifiers' was added to include areas that did not fall within either the environmental, or man-made regulatory categories, but would render land undesirable, or unlikely to develop.

Process

The mapping of each GIS layer was done by spatially mapping the regulations as progressive overlays of each layer on the other to cumulatively build up a consolidated spatial map of regulated lands. Figure 6 shows a map of the planning area for which this mapping was undertaken (Montgomery County, Maryland). The DMAT process progressively subtracts the regulated lands to show the remaining percentages of relatively unconstrained land. The final amount and distribution of unconstrained land is easy to see, and quantify.

Environmental Regulatory Layers

Figure 7 conveys the environmental layers mapped in the form of a spreadsheet. This also indicates the mapping method of how regulated lands would be graphically represented on each GIS layer. The selection of these layers (and their mapping order) was the outcome of discussions with a mix of agency expertise that included planners and GIS technical experts. The departments and agencies that provided the GIS mapping data were also consulted. The composite mapping of these layers is shown in Figure 8. The darkest areas are the most constrained indicating one or more regulations that limit that land. The final map shows that when all the environmental regulations are spatially consolidated, they cumulatively consume 60% of the total planning area or land in the county.

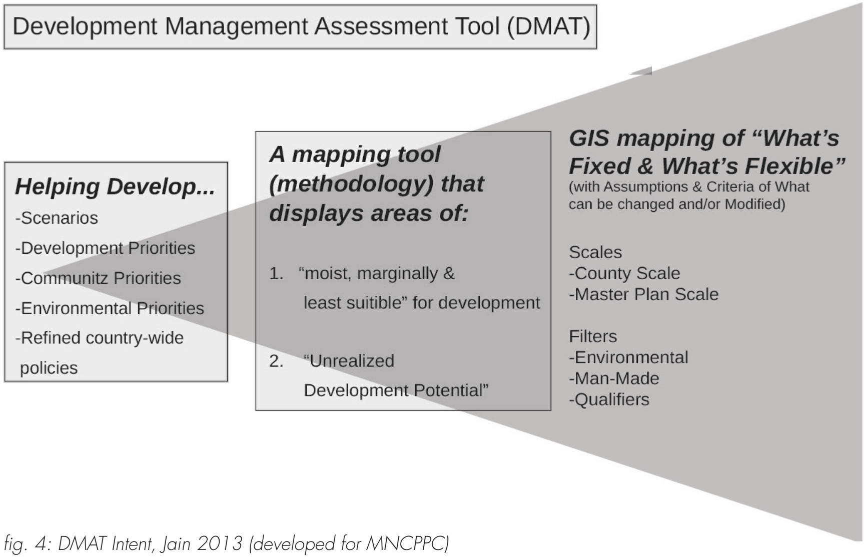

fig. 4: DMAT Intent, Jain 2013 (developed for MNCPPC)

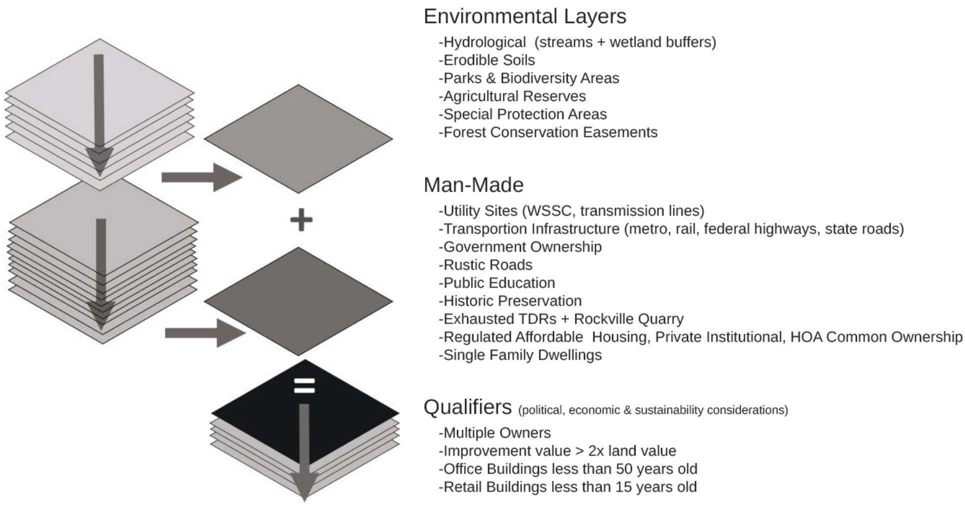

fig. 5: DMAT Data Methodology (regulatory constraints), Jain 2013 (developed for MNCPPC)

Man-Made Regulatory Layers

A similar exercise was done for regulations covering man-made elements in the county. Here also, the darkest mapped areas are those with the greatest regulatory restrictions. Interestingly, each man-made regulatory layer requires detailed criteria. Clearly stating such criteria is an important and transparent way of keeping every actor in the planning process honest, and comfortable. For example, Figure 9 indicates that utility corridor regulations require a 50' protection buffer area on either side of the utility pipeline or electric power line. Normally a developer would likely protest the buffer to be too excessive, and an environmentalist would claim it to be too small. As the mapping is simply a reflection of current regulation, both distracting voices could be easily silenced on practical and technical grounds. Often, not having an easy way to know, or see relevant regulatory considerations (expressed here as GIS layers), creates confusion. This, as experienced planners know, distracts from a range of planning issues that need to be understood collectively and decided upon.

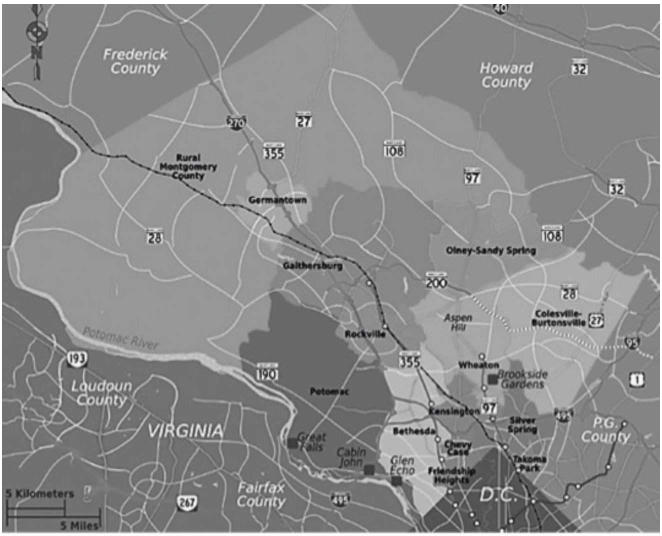

fig. 6: DMAT area boundaries, Jain 2013 (developed for MNCPPC)

Layer	Criteria		
	Least Suitable Black, 50% Opacity	Marginally Suitable 20% Gray, 50% Opacity	Most Suitable No Color
Hydrological Water Areas	present	-	-
Streams/Wetlands Buffer	present	-	-
Erodible Soils	present	-	-
Parks	park	-	-
Biodiversity Areas		biodiversity area	
Agricultural Reserve	present	-	-
Special Protection Areas	-	present	-
Forest Conservation Easements	present	-	-

fig. 7: existing environmental constraints (regulatory), Jain 2013 (developed for MNCPPC)

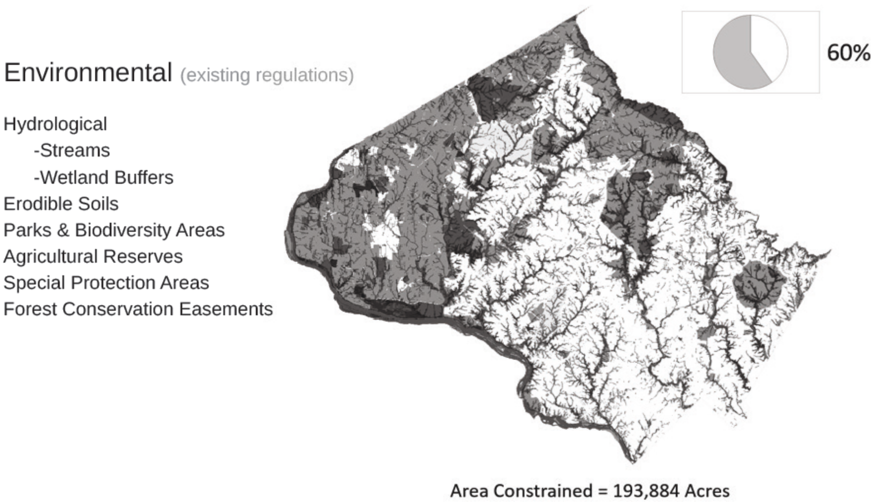

fig. 8: Composite of Envieonmental Regulatory Constraints Layers, Jain 2013 (developed for MNCPPC)

To underscore the dramatic progression of how this result emerged, the tool was visually organized by placing each individual GIS layer over the previous layer, thereby cumulatively adding up the restricted areas with each new layer.

