Design Entrepreneurship & Disinformation

Creating companies and products to afford better global consequences

Mitchell Sutika Sipus
May 2020

School of Design, College of Fine Arts
Carnegie Mellon University
5000 Forbes Ave.
Pittsburgh, Pennsylvania 15213

Thesis Committee:
Jonathan Chapman, Carnegie Mellon University
Peter Scupelli, Carnegie Mellon University

External Examiner
Robert Goodspeed, University of Michigan

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy

Keywords: Design, Entrepreneurship, Disinformation, Misinformation, Entrepreneurial Ecosystems, Innovation, Venture Design, Venture Creation, Design Methods, Design Thinking, Design Research, Innovation Ecosystems, New Growth Theory, Interaction Design, Machine Learning, Geographic Information Systems, GIS, Misinformation, HCI, Workflow Design, Information Augmentation, Lean Frameworks, Human Machine Interface, Artificial Intelligence, Business, Transaction Design, Innovation Economics, Economics

Abstract

Current models of entrepreneurship celebrate rapid experimentation and the open sharing of ideas to inspire new innovations in business. These models draw upon a range of resources such as technical expertise, infrastructure, and capital. To provide these resources, public and private institutions have collaborated to build *innovation ecosystems* to supply entrepreneurs with ideal conditions for business creation, and by extension, to drive regional economic development.

Yet this entrepreneurial model has also wreaked havoc on the world. The aggressive focus to design for immediate user needs in product design, with less consideration of future social consequences, has created vulnerabilities in products and companies for exploitation. Disinformation campaigns by nefarious actors have divided communities, undermined elections, and jeopardized global security. While the design literature demonstrates the value of design processes for complex problems in business and society, there is no current expertise in the field of design to inform new venture creation for preferred social outcomes or to combat the threat of disinformation. The companies and products produced by innovation ecosystems have in turn produced the global threat of disinformation. This research explores the role of design to create new ventures, to contend with disinformation, and to design products to afford more positive global consequences.

I conducted practice-based research over six years, as a form of action research, and consolidated my work into four case studies. I described the conditions of the Pittsburgh innovation ecosystem, the factors that inform venture creation, explored lean methods, and built rapid prototypes to formulate a venture concept. I founded the company Symkala and developed material artifacts at every stage of business creation to navigate the surplus of entrepreneurial challenges such as recruitment, ideation, production, and customer acquisition.

Symkala built a geographic information systems (GIS) software. Symkala offered a novel workflow for a GIS analyst to apply supervised machine learning techniques to poorly structured information for geographic data analysis. I then marketed this software to federal and non-government organizations throughout Washington DC. Insights from this work were then applied to redesign Geo4NonPro, a website intended to promote accurate information and citizen participation for global nuclear security via an interactive GIS interface. These case studies additionally informed a trajectory of practice transformation.

A review of the literature and selected artifacts from the case studies, alongside reflection on action, establish insights on design for new venture creation within innovation ecosystems, design to counter disinformation, and product design for systems-level impact. I found that a robust innovation ecosystem does not directly culminate into a successful venture due to resource bias, and therefore a focus on customer research through material production can enable entrepreneurs to work more slowly and mindfully to achieve bold visions. To counter disinformation through products, firms need to prioritize information validity as a central business goal, forcing changes to the organizational structures and processes that guide product delivery. To more effectively channel systems-level insights into human-scale products, the design process must prioritize clarity in goal formation, product definition, and attention to social equities throughout production.

Acknowledgements

This work is not merely the consequence of six years of research and scholarship. Rather, the journey that has culminated in the production of this thesis is older by many years and has been shaped by a multitude of people.

Throughout that journey, my wife Mallory has provided steadfast support, from the first time I shared my goal to complete a PhD in a tiny apartment in Egypt in 2009. She has always been "all in" as we continually invent new visions for our family and pursue new adventures around the world. She has long been the first to insist that my PhD will be finished. To write a thesis is a challenge, to do it as an entrepreneur is an emotional minefield, and I have continually found guidance in her clear thinking, pragmatism, and love. Our daughters, Eliza and Samara, have also offered their own special gifts and talents to support this work, and the experience has been better for it.

My committee, Jonathan Chapman and Peter Scupelli, were always encouraging and gave clear guidance and honest feedback when it was most needed. They have been fundamental to the conclusion of this work in every way. Thank you to Robert Goodspeed for your fair critique and direction. I will always be grateful to Jodi Forlizzi for her mentorship and support.

Thank you to Barack Obama for presenting the opportunity to leave CMU to serve in the White House administration. To Garren Givens and Ben Willman for an extraordinary experience as a Presidential Innovation Fellow, to Jody Daniel at the US Department of State, and to all my fellow PIFs.

Along the way, I've been fortunate to have been coached by a range of brilliant and genuine people. Sometimes a simple conversation or gesture can change a person in profound ways. Thank you, Thomas Tull, Ken Young, and Chris Cairns for the extraordinary business lessons. Further special thanks to Ken Friedman at the journal She-Ji; Gjoko Muratovski and Johanna Looye, at University of Cincinnati; to Amy Glassmeier at the Massachusetts Institute of Technology; to Dawn Deckle at the American University of Nigeria; and to Jeffrey Chusid at Cornell University for sharing his personal experiences as a former student of Horst Rittel.

Thank you to all the brilliant persons who have worked with me over the years to build new ventures and worked to realize a better world through the things we make. Those who immediately stand out are Rachel Chang, Geoffrey Morgan, Davey Gibian, Will Milner, Jeffrey Huang, Yaakov Lyubetsky, David Fouhey, and Aaron Acton. I also want to recognize Moshe Mahler, Rafael Tena, Andrew Dubois, Jackie Erickson, Eric Daimler, Erren Leseter, April Murphy and Leah Jakaitis for their unique contributions along the way.

My dear family and friends have been always been great champions. Thank you to my mother Victoria, Kennedy, Anthony, Laurence and Tony; my dearest friends Ally Krupar, Christopher Daniel, Ryan Conley, Willis Fugitt; to my friends in Detroit, my Art Academy family, and many others.

Table of Contents

List of Figures

Section 1: Design as intentional change through making

1.1 Section Abstract

From the literature it is clear that the history and transformation of Design has demonstrated an increased focus on higher levels of complexity (J. C. Jones 1970; Doblin 1987; Waserman 2013; Pastor 2013; Norman and Stappers 2015). Within current discourse, there is also a prioritization for designers to step away from systems-level solutions and to focus on the making of local human-scale experiences that are informed by large-scale systems thinking, in particular in the domain of artificial intelligence (Myerson 2017; Buchanan 2019; Weller 2019).

Design can function as a means for radical change. Design processes have an established record to drive change across systems through iterative learning for the creation of ecosystems of products. Product design provides the opportunity to channel values, beliefs, and future concepts into human experiences (Junginger 2006, J. Forlizzi 2007). Through the design of services and systems in addition to products, one has the ability to impact multiple facets of human experience including economics (Forlizzi and Zimmerman 2013; J. Forlizzi 2018). Designers have also increasingly taken on roles within local decision-making in governance, enabling citizen participation (Manzini 2015; Salinas, et al. 2018). Examples can be found globally from the inception of the Presidential Innovation Fellows by President Obama to the use of user-centered design to optimize online portals for political engagement in urban India (Bhattacharya 2015).

When channeled through entrepreneurship, and the creation of products and ecosystems, design utilize the resources of innovation ecosystems to drive social change. Design offers a path to identify, research, understand, and experiment with concepts about the future, although sometimes the results of this work take time to be adopted and designers are not always prepared in the realities of business creation (Hagedoorn, 1996; Roberts, 1998; Norman and Verganti 2014, Nielson, et al. 2017). Lean methods have been adopted as a common practice by entrepreneurs who seek a pragmatic approach to venture design while focusing on product development and value creation. Yet the success of entrepreneurship through design and lean is heavily dependent upon the innovation ecosystem (Ries 2016; Batova, Clark and Card 2016; Batova, Clark and Card 2016; Mansoori and Lackeus 2019).

The innovation ecosystem is a model of endogenous economic development founded on the fluid exchange of ideas and resources. Working through the innovation ecosystem, the design entrepreneur is not only an agent of social change, but a driving economic force. Designers are sought out within innovation industries to supply design methods within the organization and through the products generates large scale returns on investment (Council 2007; Amatullo. 2015; Maeda 2017; Heskett, 2017). A current area of interest in the value of design is the creation of machine learning products, as such products can incur systems-level change through individual-scale user interactions (Dove, Halskov, et al. 2017; Yang, Scuito, et al. 2018; Forlizzi and Zimmerman 2013). Within design of machine learning products there are extensive opportunities to experiment with underlying incentive and feedback systems (Akers, et al. 2018).

1.2 Design

How we define and understand design continually shifts with technologies, industry trends, and education models. The role of the designer as continually changed from granular object-scale problems to larger social contexts. When drawing proved insufficient as a medium to capture complex social interactions and generations of contextually informed product evolution, designers began to shift their methods from centralized graphic planning to scientific, computational, and later decentralized social interactions.

John Zeisel described design as a process of "loosely-organized," but structured, activities to achieve a goal within the physical world (Ziesel 1981, 21). This is a highly structured and methodological interpretation of design that reflects Zeisel's deeply rooted inclinations toward the value of empirical research and structured methodologies. While other design theorists have proposed similar definitions of design, a counterpoint is the recognition of tacit knowledge – knowledge that cannot be well communicated or easily shared - and the value of non-rational methods (Polanyi, 1966; Spinosa, Flores, & Dreyfus, 1999; Colins 2010). "The planning and patterning of any act towards a desired, foreseeable end constitutes the design process… design is the conscious effort to impose meaningful order (Papenek 2003)." In other work, Papenek has expressed the effort by many designers to create a methodical and rigorous approach to design undermines the broader needs of humanity. Yet he also stated that those who work guided entirely by sensation are providing no higher order of value or service (Papanek 1988). To codify and educate designers, Cross assert that design is a discipline that may be part of the sciences or arts, yet through recognition of "designerly ways of knowing" – knowledge systematically created through action and processes to facilitate the *creative leap*, design is also an independent discipline of knowledge creation (N. Cross 2001, 2006).

More succinctly, design is concerned with making things, or perhaps more philosophically, the "making sense" of things (Krippendorf, On the Essential Contexts of Artifacts or On the Proposition that 'Design Is Making Sense (of Things) 1989). Designers may have depth of insight and deep expertise into the making of things or they may not. Regardless, "design always proceeds," with or without a theory to inform it, or guide it, while it can also be improved to generate meaningful results (Winnograd and Flores 1986). Design is thus understood as a churching process of discovery, analysis, and synthesis. Through this process one can move between the "theoretical and the practical realms" as individuals translate observations into insights, and insights into actions. (Doblin 1987). This is not the same as the accumulation of technical knowledge, but is described by Schön as knowing-in-action, reflection-in-action, and reflection on reflection-in-action (D. A. Schön 1987) The creation of design expertise is thus the development of expertise through practice, on the ability to move from maintaining the "theory of intervention," to a more creative knowledge, the "theory in action (Argyris and Schorn 1974)."