The resulting GIS composite map shown in Figure 10 of only the man-made regulations shows that 62% of the total planning area of the county is constrained by them. Figure 11 shows a combination of the environmental and man-made composite maps. Because there are area overlaps, the combined constrained area is 81% of the total land area in the county. To underscore the dramatic progression of how this result emerged, the tool was visually organized by placing each individual GIS layer over the previous layer, thereby cumulatively adding up the restricted areas with each new layer. This transparency allowed each data layer to be critically assessed by stakeholders - individually and collectively. This method had the added impact of building progressive credibility and faith in the outcome.

Layer	Criteria		
	Least Suitable Black, 50% Opacity	Marginally Suitable 20% Gray, 50% Opacity	Most Suitable No Color
Utility Sites and Transmission Lines	utility site present, minor lined buffered 10 ft, truck lined buffered 50 ft	-	-
WSSC Water Mains	water main with diameter over 42 inches, buffered 35 ft	-	-
Metro/Railroad Tracks/Yards/Sidings	present	-	-
State Roads and Federal Highways	present, federal highways buffered 150 ft, state roads buffered 35 ft	-	-
Government Ownership	US Federal Government, State of Maryland	US Postal Service, Montgomery County, municipalities	-
Rustic Roads	preent, all rustic roads and exceptional rustic roads buffered 15 ft	-	-
Public Education Sites	Montgomery Collage, MCPS	-	-
Historic Preseration Information	master plan historic district of individual site	Locational Atlas Historic Districts or Individual Resource, National Register Historic Districs or Individual Resource	-
TDR Exhausted	# of TDRs remaining in less than or equal to the # of housing units on the property	-	-
Quarry	present	-	-
Regulated Affordable Housing	-	private and non-profit affordable housing (provided by DHCA), HOC-owned affordable housing	-
Private Institutional	-	hospitals, churches, swimming pools, private schools	-
HOA Common Ownership	-	HOA common ownership	-
Land Use- Single Family Detatched	-	present	-

fig. 9: existing man-made constraints (regulatory), Jain 2013 (developed for MNCPPC)

Utility Sites
- -WSSC
- -Transmission Lines

Transportion Infrastructure
- -Metro
- -Rail
- -Federal Highways
- -State Roads

Government Ownership
Rustic Roads
Public Education
Historic Preservation
Exhausted TDR's
Rock Quarries
Regulated Affordable Housing
Private Institutional
Common HOA Ownerships
Single Family Dwellings

fig. 10: composite of man-made regulatory constraints layers, Jain 2013 (developed for MNCPPC)

Environmental (existing regulations)

Hydrological
- -Streams
- -Wetland Buffers

Erodible Soils
Parks & Biodiversity Areas
Agricultural Reserves
Special Protection Areas
Forest Conservation Easements

Man-Made (existing regulations)

Utility Sites
- -WSSC
- -Transmission Lines

Transportion Infrastructure
- -Metro
- -Rail
- -Federal Highways
- -State Roads

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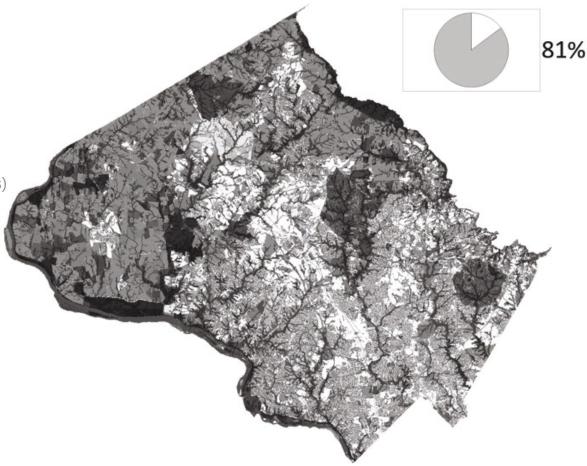

Area Constrained area = 263,260 Acres 81%
Unconstrained area = 61,059 Acres 19%

fig. 11: environmental and man-made constraints, Jain 2013 (developed for MNCPPC)

Qualifiers

The spatial mapping of existing environmental and man-made regulations, did not offer the most complete picture of the real 'playing field' identifying which areas are least constrained for development. To stay realistic, new layers of land and development constraints were added under the broad heading of 'qualifiers'. In this list (Figure 12), properties that had multiple owners were added. This is because such properties were considered too difficult and time consuming to assemble for meaningful development. Also, another layer indicating sites where the building value was more than twice its land value was mapped.

It was considered unlikely such sites would be economically viable for development. Sustainability considerations were also factored in. Office buildings that were less than 50 years old and retail buildings that were less than 15 years old, were also mapped as constrained locations. This was to acknowledge it was unlikely and undesirable for them to be torn down during their reasonable lifespans. These additional constraints removed another 4% of the land area from availability reducing relatively unconstrained land to 15% of the total land in the county (Figure 13).

Impact and Applications

The visual progression of regulatory constraints as they added up to 85% regulated land had a very sobering impact on a diverse audience of stakeholders, elected officials and technical staff. Everyone felt better after it became clear that the remaining 15% of relatively unconstrained land still added up to a considerable amount of development potential. The distribution of constrained and unconstrained land was also revealing. The finer grain of detail revealed which areas would benefit from more planning attention. This also helped determine which areas might be given priority for master plans, which had the potential to help staff to budget and prioritize their agency workload. When a separately prepared county wide rapid bus transit plan was applied on top of this analysis, it was clear some proposed station areas were in highly constrained areas, while others were not.

Man-Made	Suitability for Development		
Opportunity & Constraint Factors	Least Suitable	Potentially Suitable	Most Suitable
Multiple Owners			
Improvement Value >2x Land Value			
Office Buildings less than 50 years old			
Retail Buildings less than 15 years old			

fig. 12: additional qualifiers, Jain 2013 (developped for MNCPPC)

Environmental

Hydrological
- -Streams
- -Wetland Buffers

Erodible Soils
Parks & Biodiversity Areas
Agricultural Reserves
Special Protection Areas
Forest Conservation Easements

Man-Made

Utility Sites
- -WSSC
- -Transmission Lines

Transportion Infrastructure
- -Metro
- -Rail
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- -State Roads

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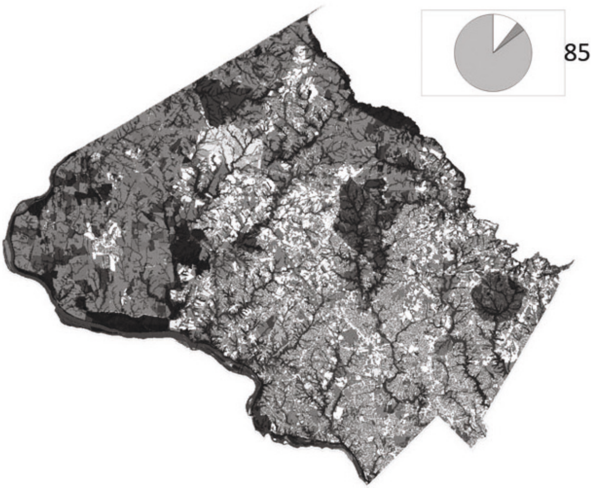
Qualifiers

-Multiple Owners
-Improvement value > 2x land value
-Office Buildings less than 50 years
-Retail Buildings less than 15 years



Constrained area = 276,515 Acres 85%
Unconstrained area = 47,804 Acres 15%

fig. 13: environmental, man-made and qualifier constraints combined), Jain 2013 (developped for MNCPPC)

This provided another constructive basis for phasing the implementation of the rapid bus transit system design and determining the different conditions around each proposed bus station. Despite its acknowledged value, this tool was not adopted by the MNCCPC as a formal mechanism. There were multiple reasons for this. A significant barrier was the lack of institutional capacity, and associated will to create and implement all the necessary protocols to ensure a fully updated open data platform across all relevant county departments. To do so would have been no small undertaking. Another was the potential loss of retaining decision making authority by appointed individuals. Finally, the full vetting and comprehension of the tool itself was hampered by a change in leadership which brought in different priorities, and perspective.

Conclusions

This narrative began by asserting the need for better mechanisms to help comprehend complex environments without over-simplification. It points out how conventional urban design practice is increasingly inadequate to comprehend and address complex urban problems. It also acknowledges that structured thinking as embodied in cybernetics might help. To develop good decision support tools, we need to not only understand the larger context in which they apply, but also, the role of relevant institutional structures, and the way decisions are administered within them. In addition, we must combine all this with a good understanding of the built and natural environment in which interventions are needed. The development of this tool was a unique opportunity to test appropriate responses in the professional world, using a methodology free from the need to simulate real conditions. It sought to address several re-occurring planning problems. And, although it was designed for the MNCPPC, most planning environments could benefit from at least some aspects of its conceptual structure and approach.

To develop good decision support tools, we need to not only understand the larger context in which they apply, but also, the role of relevant institutional structures, and the way decisions are administered within them.

Not only did DMAT provide a fast and open way to understand the complex regulatory conditions on MNCPPC territory, but it also helped prioritize the planning department's workload, with a clearer sense of planning urgencies and future development potential. This would have also helped in the forecasting and capital improvement program allocation and budgeting for the county. The DMAT tool also provided a good reality check by verifying where change is possible and helping confirm which areas were likely to experience the most change (i.e. the least regulated areas). It also supported better flexibility and adaptability by its users, providing a clear basis for scenario generation and being a reliable bench mark for competing development alternatives. Finally, DMAT also helped improve community processes by allowing more focused debate and encouraging more informed and thoughtful choices by those in both leadership and stakeholder positions. The unfortunate side effect of such tools, is that the more successful they are in becoming open platforms for public comprehension, discussion, decision making, and governance, the more they tend to threaten existing decision making authority. It is not human nature to give up such authority, and from that perspective alone it becomes clear that the will to deploy completely open information systems gives reason for pause to many who have the authority to decide, and prevail. For the foreseeable future we will continue to struggle reconciling divisive individual and collective human impulses with our need for objective and logic driven decision platforms that are easy to comprehend. While such open platforms may not always guarantee desired outcomes, they do help create civic settings in which the possibility of any actor in the process proclaiming ignorance is vastly reduced. When successful, such tools help us make better decisions on how to cope with uncertain futures with a greater sense of urgency. This is a good reason for us to consider more strategic combinations of urban design and cybernetic thinking. Both disciplines should use more deliberate approaches that are sensitive to realities, and applied in their orientation and purpose. Our cities and urban settlements could certainly use the help.

Endnotes

1 Quote: *"Unlike its predecessor, the new cybernetics concerns itself with the interaction of autonomous political actors and subgroups, and the practical and reflexive consciousness of the subjects who produce and reproduce the structure of a political community. A dominant consideration is that of recursiveness, or self-reference of political action both with regards to the expression of political consciousness and with the ways in which systems build upon themselves."*, Harries-Jones, 1988.

2 Quote: *"that it views information as constructed and reconstructed by an individual interacting with the environment. This provides an epistemological foundation of science, by viewing it as observer-dependent. Another characteristic of the new cybernetics is its contribution towards bridging the micro-macro gap. That is, it links the individual with the society."*, Bailey, 1994.

3 Quote: *"As the external environment becomes more complex, systems also need to become more complex to prosper."*, Ashby, 1956.

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Open Works for The Urban Improvise

Kristian Kloeckl

The current debate about connected technologies in cities is dominated by an emphasis on probability based predictive modeling and planning with a distinct focus on efficiency. The rhetoric tends to focus on Smart City solutions rather than smart questions and risks repeating a dynamic of generating self-fulfilling prophecies that Jane Jacobs cautioned against already more than five decades ago (Jacobs 1961, 300-01). The discourse lacks to a large extent a more fundamental reflection on how the ad-hoc and more fluid capabilities of these technologies in urban environments can be conceptually framed for the design of interactions. This may be the time to seek a new model to study and think about interactions in the hybrid city. A model that shifts the discourse from a focus on probability and planning towards one of possibility and preparation. The increasing pervasiveness of embedded and mobile connected devices has transformed the built environment from a predominantly stable and enduring background for human activity into spaces and objects that have a more fluid behavior. These objects and environments are capable of sensing, computing, and acting in real-time; they can change their behavior in response to their own system state, histories of past actions and interactions, the behavior of humans and machines within their reach, and changes in environmental conditions. Augmented environments of this type have the potential to go beyond simple action–reaction couplings and become truly interactive, displaying a dynamic and responsive behavior that engages with their human counterparts. Activity is detected and interpreted, actions are modulated, and behavior is adapted in response to unforeseen situations in feedback loops and a continuous give and take - a dynamic that closely resembles that of an improvised performance. In this article, I take a closer look at the practice and study of improvisation to inform the design of interactive artifacts, systems, and environments in the context of today's cities and focus in particular on one key position for an improvisation-based model for interaction: Openness.

Keywords: Openness, Improvisation, Urban, Interaction, Design

The City Improvised

Improvisation and public life in cities have always been intertwined. A prominent historic tie is that of the *Commedia dell'Arte* performances that date back to as early as the sixteenth century in cities of the Italian peninsula. *Commedia dell'Arte* was the first professional form of actor groups, a traveling business enterprise, based on improvisation. Based on a schema or scenario, actors would do away with a script and improvise their performances for a number of reasons. Improvisation allowed the performance to be adapted to the many local languages and dialects of the peninsula. The story could be adapted up to the last minute to embrace current local events and the political situation. And finally, by not being limited to written scripts, performers were not prone to political censorship. The subversive nature of acting-in-the-moment is also what Michel de Certeau describes in *The Practice of Everyday Life* (De Certeau 2011), when he focuses on the innumerable "ways of operating" the everyday tactics, by means of which users re-appropriate space organized by powerful strategies and techniques of sociocultural production. De Certeau looks at how people take shortcuts between formally proposed paths, what people actually do with systems put in place for them to consume, and what clandestine forms of practices and procedures of everyday interactions exist relative to structures of expectation, negotiation, and improvisation. Today, visions of the city are frequently described as an entity that functions akin to a computer—"The city itself is turning into a constellation of computers" (Batty 1997)—numerically controlled and run on a binary basis. However, this image somehow does not always resemble the motives behind people's choice to move to cities in the first place. "We move to what are essentially idea factories: cities full of people," affirms Enrico Moretti (Maney 2015). Many people move to cities for something that exceeds their expectation—a search for the unexpected and for the unforeseen.

A systems perspective of Improvisation

And this points to the very notion of improvisation: Its Latin root *proviso* indicates a condition attached to an agreement, a stipulation made beforehand. Im-provisation, then, indicates that which has not been agreed on or planned and thus presents itself as unforeseen and unexpected. However, improvisation is a process that is often misunderstood. A common interpretation is that when something is improvised, it is to make up for the lack of something, or to get by in some way until the plan that was lost can be recovered. To ex-temporize, a common synonym is indicated by Webster's dictionary as doing something in a makeshift manner, which in itself is referred to as a usually crude and temporary expedient (Montuori 2003, 245). The view of improvisation that I adopt goes beyond this interpretation. In the context of music, improvisation refers to playing in the moment, or composing in the flow. It is a process characterized by a simultaneity of both conception and presentation, and during the act of execution, the situation at hand continues to feed into what is being performed. We typically underestimate the investment in attention, study, and practice that is the foundation for every improvised performance. Requiring a heightened awareness both of self and of others, an improvisation is based to a critical extent on the artist's past practice and experience. To talk about improvisation also means to consider the notion of inventiveness, involving elements both of novelty and of repetition of past patterns. As artists improvise, they elaborate on existing material in relation to the unforeseen ideas that emerge out of the context and the unique conditions of the performance. In this way, variations are created and new features are added every time, making all performances distinct (Berliner 1994, 222; Weick 1998). While not following a previously formulated plan as such, improvisation does in this way connect with what has come before. We can "conceive of improvisation as an iterative and recursively operating process where dynamic structures emerge from the processing and reprocessing of elements" (Landgraf 2014, 36). With this understanding, we capture more of the essence of the practice, which enables us to identify structures in a process that can at first appear ephemeral. Improvisation overcomes several dichotomies instilled by modern thought. Its practice overcomes clear distinctions between repetition and novelty, discipline and spontaneity, security and risk, individual and group,