This same definition applies to the concept of "design thinking," in which one pursues a problem to "understand, improve, and apply" with user-centered focus and a prioritization for physical evidence. Designers prioritize building an intuitive understanding of the problem, often working through abstraction and through case studies or scenarios – not through structured approach to hypothesis creation and resolution. By consequence Design research prioritizes exploring the breadth of the problem space and utilizing iterative actions to align insights to outcomes (Lindberg, Meinal and Wagner 2011).

Throughout all definitions, design maintains a "creative aspect," the introduction of surprise into a problem or solution space (N. Cross, 2006). Through the continued introduction of surprise, the designer introduces bursts of insight and opportunity (Dorst and Cross 2001). Design can also be understood as more than process or as a collection of particular properties but can examined in relation to complexity. Design may exist within three levels of complexity: products (tangible objects), unisystems (sets of people and products), and multi-systems (an array of competing systems) (Doblin 1987). More recently Buchanan has summarized that the role of systems in design is commonplace, as "a system is a relationship of parts that work together in an organized manner to accomplish a common purpose," and in this regard, every product, environment or endeavor of a designer is a system within a system (Buchanon 2019).

1.2.1 The continual transformation of design

For over 100 years, the theoretical role of design in society has shifted over the decades away from the strict production of objects to an increasing focus on human relationships across time and space. This transformation has taken place as designers have increasingly engaged problems of greater complexity. Within *Design Methods: Seeds of Human Futures*, John Chris Jones reviewed a range of definitions for design, and upon analysis, concluded that while the processes or elements of the design process may vary, that all forms of design "initiate change in man-made things." Such a broad definition embodies a range of actions, practices, professions, and subject matter. Jones even goes on to express that the traditional boundary of designing, drawing, is no longer sufficient as the critical trait of design, while non-design professions now find themselves planning and structuring activities human and created systems (J. C. Jones 1970, 4-5). Jones thus orders design into four domains, where-in the highest level of complexity at which one may design is the *community level*, reduced into factors at the *systems level* (such as economic sectoral concerns of housing or transportation), further deconstructed into the *products level* such as the houses or roads, and finally the *components level*, such as the parts of the car (J. C. Jones 1970, 31).

Contemplating a future for design at the highest levels of complexity, Jones suggested that future technologies may be more informed by political and cultural processes than by their internal mechanics (J. C. Jones 1970, 32). This assertion was concurrent with Horst Rittel's arguments coming into formation at the same time, that some problems – *wicked problems* - are highly complex, continually adapting, and cannot be solved only tamed (Rittel and Weber 1973). Notably by the early 1970s, Jones his contemporaries – such as Christopher Alexander - no longer a supportive of the scientific design methods he had helped build, informed by the politically charged context of thee time (N. Cross 2001).

Arnold Wasserman has described design across four eras as design 1.0, the production of artifacts, 2.0 as human centered, 3.0 as social centered, and 4.0 as the "post-Anthropocene," a global conscious level of design for an ecologically sustainable, better world (Waserman 2013). Pastor's contribution shifts from object level design up through organizational and socially transformative design as two categories: mainstream design thinking and the *other* design thinking, again determined by the increasing complexity across each domain. To approach the other design thinking, she further advocated that designers utilize open systems and no presumptions to frame and pursue their work (Pastor 2013). This built on Schön's argument for frame reflection, in which practitioners recognize the perception and definition of a problem will yield quick steps to action, and thus designers must be active to identify their own view, expand their held perspectives of problems and account for how other actors function in light of their own frames (Schön and Rein 1994). In a similar manner, various trends have arisen to bring design to these large and complex types of problems, captured in the language of Transition Design at Carnegie Mellon University; the Systemic Design Network, and DesignX (Norman and Stappers 2015).

Across the evolution of all these models, it is fundamental to recognize that each movement of design has sought to not only change the prospective scope of design in the world, but also takes on internal considerations. Whereas the first design movement sought to apply a science to design to create greater social value, the second movement recognized that problems are not static and require co-adaptation, the third generation recognized the diversity of human experiences in problem-solving, and today's design models embrace participatory and generative design in an era of complexity. (Nousala, Ing and Jones 2018) In consideration of Design and wicked problems, Buchanan asserts that design history is more about the shifting of views on what is believed to be a design problem, and the continual adaptation of design is why design is often relegated to the role of application for another body of knowledge, such as applied science or applied art (Buchanan 1992).

More recently Buchanan has critiqued the continual focus on systems in design, as systems thinking is reductionist, fails to recognize the granular elements of a problem and human experience. He identifies that design is an action to translate observations on the environment into new human experiences, but asserts that the conception of "systems" may or may not contribute to that design act (Buchanon 2019). Myerson has a similar argument that while large scale thinking among designers is good and should be continued, that designers should maintain the large scale awareness while focusing on their efforts on smaller, human scale interactions and experiences such as manufactured products or neighborhood spaces, as the best means to channel their values and theories into tangible benefits (Myerson 2017). Such an approach may be valuable in the context of working with some emerging technologies, notably artificial intelligence, as designers must be aware of their own internal bias, points of view, references and local context as much as large-scale systems impact (Weller 2019).

1.2.2 The legacy of design as processes and technologies for change

Design has long functioned as a central process in general planning and social change. The following is not a review of literature from the discipline of planning, but rather a review of how design has been conceptualized and practiced within the 20th century to the present for deliberate change within communities, cities, and nations toward a vision.

The theory, materials, and practice of design has always been associated with technological change. The rise of design eras, such as transitions between late 19th century Arts and Crafts, into Art Nouveau, and Art Deco, and even those in later decades, reflect the efforts by artists and designers to reconcile the force of technology with value-laden visions for human living (Gorman 2003). Social demands for a higher quality of living were institutionalized by the fields urban design and architecture with the founding of the Landscape Architecture department at the Harvard Graduate School of Design. Yet beyond representing and articulating subjective values through design, there was ill consideration of the politics and complex socio-economic interactions, or debate on the diverse roles of stakeholders and disciplines within any form of design practice for many decades (Peterson 1979). Following WWI and WWII, planning focused extensively upon the physical form and function of cities. In this era, the act of shaping the social fabric was described as a function of Design as physical planning was considered technical exercise under the guise of constructing "non-political futures (N. Taylor 1998, 1-33). On occasion, designers also advanced counterproposals, providing dystopic visions, or infinite utopias, as a manner to challenge and reappraise existing social and economic structures (Scott 2010, 130). In the post-war era, the act of drawing functioned to plan and realize plans.

Yet drawing would not always remain sufficient as the design process as technologies and problems became more complex. In search of a "general theory of machines," the field of cybernetics concurrently emerged in hope to create a better world through automation and technological change (Rid 2016). Weiner argued that "human-mechanical systems" will new opportunities to design (Weiner 1964, 81). In the United States, post-WWII urban development – from public housing to transportation planning – were heavily influenced by military techniques and technologies designed for the Cold War (Light 2015, 15-30). The resulting combination of military strategy, urban planning, and systems analysis with computer modeling and simulation formulated the fundamentals of military decision making by institutions such as MIT's Media Lab and RAND. (Light 2003; Steenson 2014). In 1966, early geographic information systems were in development, methods by which discrete data could be visualized and layered on a geographic map to display spatial distributions. Much of the work began as military endeavors to advance intelligence extraction and visualization of aerial photography and satellite imagery (Light, 2003, pp. 97-138). A noteworthy example is Pittsburgh's computer modelling of its Urban Renewal Simulation Model in 1968 (Light, 2003, pp. 50-58). Contemporary GIS platforms are attributed to the work of architect Howard Fisher, who founded the Harvard Laboratory of Computer Graphics in 1965 (Chrisman, 2006). The use of data-driven information systems to produce computational simulations of urban environments demanded new models of design.

Concurrently first Methods Movement was a convergence between design, technology and planning fields through the formulation of Design Science, an attempt to conform design to a system of rules though it did not need to rely on the same structural underpinnings as the natural sciences. Herbert Simon, advanced a highly structured and scientific view of design who described a hybrid model of rational design/planning based upon the demands of complexity, adaptivity, data availability, decision analysis, forecasting, and a factoring of time and space horizons (H. A. Simon 1968, 151). Pioneers of this era such as John Chris Jones, sought to offset the utopic notions and pragmatic failures of design practice, calling for a need to integrate rationality and intuition (J. C. Jones 1959). These failures included useless objects, materials or configurations misaligned for user needs and void of consideration for greater systems integration such as social or environmental factors (J. C. Jones 1970). Christopher Alexander's Notes on Synthesis of Form, similarly articulated a rationalist model of deconstruction for complex problems to enable designers to impact the complexity of economic, social, and cultural interests str (Alexander 1964). The relationship of Design in the methods movement to Planning is best exemplified by the writings of George Chadwick, whose book A Systems View of Planning, describes in painstaking detail rational approaches to the forecasting of complex socio-economic conditions (Chadwick 1971). Such complexity was truly outside the grasp of most city administrators and publics, generating a large gap between planning experts and the masses.

The failures of design science in planning informed political protests and strong voices arose in the 1960s in response to the failure of planning institutions. In 1963 Horst Rittel began teaching in the UC Berkley College of Environmental Design after years at the experimental German Design School, Hochscule fur Gestaltung at Ulm (HfG) where he developed a body of work concerning cybernetics and the design process (Rith and Dubberly 2007). Rittel insisted that easily defined problems are therefore easily solvable. Ill structured problems, however, cannot be solved because stakeholders cannot agree on a definition. These problems are Wicked Problems (Rittel and Weber 1973).

Rittel and Weber introduced the concept of Wicked Problems within the context of professional training and process in the domain of urban planning and public policy. They argued that the education of planning and policy is antiquated relative to the nature of problems, as expert-led rationalist approach is best concerned with well-constrained problems, more akin to the domains of civil engineering. Those problems belong to the industrial era, when "where and how" to build a road were the core kinds of problems of planning – not matters of poverty reduction and social justice. In consequence, technocratic regimes and methodologically unbalanced institutions, incompetent to meet the present tense or future tense needs of a population at the "juncture where goal formulation, problem definition, and equity issues meet" (Rittel and Weber 1973, 156).