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and ultimately, order and disorder. It does so by doing away with a binary opposition and embracing a mind frame of complexity, in which order and disorder, information and noise form a mutually constitutive relationship (Montuori 2003, 241). The phenomenology of the moment for improvisational performers is as much material for their art as is their past training and practice of structures and procedures. In ensemble work, each performer feeds off and builds upon what others do. As they interact with each other, performers pass cues back and forth, consciously or unconsciously. They are perceived and interpreted and it matters less whether they are interpreted in the intended way. They become part of a collective creation of meaning that informs the interaction. Improvisational performers not only pick up on gestures, sequences played and acted by their fellow performers, but they also develop a capability to recognize form when it is in the making, attributing meaning to the completed form of which they see the seed - they feed forward. The attributed meaning and the action based on it become the novel element an actor contributes to the collective process regardless of whether the original action was executed towards that expectation or not. Misunderstandings and errors are constructive elements in improvisation. They are the noise that leads to the emergence of new structures. In improvisation many actions do not receive their full meaning until after the act has occurred. What one actor does will redefine the meaning of the previous action of another actor, which again will be conditioned by the following action. These recursive processes define themselves because their definition cannot be attributed to the intention of a single or even all participating actors.

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In systems theory, emergence describes the appearance of something new, the arrival of which could not be anticipated, expected or foreseen, but rather something that was born out of the interaction between previously present elements. This new arrival emerges from non-simple interactions between many different parts that interact both in series and in parallel, forming a complex system. A system that is self-organizing and which complicates boundaries between interiority and exteriority. A system, that is neither fixed nor static but that evolves and adapts (Simon 1969;

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Those improvising are the story. They are participating observers that make and form the story as much as they are a product of that same story.

Taylor 2001). Adapting a systems view of improvisation makes the tension between the notions of stability and variation a productive one. Parallels are often drawn between the way actors or musicians improvise and the phenomenology of the spoken language, of discourse and conversations. "It's like language: you're talking, you're speaking, you're responding to yourself. When I play, it's like having a conversation with myself" (Paul Berliner quoting drummer Max Roach) (Berliner 1994, 192). Rather than telling a story, those improvising are the story. They are participating observers that make and form the story as much as they are a product of that same story.

> *"The stories, the results of action and speech, reveal an agent, but this agent is not an author or producer. Somebody began it and is its subject in the twofold sense of the word, namely, its actor and sufferer, but nobody is its author"*.
>
> Arendt 1998, p.184

The designer of adaptive environments, as discussed by Pask, will thus not be designing the environment as such but rather the terms upon which such an environment organizes itself.

Also in the context of systems theory, the interactions between the constituent parts of a system and between systems are likened to the process of a conversation. Gordon Pask discusses how "structures may be designed (as well as intuited) to foster a productive and pleasurable dialogue" (Pask 1969). He invests the architect with the role of designing systems instead of buildings that follow rigid typologies. Since human occupants of manmade structures and environments change, evolve, and adapt, Pask sees an imperative for these manmade structures to reach similar capabilities to remain relevant and effective. It falls to the designer of such a system to specify what the environment will learn about and how it will learn, as well as how it will be able to evolve in terms of evolutionary principles. The designer of adaptive environments, as discussed by Pask, will thus not be designing the environment as such but rather the terms upon which such an environment organizes itself over time and in an ongoing interaction with its human occupants and other factors. The designer in this view loses his position as a controller, and instead instills his creations with the structural and procedural capabilities to evolve and grow.

Design for Initiative ensures Openness

Looking at improvisation as a system can help to identify a number of key positions that are recurrent in different types of improvisation. In (Kloeckl 2017) I put forth four key positions for an improvisation-based model of urban interaction design:

a. design for initiative ensures openness;
b. awareness of time ensures the relevance of actions;
c. forms of action are understood in the making;
d. interactions themselves are Other than expected.

I want here to expand on the first of these positions which relates to openness and initiative and illustrate its potential for application through examples of projects in the urban realm. A critical aspect of improvisational performance are the beginnings – and as such, notions of agency and autonomy of a person or system. Who starts? When to start? How to start? As there is no plan, the beginning of an action is born out of context and out of initiative. Making a first move, speaking the first word, taking initiative, represents a marking of an unmarked space (Peters referring to Niklas Luhmann in Peters 2012, 12). Improvisation is, however, not so much about creating or maintaining any one particular work, but rather about ensuring an openness towards a process of ongoing creation. Heidegger describes the existential triangular relation between the artist, the artwork and art (Heidegger 1971, 19): The artist makes the artwork but also the artwork, once conceived, makes the artist as there can be no artist without the artwork created by the artist. Furthermore, both artwork and artist only exist in virtue of such a prior notion of art, giving way to a tight interdependence between these three notions. This existential interdependence ensures that the creative act is not a single act but the beginning of a process. A process that ties the artist to the working of the work rather than to any one particular piece of art that may be generated as an outcome. Keeping the improvisation going upstages any structure that might emerge during the process. Designing responsive systems in this sense, then, implies viewing any process of interaction as something that

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has already begun as well as something that will continue beyond any specific instance of interaction while fostering openings for initiative. Systems that espouse this notion need to be sufficiently open so that human initiative can generate significant variations that become foundational for the interaction process itself. Taking initiative is deeply ingrained in human nature. Hannah Arendt in *Vita Activa* describes how "*to act*, in its most general sense, means to take initiative, to begin (Greek archein, "to begin", "to lead", "to rule"), to set something in motion (which is the original meaning of the Latin *agere*)" (Arendt 1998, 177). It is in the nature of beginning that something new is started which cannot be expected from whatever may have happened before

> *"This character of startling unexpectedness is inherent in all beginnings and in all origins. […] The new always happens against the overwhelming odds of statistical laws and their probability […] The fact that man is capable of action means that the unexpected can be expected from him, that he is able to perform what is infinitely improbable."*
>
> Arendt 1998, p.178

A move from probability to possibility.

Embracing this profound reflection today means also to look critically at the planning paradigm derived from probability based predictive modeling. Today's availability of massive amounts of data incidental to everyday human activity and generated in systems of telecommunication, transportation, healthcare, etc. is often used as an undisputed basis for the planning and implementation of systems based on past and probabilistic futures.

Instead, I suggest that the hybrid city with its pervasive networks of connected devices and digital/physical interfaces need not be limited to this. Quite on the contrary, the value of these technologies lies in their ability to facilitate and support ad-hoc behavior, interactions, decision formation and action in response to the moment and to a given situation. A move from probability to possibility. The questions are then how to plan and design systems for such improvisation-based interactions, how to leverage today's technological context to support people's acting in the moment, how to plan and design in a way that embraces the unpredictability of human acting, how to leverage technology systems in the hybrid city that foster taking initiative, and how to design for an openness that allows people to bring themselves in to complete interactions through their participation. For this purpose, I suggest to revisit Umberto Eco's *Opera Aperta - The Open Work* (Eco 1989) - in the context of the hybrid city. In *Opera Aperta*, Eco articulates a change in point of view regarding art and its perception culminating in the 1960s. Over centuries, the author of the work of art was seen as the sole source to instill meaning in the work of art.

The artwork is not closed by the author but is essentially open for continuous acts of interpretation and completion when interpreted and performed by an active audience.

A passive audience would then receive from the artwork what the author has bestowed upon it. *Opera Aperta* describes the shift in mindset towards what we would now call co-creation. The performance, reception, and interpretation of the artwork are all active parts in the constitution of the work itself. The artwork is not closed by the author but is essentially open for continuous acts of interpretation and completion when interpreted and performed by an active audience. The following three notions in Eco's argument are of particular interest to the issue of openness and initiative for improvisation based interaction:

a) fields of possibilities
b) dialectic in the performance of the open work
c) structural vitality of the open work

Open works are characterized by the intrinsic invitation to an active audience to make the work together with the author of the work. In an open work, the relation between the parts that make up the work is not entirely defined by the creator of the work: What the project is and how it behaves is deliberately underspecified by the author. Belgian composer Henri Pousseur describes his piece *Scambi* as a *field of possibilities*, rather than as a composition. The tape-music based piece requires the listener to actively organize the parts in different ways before engaging in the listening part of the experience. The listener collaborates with the composer, by organizing unplanned or physically incomplete structural units with multiple possibilities for realization, in this way actualizing the composition at every instance of listening. By describing his work as a *field* Pousseur moves beyond strictly causal relationships and a rigid and one-directional system in his work. Instead, he suggests a move towards a perspective of complex interactions between parts that every time anew reconfigure possible events into dynamic structures. The notion of *possibility*, then, discards a predetermined order given by the author and suggests a "devolution of intellectual authority to personal decision, choice, and social context" (Eco 1989, 15). In this way, *Scambi* always changes as it is organized and perceived by different listeners and at different instances. Eco proposes his notion of the open work as a poetic theory, a theory of creation - a design theory. This poetic theory puts into action and into tangible form systems that recognize *openness* as the fundamental possibility for both the author and the consumer of the work. Constructing a *field of possibilities* in the context of the hybrid city points then towards creating interventions that do not play out in a way that is or can be controlled by the designer. Instead, the designer constructs fields of possibilities through an intervention where audience engagement and different urban dynamics change the disposition of the field continuously.