The Second Methods Movement emphasized observable facts and empirical processes, distinct from the mathematical models and computational simulations of systems planning (N. Taylor 1998, 95-99). Such methods included post-occupancy evaluation, the observation of physical traces, and studies on the use of text within environments to better understand how an environment functions in reality vs. intended design (Zeisel 1984). Donald A. Schon, of MIT's urban planning department, developed theories on reflection and frame reflection, a process to question the basic assumptions within policy planning appropriated within design communities (D. A. Schon 1984).

These normative theories lacked a clear path to practice in social scale planning. Collaborative theories of planning focused upon diversity and debate in dialogue that explores the power dynamics of relationships and focusing upon good outcomes (Goodspeed 2016). Design practices have embraced transparency and debate, with an aim to make design explicit and communicable through social channels such as dialogue, on account that design is "inherently argumentative" (Churchman, Protzen and Webber 2006). Among the strongest contributions to the discussion of design and social planning is Ezio Manzini, who identifies the value of making and prototyping as exploratory knowledge production, an argument generally void in planning literature (Manzini 2015). The value of design in collaborative planning process is to make things.

The ability to make things and try things is by far the strongest and most unique contribution design has made to the planning discourse. Participatory design is considered activation of a value proposition within a shared social space (Dalsgaard 2012). It becomes essential that designers have a knowledge of these sensibilities so as to best facilitate a successful, collaboratively designed outcome (Harder, Burford and Hoover 2013). This demand necessitates an "opening" of the design process, to regard each participant as a designer, during the design process and after which ultimately generates the accepted design of the project, followed by the eventual design in use (Bjögvinsson, Ehn and Hillgren 2012). The intent is not to force a value, but to interject the value as a way to open the problem space into new directions, creating new opportunities for participants to introduce their own knowledge and expertise and to share in the creation of new knowledge. When this new knowledge becomes more "probable, effective, long-lasting, and apt to spread," the participatory design process has generated true social innovation (Manzini 2014).

To realize these principles, Ezio Manzini advocates new design practices that are bottom-up and peer-to-peer, enabling dialogue for new visions of daily living, and exploratory making for development sectors such as transportation, housing, and labor. Yet his argument is far from technology centered. Manzini's utopic argument is to apply the design and experimental process expertise of industrial and communications design for the benefit of decentralized social planning (Manzini 2015). While Ezio identifies the role of technology in social planning, there remains an additional need for social design and accessibility concerns within the technologies, as computation takes on greater roles in community development (Goodspeed 2016; Goodspeed, Pelzer and Pettit 2017).

Many institutions of economic consequence such as government agencies and multi-national corporations have appropriated design within their processes as exemplified by urban innovation teams in Baltimore, New York City, or at the State and Federal levels, such as US Digital Services, Presidential Innovation Fellows, and 18F. This appropriation mirrors the same models of design within modern business environments such as agile innovation, lean startup, and Google Design sprints. For example, Design Discovery consists of the application of one or more of eight standardized methods with predetermined sample sizes, scripts, and checklists for implementation (18F 2019). This approach is easily approachable and accessible for government agencies, but it also heavily restricts the possibilities for a design process to shift in relation to a given problem.

1.2 Design and entrepreneurship as a force of change

Within business, discussion of design's value has blossomed for its ability to ideate and pioneer new products, identify new markets, and enhance opportunities for adoption. (Brown 2009). Within business design provides insight into shifting contexts, enabling access to new knowledge domains, often integrating information within large corporate conditions, or supplying new knowledge within small business environments. (Bertola and J.C. 2003) The era of moving design from marketing or engineering departments in the 1980s, to embed design into business organizations was driven by Japanese corporate strategies for consumer products (Waserman 2013). Businesses embrace design because it helps them offer new kinds of products, stand out from competition, and supply services faster. Through design, a business can better access the needs of the people who will buy their goods, services, and support infrastructure (Mascitelli 2003; Brown & Wyatt, Winter 2010). With commercial success, designers have additionally moved into domains of government to tackle socio-technical problems such as systems design and technology creation (Muratovski 2017).

Design has an established record to drive change organizational scale. Focusing values, beliefs, and future concepts into human scale experiences can drive internal changes within an organization by driving processes to learn and transform that learning into action. Through iterative processes, the products are able to drive changes across social and organizational systems (Junginger 2006). Ecosystems of products and the context of human interactions facilitates and informs new social interactions and dialogue (J. Forlizzi 2007). Designing through the interaction or products and services can be a vehicle for social change, though one must work through multiple facets of the human experience including business design and economics (Forlizzi and Zimmerman 2013; J. Forlizzi 2018).

Design, when combined with entrepreneurship, is a force of radical change, the transformation of a system in a relatively short period of time. This change can take place and an elemental level or drive systematic adaptation, though the offer of new products or processes, initiated primarily by those outside of a system (Hagedoorn, 1996; Roberts, 1998). Radical product innovation – changes of frame, i.e., new solutions - is driven by technology advances or the change of meaning in a product (socio-cultural perception of a product), not by human centered product design methods. Such methods are fitting for incremental innovation – improvements to existing solutions. In this manner, radical innovation is unique and discontinuous from past actions but adopted. Radical innovations tend to emerge from inner dreams and motivations, not formal market studies. Design offers a practical path to test entrepreneurial ideas on what might be. Applied to entrepreneurship, the entrepreneur is free to experiment – through action - with business models, transaction processes, and products (Zhang and Van Burg 2019). Notably radical innovations can take time to be adopted (Norman and Verganti 2014). Thus it appears that while design can provide speed to translate ideas into actions and objects, there remains a demand for design research on the formation and actions of the business venture (Nielson, et al. 2017).

1.2.1 The implementation of design entrepreneurship through lean methods

Designers create ecosystems of value for entrepreneurship through clear communications, strategic thinking, iterative processes and products. Entrepreneurship also demands an ability to manage organizational responsibilities in business formation. A contemporary model to manage those demands is through the lean framework, a pragmatic approach to creating value through iterative experimentation, Yet the success of a lean and design driven venture remains tied upon the dynamics of the market.

Design, often labeled as design thinking has found great success within the domain of entrepreneurship to function as a force of social change on account of the value created through experimentation and exploration. Entrepreneurial design thinking often demands deconstruction of the problem, pulling insights from other fields or actions (frames), the hiring of an outside consultant to introduce new frames, internal experiments for discovery, and the infusion of those insights into the organization (Dorst 2011). The contribution of design is that designers tend to specialize on the ambiguity at the outset of a project but can fail due to organizational and societal factors. Entrepreneurship literature, in contrast, struggles to offer insight on ideation and direction, but is better positioned for managing business conditions (Nielsen and Christensen 2014).

Notably, design education is aligned to creating opportunity but is not sufficient for the making of great entrepreneurs. Exposure to macro and micro-economic concepts ranging from the influence of supply and demand on price, to the cultural of entrepreneurship are necessary to translate design into business innovations (Gunes 2012). While design methods may too quickly pose a solution to create a viable business, entrepreneurs can benefit from the value of design processes to continually reassess and reinterpret observations to identify needs and thus adapt offerings (Garbuio, et al. 2018). Applications of reflection to assert how the world "could be," further provides entrepreneurs a means to utilize and apply reflection within their pursuit of opportunity (S. Sarasvathy 2009).

New companies are often assumed to be simple in their organizational structure, yet early founders must make a range of decisions to design their business. These decisions include recruitment, reporting, hierarchy, formality of titles, and processes in communication, resulting in much diversity of organizational design across new companies (Colombo, Rossi-Lamastra and Matassini 25). It has been found that firms need to identify the appropriate governance structure to embed design processes and discoveries within their operations, such as a reliance on informal networks, hierarchical programming, or corporate partnerships (Cantarello, et al. 2011). Within an open innovation system, is an organizational design in which business and technical innovations are emergent from the firm, is created less by choice, but as an outcome of capabilities, stakeholder organization, and wider innovation systems. Design can translate the understanding and expectations between stakeholders to yield innovations and inform the organizational design (Acha 2017).

Startup of a new venture may be suited to the value of design as this stage of business creation relies upon improvisation. The emergence of the organization depends on the ability of the founder to manage the various challenges of balancing vision, business functions, decisions (Shepherd, Souitaris and Gruber 2020). To found and create a new venture, founders do not rely upon formal plans, but magnify goals through actions and action plans. A common framework adopted by entrepreneurs today is the Lean Startup.

Lean management was the result of automaker Toyota and US Department of Agriculture consultant Charles Demming, who applied statistical and iterative approaches to quality assurance in manufacturing in Japan (Rigby, Sutherland and Takeuchi 2016). The objective of the method is to make learning efficient within the organization. As a method, it holistically considers the interactions of people, tools, and technologies in alignment with project management, accounting and culture (Solaimani, van der Veen, et al. 2019).

With a focus on "hands on," and practical methods, the approach was evangelized by Eric Ries in 2011, that proposed an approach to create and validate business models through rapid iterations (Ries 2011). The iterations move through a cycle to build, measure, and learn. On multiple occasions, Ries has highlighted that the lean methodology is not different than the scientific method, as a structured approach to learning through experimentation (Ries 2016).

Lean is a byproduct of scientific management. When Frederick Taylor wrote his "Principles of scientific management" in 1911, he developed a concept in which money is the primary goal by laborers and the reduction of time and physical motion are critical to reducing costs (F. W. Taylor

1911). He argued that empirical analysis, constant monitoring, and workforce optimization are critical to pay workers the least while making the most goods, thus driving up profits. In the early 1950s, when Charles Demming worked in Japan to revive industry, he brought a similar approach, now referred to as Six Sigma. Demming argued that identification and optimization of all key variables was important to maximize production. About 10 years prior, an engineer at Toyota named Taichi Ohno developed the project management method called "Kanban," with organic phased approach to project management. As Demming worked with Toyota, the statistical approach was applied, and "lean" development methods were born.

Ohno's approach did share some of the principals as the school of scientific management, such as the priority of reducing waste in motion and time. Yet a critical distinction was all the focus on the human experience. Ohno's second principle is "to say I can do it, and try before everything." He also taught that one should to seek and apply wisdom in all things, while finding teachings within the workplace itself. This call to learning, reflection, and action is not forced into an exercise (like an Agile Sprint Retro with numbered and ranked feedback components) but is a value to be prioritized for every individual.

Within modern applications of lean, special attention is given to collaborative networks, coaching, and shifting environmental factors, with special focus on the interaction between front end and back end processes within an organization to drive innovation (Solaimani and Talab, An integrative view on Lean innovation management 2019). The value of design and lean methods when compared to traditional business planning, is the ability to manage uncertainty within the discovery and development of all aspects of the business (Mansoori and Lackeus 2019). Notably, implementation of design research within lean methods has been a weakness within lean, on account that entrepreneurs may lack the training to conduct and utilize qualitative research, that design research is often advocating for user interests, and lean entrepreneurs are seeking business opportunities (Batova, Clark and Card 2016).