Constructing a field of possibilities in the context of the hybrid city points then towards creating interventions that do not play out in a way that is or can be controlled by the designer.

A project that is oriented towards the creation of a *field of possibilities* is 'Sloth-bots' by Mike Phillips. It consists of large autonomous and box-like robots that move very slowly, at a speed that is barely perceptible to humans. By doing so, they reconfigure the physical architecture of a space over time as a result of their interactions with people. Sloth-bots pick up on the use of space they are in and how it changes throughout the day and reposition themselves in response and anticipation of new interactions with building occupants. Another example is 'Warde' by HQ architects, installed in the City of Jerusalem. The project consists of four 9-meter high and 9-meter wide inflatable flower-like structures that function as spectacular shading and lighting structures in a public space. Each flower is inflated separately in response to different environmental conditions such as pedestrian movements, arrival of tramways at

Each flower is inflated separately in response to different environmental conditions such as pedestrian movements, arrival of tramways at the adjacent station, light levels, wind, etc.

the adjacent station, light levels, wind, etc. As a third example, the project 'Open Lines' developed by a team led by the author consists of dynamic lines projected onto the floor of a busy campus atrium. The project is based on the observation of how apparently simple graphic elements such as lines in urban environment so strongly condition people's behavior. Lines in cities tend to be passive and fixed in time despite the continuously changing urban dynamics around them. In the 'Open Lines' project, the behavior of lines, instead, is conditioned by peoples' movements as it is picked up by a camera system. A program interprets pedestrian behavior in real time and over longer time periods through a framework based on the *Viewpoints* technique of movement improvisation. In *Viewpoints* individual and collective activity emerge based on actors' heightened awareness and immediate response to any of nine temporal and spatial viewpoints: Tempo, duration, kinesthetic response, spatial relationship, topography, shape, gesture, and architecture. In the project lines and people condition each others' behavior without the ability of direct control.

The three projects are characterized by an openness that is continuously negotiated between human participants and the responsive elements as both condition and reflect each other's behavior. The *where, when* and *how* the Sloth-bot moves emerges out of the interaction with building residents and the physical context. 'The Warde' sun shades open and close through a complex interplay of multiple parameters of the environment, and the Open Lines are animated by multiple aspects of people's movements in real time and over time intervals, proposing mutating projected topographies as people move through space. The projects have in common, that there is no plan as such, but rather a protocol of constraints which together with people's behavior results in movement being constantly conceived in the moment that it is enacted. 'Sloth-bot' may block passage, divide space, direct, facilitate flow or other - these meanings are attributed as they emerge from the interplay between people and the object rather than being prescribed. The effect of this ongoing process of regeneration is remarkable as it results in a continuous novelty bestowed upon a space that might otherwise seem familiar.

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Dialectic in the Performance of the Open Work

Adopting a perspective of a design intervention as an open work means also to embrace a new kind of dialectic between the work and those that will perform it through active participation. In every instance of performing the work or interacting with it, the work takes on a fresh perspective for itself. In Eco's words, "every performance explains the composition but does not exhaust it. Every performance makes the work an actuality, but is itself only complementary to all possible other performances of the work" (Eco 1989, 15). In this sense, a work can generate infinite meanings in its interaction with people. Every such interaction will unveil something about the nature of the work, but there will be more to it than can ever be uncovered. Furthermore, these different moments of interaction are connected and so are the parts they uncover. Becoming aware of multiple interactions means expanding the awareness of the field of possibilities. Every actualization of the work, if aware of previous actualizations, contributes to a growth in the scope of the work. The work grows on people and people's habitat and place. This performative dialectic can be observed in the work of architects Lacaton and Vassal commissioned by the city council of Bordeaux to redevelop Place Leon Aucoc. "The architects followed their specific approach by entering the situation itself—spending time in the square, which is located in the city's working-class district. That was all. They realized that structurally the square already had everything that was needed" (Dell and Matton 2016) and decided not to propose any physical changes at all.

A work can generate infinite meanings in its interaction with people.

> *"Instead we drew up a catalogue of maintenance measures which were strikingly obvious and yet completely neglected, including regularly cleaning the place of dog excrements in order to make it possible to play the game of pétanque on it once again."*
>
> Ruby and Ruby, 2008, p.254

By doing so they focused directly on the dialectical nature of the place in a performative way. Their intervention opened up the situation to increase possibilities for interactions between the place's constituents which would then actualize the potential of the place with every single interaction anew. In the context of the *hybrid city* we can relate this to recent developments of maintenance operations that are performance rather than operations driven. Regular operations such as the cleaning of streets and public squares, waste collection, etc. shift from the compliance of regular operations towards responsive actions in response to residents' dynamic perception of desirable urban conditions.

Structural Vitality of the Open Work

Eco distinguishes an open work from any random collection of parts by elements of structural vitality. These elements make the open work susceptible to a range of integrations. "They provide it with organic complements which they graft into a structural vitality which the work already possesses, even if it is incomplete. This structural vitality is still seen as a positive property of the work, even though it admits of all kinds of different conclusions and solutions for it." (Eco 1989, 20) The structural vitality of an open work are the positive qualities that formulate the possibilities in which the parts can be formed into wholes. The open work offers a field of relations that opens possibilities. This field of relations implies organizing rules that govern these relations. The author of the work offers this field of relations to an interpreting and performing audience that actualizes some of the possibilities of the work through their personal intervention. The work offers such personal interventions and the interpreter inserts him or herself into this field of possibilities. However, the field of possibilities always remains the world intended by the author. While the author does not know the ways in which the work will be interpreted and actualized, that form is still his or her form—it is a form made possible through his original work that created the field of possibilities in its structural vitality. Mutability is a key factor in this. The open work is like a malleable material that can mutate into different forms but that has constraints and every form is retraceable to the material. The mutability is deployed as a factor within limits authorized by the pliability of the material offered to the performer's manipulation. One project that illustrates the structural

The structural vitality of an open work are the positive qualities that formulate the possibilities in which the parts can be formed into wholes.

vitality of an improvisation-based open work is David Brown's *Available City*. It is "an ongoing speculative design that leverages the *City of Chicago's* ownership of 15,000 vacant lots to structure an improvisational production of a new public space system" (Brown 2016, 66). Organizational ideas are based on different techniques of musical improvisation that inform the *Available City* initiative. The context of this project is an acknowledgement that there is no demand economically for these existing lots that are too small a size for contemporary development and they are also dispersed throughout the city's territory. The city views development of these lots as a way to mitigate a negative impact they may have on adjacent private lots if left vacant. The *Available City* project turns this perspective around and "proposes that the city-owned lots can be catalyzing agents" (Brown 2016, 67) instead. The proposal consists in an intricate set of rules that enable private developers to extend their intervention beyond any one private lot to include up to five city owned lots. Developers can develop city owned lots as long as the development offers space accessible to the public of equal surface area as the original public lots. Also, the developed public lots do not need be adjacent, loosening yet another constraint. The objective of this framework is for vacant public lots to change from being a burden to being an opportunity for the city by engaging in an improvisational interaction with private developers as well as local change agents. "The Available City is thus an urban proposition that comprises 15,000 local effects in which the provision of greater amounts of collective space is the basis for greater amounts of building […] the system as a whole gains in impact with additional instances of collective space. […] The *Available City* is not an a priori plan, but an introduction of new qualities and relationships."(Brown 2016, 68) Through its set of rules and incentives for development, it transforms public space from an entity that is given into one that is dynamically generated. The formation of space generated is negotiated through project adjacencies and emerges through direct participation on four scales and interest levels: developer, neighborhood, ward, and City. Public space in the *Available City*, as a consequence, is not something given or predefined that is realized but instead it

Public space in the Available City is the actualization of a potential which produces public forms as a result of these improvisations.

is something that is formulated anew every time these relational rules are being performed. Public space in the *Available City* is the actualization of a potential which produces public forms as a result of these improvisations.