To entrepreneurs who rely upon design and lean methods must succeed in the market regardless of organizational design decisions. They are in the strongest position when the concept is strong and the costs to compete are low. Thus, deep consideration of the microeconomics is fundamental to success (Gans, Hsu and Stern 2002). It has been theorized that organizational strategy is informed by the local environment of commercialization, which is why some entrepreneurs align to existing firms and others compete against them. The implementation of the company's strategy is heavily contingent on the "market of ideas," not just operations and logistics (Gans and Stern 2003). Yet research by Marx and Hsu suggests that entrepreneurs with great uncertainty should always compete first and cooperate later (Marx and Hsu 2015).

Design has the ability to drive systems level change through the introduction of products and the continual pursuit of learning. Lean frameworks may assist the entrepreneur to manage the challenges of organizing the business, yet the value of the business is contingent on the design of the product and the strategy. Though the entrepreneur may apply design and lean methods to work through ambiguous decisions and grow the organization, to yield innovation is heavily dependent upon the immediate market context of the company.

1.2 The innovation ecosystem as the industry context of design practice

Innovation is not the mere creation of new tools and artifacts through the application of scientific knowledge and research. Innovation is the creation of such artifacts, the diffusion of those artifacts throughout a population, and the internalization of those artifacts by the population to render new knowledge. Innovation drives economic growth as it spurs knowledge spill overs across multiple economic (Braunerhjelm 2010). The domain of economic policy thus encourages innovation via entrepreneurships as a means toward continuous growth, given that the entrepreneur does not only generate a novel commodity, but must also invent to systems of organization and exchange to support the distribution of that commodity. In this spirit, the entrepreneur drives a churn growth and destruction churn through ingenuity, supply, and demand with rare but dramatic shifts of *disruption*, when a particular innovation shifts the underpinnings of day-to-day life (J. Schumpeter 1942).

Schumpeter argued that the entrepreneur leverages a network of resources to create new combinations of offering to meet market demand, thus driving structural transformations in the market he coined *creative destruction*. For example, the invention of the car replaced the demand for horse-based transportation. In Schumpeter's view, these resources are locally available – accounting houses and legal services, shipping and logistics, local experts – and thus his model is summarized as *Endogenous Growth Theory*. Notably, within Schumpeter's view, the product crafted and developed by the designer has no particular significance, but in a manner consistently found across economic models, is equal in significance to all other products, distinguished by the variance of demand. If a product has a greater demand, then it has higher value.

Building off the conception of endogenous innovation, Romer's *New Growth Theory* is also rooted in endogenous resourcing but takes an iterative and social approach to innovation (P. Romer 1994). Romer argues that introducing a new idea does not displace old ones (the car does not directly replace the horse) but produces fodder for other innovators to experiment and produce more ideas. The greater the population working to develop and contribute new ideas to the market, the faster the rate of transformation in the economy and the technologies. Ideas are also non-rival goods, and should be openly shared and worked upon, not locked down in patents or protections that limit their circulation. By consequence, a local economy may benefit from *knowledge spillover*, when new ideas cross industries, populations, and disciplines to formulate new insights. The formation of networks, actors, and institutions to enhance spillover toward the launching of new businesses as agents of economic growth is commonly referred to as the *innovation ecosystem.*

The innovation ecosystem is a mix of institutions and services that provide sufficient resources to stimulate new ideas, training, access to funding, physical space, business incubators and a labor market. It is a mix of human capital, cultural characteristics, and IT infrastructure. Within the innovation ecosystem, actors and elements do not work together under a central planning model but engage organically to generate suitable conditions for entrepreneurs to succeed. Various models describe the core assets needed for such an ecosystem, but there is general agreement on the necessity for the ecosystem to offer access to skilled labor, customers willing to try something new, and access to financing. Furthermore, the more successful ecosystems provide a range of public and private services to streamline the demands placed upon entrepreneurs such as simplified licensing, easy access to information on regulations, simple and efficient labor laws, and simplified tax codes (Nadgrodkiewicz 2013).

Inspired the large-scale growth of Silicon Valley, cities have pursued the development of local innovation hubs to create new markets and attract talent. These hubs are built on a philosophy of open innovation, wherein ideas and resources are openly exchanged for the broader social benefit (Katz and Wagner 2006). While innovation ecosystems are uniquely configured and not boilerplate in their design, they are frequently built upon three models:

1. The University or "Anchor Plus" in which a large existing research institution such as MIT or Stanford University pulls in external funding, develops new ideas, and spins out local businesses.

2. The "re-imagined urban area," such as the renovation of a historic waterfront to support these new models of industry creation. A feasible example its Pittsburgh's Strip District or the Cornell Tech Campus on Roosevelt Island in New York City.

3. The Urbanized Science Park, whereas business parks have been long isolated in suburb outskirts, efforts have been underway to inject new housing, restaurants, retail, and transit systems connecting these research centers with urban areas. An example is North Carolina's Research Triangle Park.

These economic development models slightly deviate away from traditional planning, which long focused on commercial development such as retail and entertainment districts or perhaps locations for offices, but less on the mechanics of business creation (Katz and Wagner 2006). Innovation-based planning empowers the entrepreneur as a key economic actor for local growth and job creation. While the state may consider the additional benefit to also creating a more agile industrial base, arguably, the conditions are not so much changed as much as the risk is placed upon the entrepreneur.

Criticism of these endogenous growth theory remain tied to the difficulty to measure the theory, as local metrics may be derived such as measuring quantities of new businesses created in a given city or year, yet even these metrics rely upon anecdotal research (Krugman 2013). This approach correlates neatly to other social theories of technical change regarded within design literature, such as the evolution of bicycle design that took place for over a hundred years and reached maturity with the rise of the women's suffragist movement (W. Bijker 1995). Yet while socio-technical theories of design are often tied to dialectical Marxism, New Growth Theory does not argue that technical change is the result of dialectics, but is an accumulation of research and development efforts spurred forward with broad access to information (Jeon 2015, 63).

1.2.1 Innovation ecosystems and the value of design

As a function of the innovation ecosystem, Design exists for the needs of the business and its disciplinary priorities are dictated by the titans of industry, much as design has always functioned in the history of mass production. Designers understand that their work in shaping how a product succeeds in the marketplace. They see how that product driven market transformation changes the world. Yet design has little insight into "how" to design products to pursue a desired change.

There is robust demand for Design within innovation industries, with the technology industry as the primary consumer of design expertise, demonstrating a an increase of 65% in demand in 2017 alone (Maeda 2017). During that same year, of 350 technology companies surveyed by the NEA, 250 of them (80%) articulated an intent to hire more designers in 2018 (National Endowment of the Arts 2017). Yet the hunger by the technology industry for design is not limited to individual hires, in the last five years, 59 design agencies have been acquired by technology companies (Maeda). Designers are additionally well acknowledged to have an important role in building a successful technology startup. Of the 278 technology companies with a valuation above $1 Billion dollars, 88% of those companies believe that design is fundamental to their success. (National Endowment of the Arts).

The aggressive recruitment is founded on clear data. Since 2007, The UK Design Research Council has been aggressive to quantify this value with broad industry surveys, concluding that up to 84% of existing businesses already find benefit within design for their products and services (UK Design Council 2007). More systematically, the McKinsey consulting firm tracked the design practices of 300 publicly listed companies over a 5 year period, to assert that the corporations that value design in their processes slightly outpace the revenue and shareholder earnings rates by 4% to 5% (McKinsey & Company October 2018). Within her doctoral dissertation, Mariana Amatullo attempted to discern the value that design brings to social innovation, concluding that a design attitude that connects multiple perspectives, tolerance of ambiguity, and brings empathy and creativity with aesthetic concerns repeatedly drives an achievement of value (Amatullo. 2015).

It is clear and certain that design practice creates an economic contribution. Yet how design differentiates products within the economy is more ambiguous. Furthermore, the relationship between design and particular kinds of products as an economic engine remains undefined. The design of a chair, a milk carton, and a statistical software all yield different market repercussions. Within Design theory there is no solid theory on the role of a product in shaping the world. The economist Paul Heskett is credited with doing the most to provide an economics perspective to Design, and yet Heskett's work primarily discussed the value created by a design firm to inform strategy and optimization of production of goods. His account on the impact of goods themselves merely argued that design exists to disrupt market equilibriums, by regularly pushing for imperfect competition (Heskett, 2017).

Perhaps the most poignant articulation of the economic impact of a design product, is the study commissioned by software company Invision on "The Total Economic Impact of InVision," by Forrestor (2019). Within this study, Forrestor conducted a range of studies to craft a composite company profile of 500 software developers, growing at 10%, per year. The calculated impact of Invision, an asynchronous workflow prototyping tool, was an approximate savings of $1.5 million USD in the first year, accumulating to a total of $4.6 million dollars in savings by year 5. Given the low cost of the application of $400 dollars per user, this generates a 5-year return on investment of 475%.

Notably, the InVision case study fails to describe the value to be generated through the use of their product through enhanced capacities for teams to create and inject value into the world. The economic value of a product is imprecise to measure and predict. Brynjolfsson and McAfee argue that standard economic measures are ineffective to identify and understand the impact that new models of production will have upon humanity, and are additionally ineffective to prepare humanity to thrive in the pending future (Brynjolfsson and McAfee 2014). If our new production models are not effectively measured, the optimizations and enhancements created through design cannot be accurately determine either.

1.2.2 Design for emerging technologies

Designers intuitively work as mediators between technology and society. They recognize technology as a social construction (Bijker 1997). Or, more radically, that technologies are independent entities that come into formation through undulating processes of social negotiation, a series of sociotechnical compromises (Latour 1996, 99, 101). In our current age, designers have employed computation and technology toward political ends through contentious practices coupled with collective organization in the form of hackathons, community robotics, and the redesign of government services and products (DiSalvo 2012). Such tools have a role within the social landscape to provoke change, as technology is more than a product, but is a discipline of systematic thinking, and to possess a technology is a to possess a discipline of thinking (Buchanon 1992). The interface between technology and society is a domain of rich activity, as the tasks for designers has long been to build experiences from abstract materials (Moles 1995). The ability for designers to mediate technology and society with abstract materials is exemplified by design with information systems.

Information technologies acquire material form through their physical presence in the day-to-day experience of human life. These information infrastructures have changed how we engage with space, engage with one another, and have changed institutional processes. The material of an information technology is not restricted to the ontologies of encoding, graphic representation, or organizational schema. Digital systems maintain a physical interface through the physical form of mobile phones, desktop computers, and graphical interfaces. This is most evident in the ubiquity of mobile computing that has established constant connectivity with information systems and mobile spatial knowledge, as this constant connection to geographic data is modifying human experience of space, time, place, and meaning construction (Wilson M. 2014). The materiality of information systems is not only accessible through these channels for manipulation, but the information systems are re-materialized for the user in the creation of physical objects (Dourish, 2015).