Structural Vitality of the Open Work

Developing open works for improvisation-based interaction fosters an awareness that every situation is constructed through direct individual and collective participation. An open work fosters the bringing in of multiple points of view and diverse positions to complete the work in unique ways. Designing for openness relates, then, to a view of human development based on participation and growth. Taking on the risk of acting in the moment, of acting without knowing what to expect, of improvising, is then fundamentally an attitude towards change and adaptation. It is a turning away from getting stuck and from preconceptions. It is a perspective on human development as a productive commitment to the development of ones own mental faculties and experiential horizons. Design for improvisation based on openness and initiative assumes a profound ethical dimension of respect for the Self and the Other and "we might see these poetical systems […] as expressing the positive possibility of thought and action made available to an individual who is open to the continuous renewal of his life patterns and cognitive processes." (Eco 1989, 17). "The worth of cities is determined by the number of places in them made over to improvisation," notes Siegfried Kracauer (Kracauer 2009, 71). Graeme Gilloch synthesizes the pledge emphatically as "for moments, against monuments" in his thesis for a future city (Gilloch 2011, 201). Improvisation has always been tightly linked to the urban dimension and a detailed look at the nature of improvisation as a system has allowed us to formulate a number of key positions that point toward an improvisation-based model for urban interaction design. Revisiting Umberto Eco's seminal text *Opera Aperta* has helped to shed more light on the first of four positions for this model - *Design for initiative ensures openness*. Design has so far looked at improvisation predominantly for the enactment of user scenarios and personas to identify opportunities and challenges of design

It is a perspective on human development as a productive commitment to the development of ones own mental faculties and experiential horizons.

interventions. The art and practice of improvisation and the emerging field of improvisational studies, in conjunction with the current and imminent development of connected technologies, instead provides an opportunity to bring a more foundational perspective of improvisation into the design domain. Design, in this perspective, moves the behavior and the performance of things center stage, taking inspiration from non-scripted forms of interaction and embracing the unforeseen and unexpected as constructive aspects of its production. Designing for initiative and openness is a key principle for building towards this new reality.

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Deconstructing the smart Home: AI vs Second-order Cybernetics

Delfina Fantini van Ditmar

As a result of the fast-growing market of the *smart* home the embedded algorithmic logic, based on the Internet of Things technology, is permeating into our lives transforming the experience and understanding of it through data collection, data aggregation and automation. Under market principles such as efficiency and optimization, this technology branded as the epitome of innovation claims to *understand*, *know* and *predict us* (*Algorithmic Paradigm*). However, its origins trace back to AI, a deterministic foundational epistemology—very much revived these days in Silicon Valley. Although considered as the main way forward, through contrasting it with second-order cybernetics, it is being revealed that a more constructivist epistemology is needed to address human complexity.

Keywords: smart home, AI, second-order cybernetics, algorithmic paradigm, epistemology

The Smart Home

The aspiration of broadening intelligence led to the incorporation of a wide range of smart devices into the built environment.

Historically, technological developments have played a key role in the way we understand how cities operate as well as how they transformed our daily routines within. Over the last few decades, the technological advancement in combination with reductions in the cost of processors, network capability and sensors, led in the rapid development of Internet of Things (IoT) industry. This development led to one of the most significant technological shifts: the *smart* age. While its growth is undoubted, the speed and expectations of it have resulted in a disparity on projection. Cisco stated that in 2020, 50 billion objects would be connected (Evans 2011), while Gartner (2014) has estimated that 25 billion connected 'things' will be in use by 2020. Due to advantages in optimisation, efficiency, tracking, managing resources and reducing costs IoT technology was successfully applied in the industry since its introduction, in the late 1990s.

The aspiration of broadening led to the incorporation of a wide range of *smart* devices into the built environment which fueled the fast-growing market of the *smart* home. It is forecasted that the IoT industry will be the world's most massive device market, where the home is "gaining momentum" [1], grows at a "steady clip" [2] and *smart* home products are 'gaining steam'. These data-driven devices will generate a radical shift in architecture once embedded in the architectural infrastructure itself. As Rem Koolhaas [3] suggests,

These data-driven devices will generate a radical shift in architecture once embedded in the architectural infrastructure itself.

> "*architecture has entered into a new engagement with digital culture and capital—which amounts to the most radical change within the discipline since the confluence of modernism and industrial production in the early twentieth century […] for thousands of years, the elements of architecture were deaf and mute—they could be trusted. Now, many of them are listening, thinking, and talking back, collecting information and performing accordingly.*"

Korody, 2015

As Koolhaas [4] points out in relation to *smart* technologies and architecture "this shift has gone largely unnoticed because it has not taken the form of a visible upheaval or wholesale transformation. To the contrary, it is a stealthy infiltration of architecture via its constitutive elements." The *smart* home market includes areas such as home security, heating control, lighting automation, various household appliances and object communication systems (e.g. home chats, that allow the users to communicate with appliances, and assistants, like Amazon's internet-connected speaker Echo and recently Apple's HomePod). *Smart* features range from automating, controlling, and monitoring the device itself, to learning users' behaviour and making suggestions. Leading companies in the *smart* home industry are technological giants such as Google (Nest), Apple (Home Kit), Amazon (Echo, Dash buttons) and Samsung (SmartThings) [5]. Most of these domestic examples are exhibited at the Consumers Electronics Show (CES) that takes place annually in Las Vegas. On 2017, *smart* homes were the key focus of CES [6].

'Smart' features range from automating, controlling, and monitoring the device itself, to learning users' behaviour and making suggestions.

The series of IoT domestic devices come with industrial principles and an algorithmic logic. As Wajcman (2015) notes,

> *"with few exceptions these visions of the domestic space celebrate technology and its transformative power at the expenses of the home as a lived and living practice […] domestic spaces are subject to a quite different set of considerations than those governing the offices, factory floors and workplaces within which information technologies have conventionally being deployed."*
>
> Wajcman, 2015

Smart market, often envisions the users' 'upgraded life' under principles such as productivity, security, efficiency, optimization, convenience and automation.

Through algorithmic processes of the embedded *smart* technology, the complexity of the domestic space is often replaced by a quantified approach. *Smart* market, often envisions the users' 'upgraded life' under principles such as productivity, security, efficiency, optimization, convenience and automation. As Wajcman (2015) describes the IoT-home industry exhibited at CES as "the attempt to find home applications for the functions that computers have excelled at in business and scientific settings, information processing and numerical processes".

Algorithmic logic: Our life through numbers

Smart devices through sensors extract data from our behaviour, analyse it through algorithms, to often include automatic decision-making. I characterize this quantified approach inherent in current notions of *smart* technology, as the *Algorithmic Paradigm*. The Algorithmic Paradigm represents and models the data of the user's body and surroundings (domain of behaviour), aggregation of data (the decision-making process uses advanced analytics to predict probabilistically how an individual is expected to behave in the future e.g. big data and machine-learning) and automation in real time (algorithmic control and the potential of it to change its procedures without informing the user). In branding terms, the *smart* industry claims that *smart* objects are *conscious (e.g. Nest)* and that they can *know, understand* and *predict us*. According to

Antoinette Rouvroy (2012), this reductionism or 'data behaviourism' has several implications. She defines the concept as "the way of producing knowledge of future preferences, behaviours or events without considering the subject's psychological motivations, speeches or narratives, but rather relying on *data*" and describes these algorithmic issues as "indifferent to the causes of phenomena. 'Data behaviourism' is anchored in the purely statistical observation of correlations (independent from any kind of logic) among data collected in a variety of heterogeneous contexts". This *smart* vision of the domestic space is characterised by the premise that *smart* objects are constantly sensing and 'doing things for you'. This approach towards dwelling, risks disregarding human individuality and our complex life. As Nest CEO, Tony Fadell (2014) indicated at a panel discussion at the Venice Biennale 2014, when asked about the values of the technology, he replied: "you are always in control. So these products don't take control away from you. All we're doing is we're learning from your habits. So, we're not imposing anything on anyone. In fact, in most cases we're actually just educating and giving you feedback on what your what your abilities are".

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Aiming for *smartness* to 'solve' or 'fix' a problem might be at first sight appealing. However, the interweaved dynamics between environment, surrounding infrastructure, objects and humans makes it impossible to grasp such complexity through numbers. When reflecting on *smart* technology, the problem, the problem-framing, and the agenda of the market related to it need to be significantly considered. Morozov (2013) refers to 'technological solutionism' in his book To Save Everything Press Here: Technology, Solutionism and the Urge to Solve Problems that Don't Exist as the tendency of technologists to create, define and 'solve' 'problems' quickly, through algorithms. He continues indicating, "what is contentious is not their proposed solution, but the definition of the problem itself" and asserts "solutionism and quantification are thus inherently linked". Considering that our life is increasingly being delegated to algorithms, it is relevant to question how the algorithms get to *know* the world. As Gillespie (2014) suggests, algorithms are mathematical procedures [claiming to] producing and certifying *knowledge*. The

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algorithmic assessment of information, then, represents a particular *knowledge logic*, one built on specific presumptions about what knowledge is. Gillespie (2014) calls "the promise of algorithmic objectivity, the way the technical character of the algorithm is positioned as an assurance of impartiality, and how that claim is maintained in the face of controversy". These *smart* technologies are not free from bias. *Smartness* in dwelling has systemic and socio-political implications which go beyond the technical domain of efficiency. As Markoff (2015), notes "the best way to answer questions about control in a world full of *smart* machines is by understanding the values of those who are actually building those systems." Behind the *smartness* there are ideologies that define how the world is being *known*.

AI was created by the Artificial Intelligence Group, founded at the MIT, by John McCarthy and Marvin Minsky, in 1958. As John McCarthy (1955) declared in relation to the foundational principles of the nascent field "the study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it." Paul Pangaro (2013) points out that AI is characterized by "the cultural view of the brain as a computer" and that for AI the stored *knowledge* of the real world constitutes *intelligence* leading to the idea that *knowledge* can be a commodity inside a machine. By eliminating the complexity of daily life (non-linearity) and the observer's interpretations (subjectivity), the ruling principles of numerical efficiency diminish the human into a machine-like operator. As Morozov (2013) argues, technology should allow humans to "continue exercising the tough, challenging choices that distinguish them from machines". While recent approaches to machine-learning 'declare victory' for intelligent devices—because they can now adjust from experience—AI's logic structure still dominates. In Silicon Valley, the epicentre of high-tech corporations and start-up culture, AI constitutes one of the hottest trends. Machine-learning techniques have led to a dramatic revival of interest with 'deep learning', the latest excitement [7]. This comeback has also led into digital deterministic trends such as rational-choice, behavioural

Paul Pangaro (2013) points out that AI is characterized by "the cultural view of the brain as a computer.

In Silicon Valley, the epicentre of high-tech corporations and start-up culture, AI constitutes one of the hottest trends.

design and nudge among others. The *Algorithmic Paradigm* strongly interweaves with AI. In contrast to AI's first-order epistemology—which aims (and claims) to know the 'world as it is' the significance of second-order cybernetics as an alternative, constructivist epistemology contradicts this assumption. Second-order cybernetics is a movement that emerged around 1968 from the 'cybernetics movement', originated in the Macy Conferences (1946-1953) more than a decade before AI. As Glanville (2002) indicates about the field "second-order cybernetics presents a (new) paradigm in which the observer is circularly (and intimately) involved with/connected to the observed. The observer is no longer neutral and detached, and what is considered is not the observed (as in the classical paradigm), but the observing system. The aim of attaining traditional objectivity is either abandoned/passed over, or what objectivity is and how we might obtain (and value) it is reconsidered […] in this sense, every observation is autobiographical". As opposed to the current linear directionality of algorithmic logic, second-order cybernetics implies the extension of control as a mutual notion, since the 'controlling' and the 'controlled' elements of a system share a goal. A relevant second-order cybernetics practical and conceptual example, related to how second-order cybernetics, addresses human complexity is Heinz von Foerster's (1984) model of *non-trivial machines*. In contrast to *trivial machines* which are not influenced by previous operations (history independent), are analytically determinable, therefore predictable, the non-trivial machines are history-dependent (every operation changes the operator), analytically indeterminable, hence, unpredictable. Such approach addresses the complexity of cognitive behaviour and highlights the computational limits.

The observer is no longer neutral and detached, and what is considered is not the observed (as in the classical paradigm), but the observing system.

The user of the *smart* home is not a consumer who receives normative outcomes from the algorithms, but a subject who is able to reflect on data and behaviour. By a systemic understanding embracing the impact of context and experience, by valuing the observer's observing, and by considering the meaning that is constructed, a second-order cybernetics approach is more suitable to address human complexity. In opposition to AI, this epistemology leads to the acknowledgement of the limitations of *smart* devices and

The user of the smart home is not a consumer who receives normative outcomes from the algorithms, but a subject who is able to reflect on data and behaviour.

Applying second-order cybernetics provide opportunities to rethink the smart home.

the impossibility to grasp the human condition through algorithms. While the potential of *smart* technology, in specific cases, can't be doubted, humans must not be envisioned as efficient consumers. The reflection on the current epistemological stance embedded in the IoT technology as well as the consideration of the limits and implications of algorithms are of great significance. Applying second-order cybernetics provide opportunities to rethink the *smart* home. As Morozov (2013) indicates,

> *"a truly smart system will find a way to turn us into more reflective, caring and humane creatures. Technologies can assist in the mission, and both, technologists and social engineers, guiding them would have to acquire a very different mindset."*
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> Marozov, 2013

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Raoul Bunschoten, The Second Skin of the Earth: From Cybernetics to Conscious City

Raoul Bunschoten is Professor of Sustainable Urban Planning and Urban Design at the TU Berlin. He is a specialist in Smart City planning and is involved in a range of Smart City and low carbon developments in China, both with academic and central government partners, as well as with local authorities. He is a member of the Climate KIC Sustainability City Platform, an EU initiative, and is co-founder of an Urban Lab for Smart City research at the TU Berlin. Special research areas at the TU are the creation of the Conscious-City-Lab, an interactive urban performance space for the study of complex dynamics in urbanism, especially Smart City development, and the Urban Gallery, an interactive planning support tool for Intelligent City Systems. He is founder and director of CHORA, an architectural design and urban planning group, both, at TU Berlin and outside of the academic context.

Delfina Fantini van Ditmar, Deconstructing the 'Smart Home'

Dr. Delfina Fantini van Ditmar completed her PhD at the Royal College of Art in Innovation Design Engineering under the supervision of Dr. Ranulph Glanville. She holds a BA in Biology and accomplished a year of a MFA at Konstfack University in Stockholm. Delfina was awarded the 2011 Heinz von Foerster Award by the American Society for Cybernetics. The incursion with the field of second-order Cybernetics led to her PhD research, and to the thesis entitled The IdIoT. The thesis focuses on questioning and critically analysing the embedded epistemology of Internet of Things (IoT) technology related to human centred activities in the context of the 'smart' home. Her thesis was an investigation of how human experience and behaviour is represented within the quantified approaches inherent in current notions of 'smart' technology derived from Artificial Intelligence (AI). Through a series of practice-based projects, an important part of her research was to bring second-order cybernetics into design research. The research outcome highlights the importance of developing a critical approach towards the algorithmic logic applied in the lived environment.

Raúl Espejo, Cybernetic Argument for Democratic Governance: Cybersin and Cyberfolk

Raúl Espejo is Director of Syncho Research, UK, President of the World Organization of Systems and Cybernetics (WOSC) and appointed full professor of Systems and Cybernetics at the University of Lincoln UK in 1995. From 1977 to 1994, he was senior lecturer at the University of Aston UK. Visiting Professor at several universities, including the universities of Amsterdam and Nijmegen in Holland and the University of Witten-Herdecke in Germany. During the mid and late70s he was research scholar at the Manchester Business School, UK and at the

International Institute for Applied Systems Analysis, Laxenburg, Austria. The focus of his research has been organisational cybernetics and systems. His most recent book, with Alfonso Reyes, is Organizational Systems: Managing Complexity with the Viable System Model (Springer, 2011). Professor Espejo has worked with a wide range of organisations worldwide, including national and local governments and small and large enterprises, mainly in aspects of organisational transformation and learning, information management, communications, transparency, and democratic processes for decision making. From 1971 to 1973 he was operations director of the CYBERSYN project - the project of the Chilean Government for the management of the industrial economy, under the scientific direction of Professor Stafford Beer.