Underlying all computational information systems is a database. Databases encode objects, humans, and human actions and provide new ways to observe the relationships between those encodings. A common problem in database management is to maintain the richness of human experience within the coding process and to design fluid processes for observation and examination of the data. This is extrapolated through the introduction of machine learning. Machine learning is an application of statistical reasoning for machines to identify patterns with seemingly disaggregated and massive quantities of information.

As a material, designers have found creating machine learning technologies to be challenging on account that the technology is highly abstract, and thus designers are able to better pioneer solutions when they approach machine learning as metaphors (Dove, Halskov, et al. 2017). Given the service framing and focus on experiences rather than math, Zimmerman and others have identified collaborative processes are key to yielding higher quality design for machine learning applications (Yang, Scuito, et al. 2018). For example, the use of service design has proven effective for products with a core machine learning role (Forlizzi and Zimmerman 2013).

Within design of machine learning products there are extensive opportunities to experiment with underlying incentive and feedback systems (Akers, et al. 2018). For example, it is additionally possible to design for digital nudging to reinforce positive information behaviors (European Parliment 2019). Positive user activity can reinforce desirable architectures for human interaction and experience in the world.

1.3 Section Summary

Design is a loosely structured process for creating change in systems and to create knowledge through action. Over the 20th century till now, designers have taken on problems of increasing complexity, though today some design theorists' question if systems-level concerns are more effective when designed into object-level human products and experiences. ((N. Cross 2001, 2006; Myerson 2017; Buchanan 2019; Weller 2019). Ecologies of products and services have the power to create systems level change at social and economic scale (Forlizzi and Zimmerman 2013; J. Forlizzi 2018).

These designed products and process can be a force of radical change through entrepreneurship (Mascitelli 2003; Brown & Wyatt, Winter 2010). Yet many designers are not equipped to manage the conditions of business, and thus turn to lean methods. Lean is as a pragmatic approach to venture creation through systematic experimentation for venture creation to deliver value to the customer as fast as possible, while the value of design for new business creation is unclear (Nielsen and Christensen 2014). What is better understood, is that successful entrepreneurship though lean or design is heavily dependent upon the innovation ecosystem (Ries 2016; Batova, Clark and Card 2016; Batova, Clark and Card 2016; Mansoori and Lackeus 2019).

The innovation ecosystem is the social formation of networks, actors, and institutions to enhance spillover toward the launching of new businesses (J. Schumpeter 1942; P. Romer 1994). The industries that participate within the innovation economy maintain a robust demand for designers, with a 65% increase in demand in 2017 alone (Maeda 2017). Yet it remains unclear how design can inform entrepreneurship within the innovation economy. The modern practice of design is deeply integrated with technology innovation. As an emerging material, designers are increasingly working with machine learning, a challenging on account that the technology is highly abstract (Dove, Halskov, et al. 2017; Yang, Scuito, et al. 2018; Forlizzi and Zimmerman 2013).

The literature demonstrates that design processes are effective to create goods and services for radical change through entrepreneurship, but it is not understood how design can inform the work mechanics of venture creation. It is also unclear how this process borrows from or is informed by lean methods. Furthermore, While the research states that systems-level insights can guide the design of products to generate human-experiences for systems level change, the argument is based in iterative learning and for products to enable communication. This iterative approach, and modern entrepreneurship both take place in the context of the innovation ecosystem, informing applications of design to emerging technologies such as machine learning.

To better understand the relationship between designed products, venture creation, and systems level change in the context of innovation ecosystems, the next section reviews the creation and circulation of disinformation within modern technologies. Following study of disinformation, research will be conducted concerning design-based venture creation, and product design, to counter disinformation.

Section 2: The global threat of disinformation

2.1 Section Abstract

To better understand disinformation as a design problem, I have conducted a literature review on the construction, history, and critical elements in the formulation and diffusion of disinformation. I have also examined the limited extent of design research concerned with disinformation.

Disinformation is the creation and circulation of false information either by intention as disinformation, or by accident, misinformation, has immediate and far reaching impact upon the economy (Dohse 2013; Jain 2018; Vosoughi, Roy and Aral 2018). Disinformation campaigns have specific targets but create general chaos. The rapid movement of disinformation can drive new social divisions and deepen existing inequalities (Hall 2019; BBC Media Centre 2018; OECD 2014). The result of disinformation is a loss of trust in public institutions and traditional sources of information (Kavanagh and Rich 2018).

Disinformation is primary spread through text and imagery with unique interaction patterns to undermine viewer/reader cognition. These methods are extrapolated through the use of machine learning to build *echo chambers* of information (CEPA; Thompson and Lapowsky 2018; Tenove and McKay 2018). Current efforts to combat disinformation by the public sector tends to focus on journalism standards, digital education, and technology standards (Bradshaw, Neudert and Howard 2018). Within the private sector, the focus is on content moderation, machine learning tools to combat the problem, and inoculation strategies (K.-C. Yang, O. Varol and C. A. Davis, et al. 2019; Candogan and Drakopoulos 2017). None of these tactics have been successful.

Current methods to combat disinformation fail because current technologies are not transparent. Users do not understand the algorithms, the workings of bots, the design of these systems, or how their data or the data of others is consolidated for use (Hindman 2018; Bradshaw and Howard, 2019). Furthermore, information is spread by individuals based on trusted social relationships and delivered in a fashion to undermine deep critical reflection (Lewis 2018; Institute for the future, 2018; Canan and Warren 2018).

2.2 Disinformation

The creation and circulation of false information either by intention as disinformation, or by accident, misinformation, has immediate and far reaching impact upon the economy. Multiple industries are undermined by false information, including health care, education, travel and retail, as the circulation of false content can harm the reputations of businesses (Dohse 2013). This is not a new problem. In 1803, a forged document provided to the Mayor of London generated a 5% increase in stock gains, as speculators traded on confidences of disinformation (Jain 2018). In 1951, popular rumors were recognized as manipulators of public opinion with direct influence upon the stock market (Rose 1951). More recently, the explosion and collapse of cryptocurrencies functioned on same rise and fall of public opinion, bought and sold by the madness of crowds. Unfortunately Vosoughi et al. have demonstrated through their analysis of 126,000 rumors spreading amidst 3 million people, that false information spreads faster than truth (Vosoughi, Roy and Aral 2018).

Disinformation functions through three kinds of disorder: Misinformation, Dis-Information, and Mal-Information. These distinctions are made upon the intent to cause direct harm to a person, social group, organization or country. Disinformation is a deliberate fabrication to cause harm. Misinformation is false, but lacks the intention to create harm, though it may do so. Mal information is the manipulation of truth to create harm (Derakhshan and Wardle 2017).

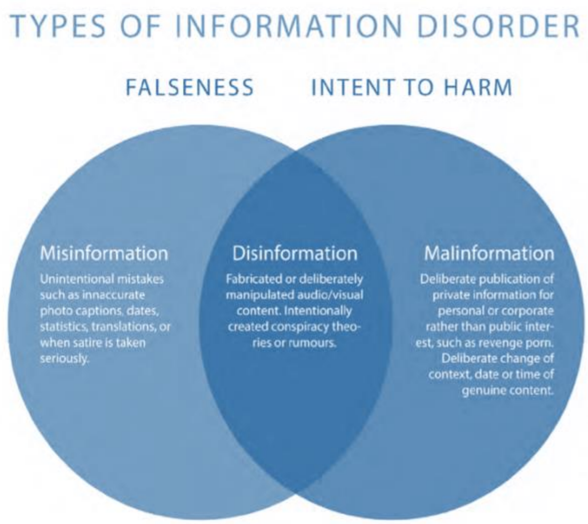


Figure 1 Three types of information disorder from Derakhshan and Wardle, 2017

Disinformation generates a general sense chaos, but more frequently disinformation campaigns are highly targeted. Russian fabrication of chemical spills, disease pandemics, and right-wing propaganda have directly harmed small and growing businesses within the United States. Copyrighted and trademarked imagery are frequently appropriated with no requests to the rights holder, then used to create misleading memes or false news articles. For example, apparel entrepreneur Jay B. Sauceda saw his graphic design for his small business, Heart of Texas, consistently appropriated and applied to inflammatory Facebook sites calling for Texas secession (Foster 2019). The creation of fake maps is a popular approach to sewing discord among fragmented social groups (Robinson 2019).

Media organizations have demonstrated the inability to always identify disinformation, including synthetic videos known as "Deep Fakes," and are prone to sharing this content with local audiences as legitimate (Hall 2019). Some global media organizations have dedicated extensive effort to better understand and mitigate this problem, such as the BBC's "Beyond Fake News" initiative (BBC, BBC Media Centre 2018). However, such large-scale investigations are beyond the means of many smaller news organizations, in particular in the developing world.

Disinformation undermines civil society at large. Research conducted by the BBC has found that the proliferation of disinformation erodes trust, divides communities, undermines citizen action and decisions, distorts democratic processes, and even can create threats to public health by weaponing information, leading to violence and death (BBC 2018). The proliferation of false messages can make it difficult for citizens to identify and respond to early warning systems for public safety (T. Harper 2018). Studies have demonstrated that civil conflict within Jordan from the years 1967-2009 have had a negative impact on economic growth (Sweidan 2016). Social and economic policies founded on instability can further drive inequalities in education and income, demonstrating negative influence on economic performance (OECD 2014)

With widespread technologies, and deteriorated social systems, a singular disinformation incident in December 2017 created as much as $300 billion dollars in stock market losses (CHEQ: University of Baltimore 2019, 6). While direct costs may be captured across various incidents, the indirect costs are tied to lack of trust in markets. Trust in news media, peer and online review has dropped by at least 30% in 2019. The energy and resources consumed by large corporations to constantly monitor and mitigate damages are diverted away from more growth-centered uses such as workforce development, entrepreneurship events, and research funding (CHEQ: University of Baltimore 2019). A relevant example of the cost by Tesla to counter a false video created by a Russian media firm on the *death* of a robot (Atkinson 2019). Demanding extensive attention by the company leadership to manage public relations, managing this one false issue was at a direct corporate cost, given their successful deployment of thousands of perfectly functioning vehicles on the road.

2.2 Disinformation in History

The pervasive growth and use of disinformation in the world are threats to international governance by reducing trust across nation states while internally driving social fragmentation. Disinformation is founded on the intent to deceive, as opposed to the mere circulation of misinformation, which is simply the circulation of incorrect information with no intent to mislead (Fetzer 2004). Disinformation as a problem is not tied to single technology or set of actors, although the breadth of the problem is heavily connected to the rise of machine learning, social media platforms, and politically divisive actors. Disinformation as a global problem is not the consequence of a single entity but is the consequences of a network of actors and technologies, though some entities are obviously more focused and aggressive in its use.

Disinformation has a long historical legacy as a political tactic to manipulate populations and to manipulate the geopolitical landscape. In ancient Rome, circa 44 BCE, Octavian painted slanderous messages about Antony throughout the city, enabling his rise to emperor (Posetti and Matthews 2018). Yet Joseph Stalin is commonly cited as the first to coin the phrase, dezinformatsiya, as false information used to deceive the public, and possibly as a means of leading. It is believed that Russian legacy of disinformation as a formal political tactic reaches to the mid-18th century, when Grigory Potyomkin created false villages to impress the visiting Catherine the Great. Notably, a Potemkin Village is a common term to describe government efforts to present something as better than the truth (A. Taylor 2016).

Russian is by no means the only modern political entity with disinformation expertise. One can easily find examples of American efforts, in particular through the actions of the CIA, to utilize multi-channel disinformation campaigns to drive social instability and reinforce the overthrow of political leaders (Ferreira 2008). Nearly 25 years prior to Potyomkin's ruse, Spanish colonial New Granada fell victim to a disinformation campaign as the use of the printing press circulated false information within the Viceroyalty months driving divisions before the war of independence (Earl 1997).

In the earlier years of the internet, while the notion that entities with ignoble intent may attempt to utilize the internet to spread disinformation, it was argued that the problem held low risk on account that "the Internet is presently an interactive group medium used by a restricted elite which, to a large extent, is capable of controlling the world of information, it is also a much less efficient instrument of disinformation than any other unidirectional mass medium. (Floridi 1996, 7)." The circumstances are quite different today.

Individuals and groups are now able to manipulate large swathes of content and online media by manipulating frames, setting agendas and pushing ideas. News media organizations maintain a fast news cycle are heavily dependent upon social media and sensationalism and are thus prone to illuminate fringe groups and ideas. Aware of the demand for sensational news, far-right groups and nations states have developed methods of attention hacking, online strategies to enhance visibility of content through the strategic use of social media platforms, bots, and memes, targeting others information producers such as journalists and bloggers, to drive content. This vicious cycle contributes to a decreased trust of mainstream media and reinforces radicalization through manipulated misinformation (Marwick and Lewis 2017).

2.3 Contemporary Agents of Disinformation

The most well-known actor concerning disinformation is the Russian state. A US Senate report identifies Russia, in particular as having utilized disinformation campaigns to affect 27 national elections around the world (US Senate 2018). Russian efforts are highly centralized. Directives are established by top leadership, distributed through various organizations and proxies, then amplified through social media platforms to information consumers. Yet no symmetrical response system has been established by the United States to counter Russian political influence (Bodine-Baron, et al. 2019). This is surprising, given the reach of Russia's influence into everyday life. Today, 72% of American obtain their news from Smart phones, and nearly half of all Americans viewed Russian-sponsored posts during the 2016 election (McGeehan 2018). Yet Russia is not the only nefarious actor. Other nations and non-state actors are equally adept in the user of social media and information campaigns to recruit, spread propaganda, and proliferate threats (Prier 2017).

Independent analysis by Oxford University Internet Institute has found evidence of social media manipulation within 48 countries in 2018, and within each country, there was at least on party or government agency using social media to manipulate domestic perception. In one fifth of these same countries, these campaigns were operated over direct chat applications such as WhatsApp and WeChat (Bradshaw and Howard 2019). Deliberately created disinformation, and its slightly more innocent partner misinformation (inaccurate), conform primarily to 7 types: satire/parody, misleading content, imposter content, fabricated content, false connections, false context, and manipulated content (Ray and George 2019).

While such actors may have a historical record of disinformation strategies and tactics toward political aims, the circumstances today are different due to the nature of technological augmentation. Specifically, the decentralization of content creation via social media platforms, a rapid news cycle with click-through economics, wide reach and interaction, the rise of machine assisted filter bubbles, non-transparent algorithmic curation of content, and the scalability of anonymous online accounts (Akers, et al. 2018).

The role of machine learning within disinformation crafts a particular risk to ideological radicalization and polarization as individuals and groups engage an endless feedback loop of optimized messaging, reinforcing worldviews rather than driving dialogue or opening new paths toward empirical learning. This creation of echo chambers is dependent upon individuals receiving content from an external network that aligns to an internal bias. The creation of an echo chamber can take form at an alarming rate, as the spread of false information on twitter, for example, has been found 70% more likely to be shared compared to true information even though algorithms treat all data equally, indicating that human action is at the root of this rapid diffusion (Vosoughi, Roy and Aral, The spread of true and false news online 2018).

The social reproduction of disinformation is naively reproduced and shared as receivers of the content frequently care more about their personal experience of the origin. For example, if content derives from a trusted friend, individuals also assume the content to be true. Sharing news among peer groups is socially validating, and individuals will frequently only read parts of the message before sharing it with others (BBC 2018). In this manner the echo chambers are reinforced across social networks, as audiences organically segment themselves through the rapid reproduction of similar content.

While popular understanding of the threat of disinformation is tied to the manipulation of social media, it is vital to recognize the threat is far more sophisticated. Harmful intent has been applied to the manipulation of data within prosaic databases for urban government and manipulation of data within voting machines and interfaces. The combination of disinformation tactics with offensive cyber-attacks is crippling governments within public political contexts and day to day operations (Tenove and McKay 2018).

2.4 The Material Forms of Disinformation

Any medium utilized to communication information can be configured to deliver falsehoods. I have consolidated a list of the most common methods to produce and share disinformation.

2.4.1 Text

Text is the most common medium for exchange. The promotion of erroneous text within public forums, such as Reddit, Facebook, Twitter, email campaigns or comments on trusted websites. This is highly common within political messaging. This content may be created by an individual, or within highly organized and sophisticated operations such as the Russian Internet Research Agency, in which hundreds or more persons managed hundreds of artificial bots to create false content (Thompson and Lapowsky 2018).

2.4.2 Imagery

Disinformation conveyed via imagery is slightly more sophisticated. The modification or creation of false imagery for distribution most commonly occurs along the following processes:

1. The labeling of photographs with erroneous content to be circulated online.

2. The creation of fake photographs utilizing software's such as Photoshop to be circulated online and pushed to trusted news vendors, or under the guise of trusted, traditional media outlets such as Russia's Sputnik news agency (Ross 2019).

3. The manipulation and distribution of real audio and video clips to shift language or gestures, often with erroneous support commentary. A relevant example is the editing of public footage by the White House to make reporters look aggressive through speeded actions and movement (Harwell 2018).

4. The complete or partial fabrication of video, often by means of machine learning tools and known as Deep Fakes, that in all ways look authentic and depict identifiable individuals conducting behaviors outside of individual norms.

5. The intentional production or modification of socially accessible databases or information repositories. This may include banking data, environmental data, economic data and so on. Sites such as Data.Gov may be subject to outside hacking, while popular data repositories such as Kaggle or open street map have no proven provenance authentication. Data sets by large corporations such as Google are trusted, but subject to manipulation. Resulting analysis and visualizations, such as maps, are highly skewed.

6. Fake products, environments, or misleading policies have not been discussed within the domain of disinformation, though arguably, the counterfeiting of goods, currency, or the intentional creation of fake towns for satellite documentation would qualify.

2.4.3 Tactics in the Social Diffusion of Disinformation

Fabricated Text, Imagery, and Media of disinformation may delver a variety of mechanisms to enhance receptivity. Within a software environment, the user experience of disinformation is frequently tied to the sequencing of information and the context of the engagement, formulating conditions of trust, often reinforcing the individual's world view and the presentation of the new content. Malicious actors have developed additional techniques to enable the rapid transmission, consumption, and sharing of disinformation. These mechanisms drive participation, reinforce trust, and drive emotional reactions. The Center for European Policy Analysis (CEPA) has created a list of 22 disinformation techniques that I have consolidated into the following list:

1. Intentional deceit within the sharing of information, such as through selective censorship, manipulation of search rankings, hacking and releasing private information, or the direct

sharing of information (Tucker, et al. 2018). One can enhancing circulation by resharing content through multiple sites (ping-ponging).

2. Fact Stacking – Utilizing many fragments and half-truths to assemble a verifiable but entirely false narrative.

3. Over-generalization, creation of false facts, or utilizing a single point of view as the entire story, such as relying on the input of one expert scientist, skeptical of climate science, to undermine the whole scientific community.

4. Loaded language – Words like "murder," trigger strong emotional reactions and undermine the ability for the reader to internalize the nuances of a story.

5. False References and Balancing – Claiming to uphold ideals of 'balanced debate' while not sharing the full range of information.

6. False Dilemmas – Forcing audiences into a binary choice when the problem is not binary

7. Misleading Framing / Priming – Presenting a sequence of stories that are not directly related, but plant a seed into the mind of audience that will influence reception of key points later in the narrative

2.5 Current Efforts to Counter Disinformation

Unfortunately, there has been limited imagination concerning how to combat the rise of disinformation. A fairly typical set of recommendations by the Brookings Foundations advises that governments should encourage independent journalism but avoid censorship, the news industry should focus on quality reporting and should call out false media, that technology companies should build technologies that recognize and combat disinformation, and that education must improve regarding digital literacy (D. M. West 2017). Additional attention is given to the transparent use of social data by governments and technology firms (Morgan 2018). By and large the focus is on the content, the actors, and the institutions. Little thought has been given to how disinformation weaves into daily human experiences, how individuals shape it through interaction, and how it changes, or how new information is created through interactions.

2.5.1 Public Sector Engagement

Governments are highly concerned and intent to regulate technology companies, in particular those that create and manage social media platforms, and are pushing policies to remove content, improve transparency, or tighten data protection. Civil society actors and media organizations in comparison are pushing digital literacy advocacy to raise public awareness and to raise the standards for journalists producing content (Bradshaw, Neudert and Howard 2018). Governments under threat are forced by necessity to focus on defensive actions, primarily in the domains of cyber security.