Michael Hohl, Ecology, Systems Thinking, Designing and SOC

Michael Hohl is Professor of Design Theory at Anhalt University of Applied Sciences and research tutor at the Royal College of Art, London, in Innovation Design Engineering (IDE). He is a designer, design researcher and educator, holding a Ph.D in fine art and computer science from Sheffield Hallam University and a Diploma in Digital Media Design from the Berlin University of the Arts. Michael investigates questions around data visualisation and epistemology, practice-based research in design, knowledge and 2nd order cybernetics. He is also interested in how conferences may become places of asking questions and discussion instead of listening to answers.

Timothy Jachna, Managing (with) the Unmanageable City

Timothy Jachna is a Hong Kong-based educator, architect and urbanist. He is Professor and Associate Dean (Research) of the School of Design, the Hong Kong Polytechnic University, where he leads the Urban Environments Lab and the Master of Design (MDes) programme in Urban Environments Design. He practiced as an architect and urban designer in Chicago and Berlin. Jachna holds degrees from the University of Illinois at Chicago (BArch), the Architectural Association - London (AADipl) and RMIT - Melbourne (PhD). His research deals with psycho-sociological aspects of the planning, design, inhabitation and critique of urban environments – with particular focus on the future of cities in the East Asian context. Jachna has presented and published in disciplines as diverse as urban theory, tourism, digital culture, semiotics, art, architecture, planning, cybernetics, and human-computer interaction. He is Vice-president of the American Society for Cybernetics, and his recent research applies principles of second-order cybernetics – including processes of conversation and learning, metabolic metaphors and the dynamics of control and choice – to understand and envision urban processes and practices. A prominent stream of his work investigates the implications of digital technologies for the ways that cities are planned, designed and inhabited.

Arun Jain, Uncertainty, Complexity & Urgency: Applied Urban Design

Arun Jain is a US and Indian educated planner, urban designer and urban strategist with over three decades of global experience in practice and academia. Based in Seattle, Washington, he is an international urban design and development consultant to public institutions and private entities. He has influenced over 90 projects with a combined investment capital of 14 billion US Dollars and serves on several international boards. In 2016, he was a German Federal Government (DAAD) funded Guest Professor at the Institute for City & Regional Planning (ISR), Technical University of Berlin. From 2003-09 he was Portland, Oregon's first Chief Urban Designer. Arun is intensely multi-disciplinary, and currently focuses on urban decision support tools, behavior sensitive infrastructure strategies, and development frameworks across diverse geographies, scales and conditions. A lead expert in the UN Habitat Urban SDG development process (Goal 11), he continues as an expert advisor to UN Habitat III leading up to, and after the New Urban Agenda declaration in Quito, Ecuador. Arun received his Bachelor's in Architecture from the School of Planning & Architecture, New Delhi, India, and has two Master's Degree's (City Planning & Architecture) from the then Urban Design Program at the University of Pennsylvania, Philadelphia, USA.

Omar Khan, Foreword

Omar Khan is the Chair of the Department of Architecture at the University at Buffalo, where his research and scholarship spans the disciplines of architecture, installation/performance art and digital media. Khan's projects and teaching explore the intersection of architecture and pervasive computing for designing responsive architecture and environments. At Buffalo he co-directs the Center for Architecture and Situated Technologies and is an editor of the Situated Technologies Pamphlet Series. He received his Bachelor of Architecture degree from Cornell University and a Master in Design and Computation from MIT where he was a member of the Aesthetics and Computation Group at the MIT Media Lab. He has exhibited nationally and internationally including the Incheon Digital Art Festival (Korea), Urban Screens Melbourne, ZeroOne San Jose, Storefront for Art and Architecture, the National Building Museum and the Urban Center. He is a fellow of the New York Foundation for the Arts and has received grants from the New York State Council on the Arts and the Department of Education. He is also co-principal with Laura Garófalo of Liminal Projects, an architecture and design office.

Kristian Kloeckl, Open Works for the Urban Improvise

Kristian Kloeckl is Associate Professor at Northeastern University in the Department of Art + Design and the School of Architecture. Prior to coming to Northeastern, Kristian was a faculty member at the University IUAV of Venice and a research scientist leading the Real Time City Group at MIT's Senseable City Lab as part of which he established the lab's research unit in Singapore. There, he and his team pioneered a data platform and data visualization research initiative that brought together real time data from Singapore's key public and private urban systems operators. As a design practitioner he has worked with companies in Austria, Germany and Italy. His work focuses on interaction design in today's context of cities as they are becoming physical-digital hybrids in which information is, in significant ways, material, and matter is informational. He is interested in the growing complexity of the relationship between these dimensions as a consequence of people's interaction with pervasive digital technologies in everyday environments and activities. Kristian has published books and in international journals on these issues and his work has been exhibited at venues such as MoMA, Vienna MAK, Venice Architecture Biennale, Singapore Art Museum, China Millennium Monument Museum of Digital Arts.

Paul Pangaro, Cybernetics as Phoenix: Why Ashes, What New Life?

Paul Pangaro's career spans research, consulting, startups, and education. He relocated to Detroit in April 2015 to become Associate Professor & Chair of the MFA Interaction Design at CCS. He has taught systems and cybernetics for design at School for Visual Arts, New York, and at Stanford University in Terry Winograd's Human-Computer Interface program. His most recent startup is General Cybernetics, Inc., dedicated to new ways of reading and writing in digital media. He has worked with and within startups in New York and Silicon Valley, in product and technology roles. His consulting clients including Nokia, Samsung, Intellectual Ventures, Healthline.com, Instituto Itaú Cultural (São Paulo), Ogilvy & Mather, and Poetry Foundation. He has lectured in São Paulo, Paris, Berlin, Vienna, Linz, and in cities in the US. His writing explicates "designing for conversation" from his research and his implementations of software and organizational processes. Pangaro was awarded a Bachelor of Science in humanities and computer science at MIT. He was hired by Nicholas Negroponte onto the research staff of the MIT Architecture Machine Group, which morphed into the MIT Media Lab. With Gordon Pask as his advisor, he was awarded a Ph.D. in cybernetics from Brunel University in the UK.

Liss C. Werner, Cybernetification I: Cybernetics Feedback Netgraft in Architecture
Liss C. Werner is Assistant Professor for computational architecture at TU Berlin, founder and principal architect of 'Tactile Architecture – office für systemarchitektur' Werner practiced in Germany, the UK and Russia. Between 2003 and 2016 she held teaching positions at Universities in London, Nottingham and Dessau and lectured at MIT, Texas Tech University, California Institute of Arts, University of Innsbruck and others. She further acted as Guest Professor at Carnegie Mellon University and Honorary Professor at Taylor's University Malaysia. At DIA Dessau Werner established her design studio 'Codes in the Clouds' (2010-16). At TU Berlin Werner is leading the intelligent prototype research track in the Chair of Sustainable Urban Design. Werner co-chaired several international conferences on design strategies for an age of human-machine-collaboration. She is the editor of '[En]Coding Architecture' (2014), and author of numerous papers including 'The Origins of Design Cybernetics'. Werner exhibited at the Venice Biennale 2012 and is invited to exhibit at the Malay Biennal 2017 and Venice Biennale 2018. She was educated in the at University of Westminster, Royal Melbourne Institute of Technology (RMIT), The Bartlett School of Architecture (UCL) and Humboldt-University. In 2017 Werner received the German Enterprise Award for 'Best for Modern Urban Architecture & Design' and was selected as 'Young Digital Changer'.

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Raoul Bunschoten is Professor of Sustainable Urban Planning and Urban Design at Technical University Berlin, Germany, where he is leading the Conscious City Lab, an interactive urban performance space for the study of complex dynamics in urbanism. Bunschoten is a specialist in Smart City planning and involved in projects in Europe and China. He is founder and director of CHORA, an architectural design and urban planning group, both, at TU Berlin and outside of the academic context.

Liss C. Werner is an architect. She is Assistant Professor for Cybernetics and computational Architecture at the Institute of Architecture at Technical University Berlin, Germany, where she is leading the cyberphysical systems research group. Werner has been specializing in cybernetics in architecture and Gordon Pask since 2002. She is a member of eCAADe and the American Society of Cybernetics and founder of Tactile Architecture- - office für Systemarchitektur.

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