The U.S. government has 21 intelligence agencies, and one of them, the National Geospatial Intelligence Agency is trusted with the analysis of satellite and spatial data to identify points of interests, to make predictions, and to supply specialized maps for other government entities, such as the Department of Defense, the National Security Council, the White House. Though NGA has traditionally had the role to assess photographic and satellite data to create maps, the rise of IoT, public data, and the massive availability of imagery has driven NGA toward new methods in recent years. Recently NGA has advanced partnerships to support the cybersecurity of State agencies. This is a strange departure for NGA given the clear geographic mandate of the organization. Given that NGA does not rely upon States for satellite imagery, ground-verified imagery, or analytics, the activity suggests that NGA's reliance upon domestic data created at the state and local levels such as transportation, environmental, social, economic and biological. For NGA to exert and interest in partnership over such data - the point of investment - it is reasonable to believe that these mundane public data sets are at risk of corruption and manipulation.

2.5.2 Private Sector Engagement

The matter cannot be left merely to non-profits, academia, and government. Private sector stakeholders are key to combating disinformation by taking responsibility in information creation. Yet current efforts to combat disinformation by technology are generating mixed outcomes. Facebook has managed to decrease engagement with fake news over the last two years, although engagement numbers with fake news on Twitter have increased during the same period of time (Allcott, Gentzkow and Yu 2018). Content moderation contains many other challenges within the technology, as these tools may remove massive levels of content but fail to educate users about the risks (S. M. West 2018) Very few, but some, new companies are emerging with strong ties to the intelligence community to counter very specific threats concerning the quality and reliability of data and machine learning algorithms within analytical processes. As contemporary mapping is increasingly dependent on automated systems, maps are subject to the same risks and limitation.

2.5.2 Machine Learning as a Problem and a Solution

One approach has been with the use of machine learning to combat nefarious activity, yet a challenge to combatting bots is that the bots evolve continuously, creating an arms race between nefarious actors and defensive research communities. Current efforts in bot detection are based on supervised machine learning, demanding an extensive set of training data on known bots. This training data is itself a risk, as training data can vary as ground truth and feature identification within training data is additionally highly subjective. (K.-C. Yang, O. Varol and C. A. Davis, et al. 2019)

To combat bots, it is believed that 6 machine learning elements matter: user metadata, known (friend) metadata, network structure of interactions, content and language, sentiment, and temporal features. Such features are used to train models to identify known possible bots. This may work to identify specific accounts but struggles to combat networks of bots. Unsupervised learning can identify commonality within networks to flush out suspicious bot networks, but this research remains in early days. (K.-C. Yang, O. Varol and C. A. Davis, et al. 2019)

As governments and technology companies struggle to counter the rise and reproduction of disinformation by themselves, the formation of new public-private partnerships is a likely necessity. It is suggested that the government will need make the public more aware of information manipulation, provide resources to combat it in collaboration with private technology companies, but refrain from censoring content (Barrett, Wadhwa and Baumann-Pauly 2018). This process will likely demand that we additionally bring conservatives into the political conversation, to work closely with journalists to broadcast messaging, and to develop community shared resources for research against misinformation (Lazer, et al. 2017).

2.5.3 Inoculation Strategies

Research by Candogan and Drakopolus suggests that providing indicators to you social media users about post popularity may maximize engagement while reducing fake news diffusion, as individuals prefer to share unique content with social groups rather than reproduce already popular stories (Candogan and Drakopoulos 2017). While efforts to "pre-bunk" by providing users warning information on false content appears to work, it also requires that individuals have not previously been exposed to the content. Consequently, software systems that seek to educate users and reduce disinformation by this method need to constantly present the new information as a problem before exposure. In this manner, debunking can work, but rarely (van der Linden, et al. 2019).

2.6 Why Current Approaches Fail

Considerable efforts are underway within public and private sectors to counter disinformation. The following section outlines the challenges that deter success among existing methods.

2.6.1 Non-Transparency

The role of machine learning continues to expand within domains of social and political importance. Black box algorithms however continue to deny clarity on internal bias of decision making while bias within data continues to introduce problems that magnify within product adoption. Deep learning methods in particular are a challenge to assign accountability. (Hindman 2018). Transparency is particularly important when considering matters of personal data, the use of non-personal data to micro-target people, and the ability to reconfigure social environments through the manipulation of data tied to individual vulnerabilities (Lievens 2019).

2.6.2 Inaccessibility

Complimentary to the lack of transparency is the inequitable distribution of access to information creation. Large datasets about public and private life are concentrated among small elite groups (Bradshaw and Howard, Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation 2019). This problem is reinforced with black box algorithms and sophisticated computational architectures which distort the provenance of information, disarm individuals and spread information through bots, create endless echo chambers of messaging, and develop extrapolations of information that chaotically circulate through public spheres to manipulate public perceptions of the world.

2.6.3 The Insular Demands of Machine Logic

Whereas all technologies may be used for to accomplish a given goal with positive or harmful intention, advanced artificial intelligence systems are different from other technologies as such technologies possess their own goals, objectives, in combination with advanced reasoning and extensibility (such as robotic hardware extensions), become technologies that can misuse themselves. In this manner, the logic of the machine is to optimize the world according to the demands of its goal, not human values. At this time, a highly advanced artificial general intelligence (AGI) does not exist, yet as our learning technologies become more sophisticated a viable threat begins to arise as an AGI system applies its energies to itself, recursively developing a superior intelligence. With extended intelligence and goal stability, such a machine becomes superior only to the needs of itself (Bostrom 2018).

2.6.4 Simulated Social Actors (Bots)

Social bots are computational simulations of human actors that can assist with computational tasks in substitute of a human actor. However, these bots can also exploit human vulnerabilities by manipulating shortcoming in human reasoning, by deploying cyber-attacks, or by generating fake online profiles that distort the public information landscape by creating and circulating false content. Bot use proliferates within election manipulation or high-stress political conditions, as the 2016 US election surfaced that 33% of all user accounts generating disinformation were in fact bots (Hindman 2018). In another example, Russian media uses negative news about the US to distract Russian citizens when its own economy is facing challenges (Field, et al. 2018).

2.6.5 Social Media Platform Design

Social media platforms have democratized content creation via the design of decentralized systems with multiple contributors. While technological capacities exist to recognize disinformation more vigorous forms of self-governance are in demand (Hindman 2018). As it stands, a range of social computing design elements within social media platforms drives particular kinds of behaviors and empowers particular kinds of actors. In addition to the use of bots, a specialized form is called an automated sociopathic actor, a bot that is used to amplify information as it moves through network. Additionally, elements that act as information recasting tools craft and apply subtle variations to information and redistribute to drive the proliferation of subtle nuances, increase distrust, and drive animosity.

2.6.6 The Challenges of Social Complexity

While much of the problem is embedded within digital systems, non-digital elements are equally critical in the building of trust that can be later exploited. This is particularly salient within the US 2016 election, wherein only a small quantity of Twitter accounts held an outsider role in spreading fringe ideas by means of their sophisticated trust and audience relationships (Lewis 2018). This is possible because human actors with malevolent intent may build unique content to develop a following for a long period of time, but later shift toward the introduction of false information. By extension, human social media consumers may rely upon trusted non-digital networks (work colleagues, friends, family) to build a trustworthy digital footprint, yet the diffusion of disinformation within this network may spread in a manner than is difficult to analyze (Akers, et al. 2018).

The human consumption of disinformation is a social process as much as a technological, and highly successful disinformation campaigns adopt elements from the existing socio-cultural fabric. Campaigns are typically built upon existing and known narratives and convey stereotypes as actual news stories. When diffused across multiple channels, these tactics reinforce existent patterns of social marginalization concerning immigration or refugees (Akers, et al. 2018). While personal memories and beliefs inform receptivity, so does group dynamics, as social goals and values drive social cognition (Ray and George 2019). As decisions are frequently tied to group level narratives, not individual rationalism, reception of messaging is heavily informed by creditability of source and social pressures (Lazer, et al. 2017).

The use of memes, small concepts, catchphrases, or behaviors that rapidly spread via images, text, video, are able to rapidly move across social groups through the triggering of individual cognitive responses. The human brain is more reactive to imagery than text, and the aggressive supply of imagery creates cognitive challenges to sort and classify the inflow of information. The design of memes bypasses System 2 cognition, the faculties of slower deliberative logic and reason, and engage only with System 1 cognition, the fast, institutive response to stimuli rooted in heuristics (Institute for the future 2018). With continued exposure to disinformation optimized for consumption, individuals may develop a bias (cognitive schema) that may constrain future information seeking. Actors are thus able to exploit this phenomenon and use repetitive memes to target non-informed decision makers such as voters (Canan and Warren 2018).

2.6.7 The Social Segmentation of Disinformation

Notably, the likelihood to engage and disseminate false information is not evenly distributed. Although politically conservative voters were more effected in the 2016 US elections, research has demonstrated the most susceptible population are over 65 years of age, regardless of ideology, education, or partisanship (Guess, Nagler and Tucker 2019). In contrast, younger Americans are able to better identify false information online regardless of political leaning by roughly 10%. Other factors of significance beyond age include the degree of general political awareness by the individual, and the more one continues to trust national news media (Gottfried and Grieco 2018). Individuals who were more political aware and trusting of national news media tend better identify disinformation than those who are suspicious of traditional news sources and less familiar with political issues.

2.6.8 Loss of Public Confidence in Traditional Institutions

With the rise of disinformation in society the equally symmetrical impact is the decay of social constructions of truth. This phenomenon has been labeled by the RAND Corporation as truth decay, and can be discerned by the rise of four trends: increasing disagreement about facts and data, the blur between opinion and fact, the increase of volume over accuracy of facts, and the declining trust in traditional sources of reliable information (Kavanagh and Rich 2018).

The reduction in trust of venerable information channels expands the influence of alternative sources including nationalist and foreign entities committed to the destabilization public institutions. This decline of confidence in institutions further undermines government messaging to the public on matters of grave importance including national security. Governments departments, such as the US State Department's Bureau of Arms Control and Verification, have previously recognized that it is not enough to use technology to identify and assess nuclear risks in the world, but under threat of today's chaotic information landscape and the impact of truth decay, that partnerships, engagement with technology creators, and 3rd party verification of government messaging is critical (Daniel 2017).

Shortly after the public realization of election meddling by Russia in 2016, the US Department of State contracted the RAND Institute to conduct a study on the social phenomena of disinformation. In 2017 the researchers presented their findings to the Undersecretary for Arms Control and International Security. Those findings are captured within the contents of this thesis.

Yet sitting in the room, listening to the conversation that followed consistently I observed that the conversation repeatedly returned to the topic of public education and digital literacy. Everyone in the room was intimate with the practices adversarial governments and it was a commonly held view that a technology company is ill equipped to wrestle with the geopolitical consequences of its work. Ultimately the responsibility to contend with the weaponization of technology was seen as a social burden, and with public education outside the lane of the State Department, there was a general feeling in the room that nothing can be done.

2.7 Section Summary

This section reviewed the state of Disinformation today. Disinformation is intentionally created to harm a specific target but forces communities and nations into general chaos. The consequence is a failing trust in formal and state institutions. It is primarily spread through trusted social networks but reinforced by machine learning to create echo chambers for information consumers. Efforts to combat disinformation at the policy level and at the technological level have had limited success as perpetrators and techniques of disinformation are constantly changing. In the next section, I will review the contributions of design research on how to combat and manage disinformation.

Section 3: State of research for design, and by design, to counter disinformation

3.1 Section Abstract

At present there is little to no design research on countering disinformation and only a limited amount of discussion within the design research community. Although disinformation is circulated through technologies generated by the same innovation economy that heavily employ designers, there is no research literature in place on how designers may confront and manage disinformation within businesses or products. While disinformation is heavily tied to machine learning, disinformation does is not a part of the current research agenda. Furthermore, these technologies are the consequence of innovation through entrepreneurship, the use of design entrepreneurship to combat disinformation remains completely unexplored.

Yet there is some historical precedent within historical design literature. Horst Rittel developed an issue-based information system, IBIS, as a means to manage human dialogue for general planning (Kunz and Rittel 1970). Through the mapping and qualification of information Horst believed IBIS could enable the taming of wicked problems. From the mid-1970s till his death in the late 1990s, Horst explored computational applications of this technology, as well as methods to make information systems and computational processes more transparent to benefit social interests.

While most popular discussions of disinformation concern social media and the consequence of social fragmentation, an emerging threat is the circulation of disinformation within Geographic Information Systems (GIS). GIS supplies data analysis for a range of public and private, and the persistence of disinformation within GIS data can have detrimental effects upon public health, economics, national security, and the natural environment. GIS capabilities have much evolved for participatory methods, with consideration of cloud computing, participatory processes and visual representation through virtual and augmented realities, (Brennan-Horley, Luckman, Gibson, & Willoughby-Smith, 2010; Kamel Boulos, Blanchard, Walker, Monterro, Tripathy, & Guiterrez-Osuna, 2011). Yet from review for commercial platforms the user experience and interaction design has changed little for the common planner, designer, or analyst.

Given the limited amount of change in the user experience and interaction design of commercial GIS software, GIS presents an interesting opportunity for to research the management of disinformation through software design. To design a new approach to GIS, the materiality of information opens opportunities for creative processes, metaphor construction, research into machine learning (Dove, Halskov, et al. 2017; Yang, Scuito, et al. 2018; Forlizzi and Zimmerman 2013, Dourish and Mazmanian, 2011; Dourish 2014).

3.2 The discussion of disinformation within design literature

Under the threat of disinformation, Manzini and Margolin contend that the international democratic system is under threat, and that designers must improve democratic processes by enabling participation through technologies and institutions with new approaches, methods, and ideas (Margolin and Manzini 2017). Although domains of concerns focusing upon employment, welfare reform, and environmental sustainability are highlighted as key areas of interest as pillars of government, it is not articulated how design must be different or how design that exists within existing participatory models must adapt, change, or expand. Notably, it is also unclear how responsible and effective governance for areas of human interests are directly tied to the democratic model as opposed a less biased focus upon trans-political design (Agbo 2018).

Manzini contends that the dimension of design for democracy is a "hybrid, physical and digital space," for individuals to converse, share perspectives, and to collaborate. He further states that a democracy enables individuals and groups to realize change through "concrete results." This articulation is distinct from the current social media landscape, in which engagement is reduced through the technology, individuals focus exclusively on the generation of opinions, there is little opportunity for mediation. Manzini promotes a technological future in which our technologies enable meaningful dialogue (Manzini, Collaborative, design-based democracy 2017). This argument is compelling and may offer direction toward a designed path for countering disinformation, as the materiality of disinformation is under-explored and provides a clear contribution by the design communities.

There has been some reflection on the value of design as a process to counter disinformation, contributed by Tonkinwise. Specific to the issues of information threats within social media, Tonkinwise highlights that service and interface design are appropriate vehicles for systems design, to counteract these processes. "To stand up for democracy as an interaction design is not therefore not a vague commitment, but a very specific, material design challenge." Furthermore, Tonkinwise identifies that "instituting the outcomes of any successful designs will then require challenging those in power at Facebook and Twitter, whether founders or investors (Tonkinwise 2017)." This stance is compelling as it forces one to explore disinformation as more than a technological or process problem, but as a problem of social organization as well.

Concurrent with Tonkinwise's assertion that democracy may require design, but that design is not democratic, legal scholar Antonios Broumas, highlights that technology design is an assertion of power by designers over users, and that the processes used to bring forth technological innovation must be grounded in moral and ethical processes. Broumas also asserts that participatory models of design, though reflective of moral intent, are also likely to replicate existing dominant power structures within the technology architecture (Broumas 2013). The risks are enhanced when central and strategic decisions within governance are left to a data driven algorithms. Unless, perhaps we can extend the transparency and reflexivity of these algorithms? This is uncertain.

To explore the implications of Tonkinwise's assertion demands that one examine the systems of disinformation in terms of the technology, stakeholders and the processes, to adopt a product-systems ecology (J. Forlizzi 2008). Furthermore, one must assess how the technologies, the participants, and the human computer interaction work together to manage and manipulate information and communication with implications on constraints and creativity. Notably the interest of the corporation may not be in alignment with the goals, beliefs, priorities and offerings of the stakeholders. Steps are needed to bring transparency to these systems and underlying tensions (Gallant 2011). HCI researcher Kate Starbird closely studies the spread of disinformation online through journalism tools and social media, but admits there is very little insight into the underlying political and financial forces that inform these forces (First Draft 2020).

As it stands, the state of thinking to countering disinformation or any malicious impact associated with machine learning within the design industry maintains an excessive focus on AI ethics and risks. Commonly cited risks include marginalization of people and communities within algorithmic training, polarization through creation of echo chambers, or the creation of direct safety risks, such managing pedestrian safety with the development of autonomous vehicles. The insistence on a *human centered AI* offers some value outside of conventional design thinking, given the expansion of scope beyond users and immediate time series (UX Collective 2019). Yet the proposal to bring values and expansion of scope is in no way certain to counter the threat of Disinformation within information products. Facebook has proposed user interface design features to report suspicious information for review and using known fake news to train machine learning models, in hope of identifying other erroneous content (Facebook 2017). Yet these efforts resemble the same tried and failed tactics covered within the literature.

3.2.1 A precedent of technology systems research by design to combat wicked problems

Throughout the 20th century, the disciplines of design and planning have consistently pursued large systems level change through systems level interventions, while relegating the impact of products to individual user experience. Consequently, the literature within these fields has ascribed social and economic change to design processes that are either "top-down" impositions upon the system, or through participatory and decentralized action. Yet the contemporary power and influence of disinformation within decentralized information systems, in particular those information systems that utilize machine learning to optimize the experience, proves that product-level technology design can wield massive social and economic repercussions. Where the proliferation of disinformation has rendered great harm to nations and communities, I ask how does one explicitly create an information system that relies upon machine learning to incur positive economic value?

Such a proposal, that product design can function as a form of general planning, is a distinct axis of inquiry perpendicular the conventional binary division between top-down and bottom up. Having reviewed the 20th century relationship between design and economics, it was notable that computation and technology was long a central element of that relationship until the 1960s and 1970s. What if the binary opposition of methods is a false proposal? There is no reason to believe that economics is reliant upon such limited social models, when other factors certainly weigh upon the ability for humankind to flourish. Rittel himself, who advocated for dialogue and was not altogether a supporter of design science, experimented with the role of technology throughout his life to counter wicked problems.

To engage wicked problems with the power of argumentation, Rittel developed a tool for making communication transparent and explicit known as Issue Based Information Systems, or IBIS (Kunz and Rittel 1970). IBIS is a form of dialogue mapping in which questions and arguments are sketched in relation to a provided topic. Participants are welcome to provide counter arguments, based on warrants, and issue alternative proposals for group consideration. Within the IBIS session, all stakeholders are considered equal in expertise on the topic, and their interaction provides a network-centric approach to exploring the topic at large and eventually focusing the broad issue into primary nodes of agreed importance. The primary outcome is shared agreement across the group on the nature of the problem. Rittel argues that understanding the problem provides a path toward taming it (Werner and Rittel, 1970).

IBIS was a sufficient tool for organizing the flow of argumentation among a group of stakeholders. It furthermore functioned as a computational process for collaborative design (Rittel and Noble 1988). The design keeps participants focused on the primary issues of concern, and functions as a constructive platform so that critical perspectives can introduce new opportunities rather than purely detract from existing lines of argument. IBIS was primarily intended for use in bottom-up participatory planning processes and intended for organizations tackling wicked problems. This work was continued by and commercialized by Jeff Conklin to benefit organizational strategy and operations as a computational design exercise (Conklin, 2006).

Since Rittel launched IBIS, the field and role of Design has also changed. Design is a professional practice increasingly functioning in the domain of organizational change via design thinking, visualization, modeling, product development, and design strategy (Buchanan, 2008). But beyond organizations, objects play a central role in culture and society, providing a point of entry for Design to elicit radical change via niche innovations. To use a human centered design in product development with the intent of scaled impact, it is possible to work at the edges and incrementally move deeper into a process of transformation with iteration of product development (Junginger, 2008). As objects play a central role in culture and society, and therefore value may be obtained through designing dialectically by working between the material object and the social context (Ingram, Shove, and Watson, 2007).

While technologies do not dictate general practice or social organization, but the technology's materiality does set constraints on and offer affordances for use. Particular constraints and affordances can push the social practice in one direction or another, sometimes limiting the perceived accessibility of another form of practice (Leonardi and Barley, 2008). For example, full product prototyping can be considered dangerous within communication because prototypes might contain hidden assumptions, are frequently expensive, and direct too much attention on materiality rather than underlying structures of the problem. Yet it is possible to deepen the exploration of materiality as a theory of change by studying how individuals and organizations work in relation to the materiality of information (Leonardi & Barley, 2008).

Notably, the materiality of information remains absent from Rittel's IBIS model. While dialogue can structure agreement on a problem, this dialogue is abstracted from the material nature of the problem. Aside from the other listed criticisms, a key feature in design practice is the socio-material process of working through a problem, and while this process may be described as the structuring of argument (in the words of Buchanan), it is argumentation through physical engagement. To build upon IBIS and refashion this way of engaging Wicked Problems into a sociotechnical form, Rittel's process must find material means of obtaining, processing, and producing information.

Among most sophisticated post-IBIS information systems, Geographic Information Systems (GIS), have emerged as powerful computational tools to organize and analyze large bodies of information for data-driven decision-making. While this is not the same thing as IBIS, GIS tools have become more complex and there have been extensive research efforts among geographers to use GIS as platforms for collective problem-solving in the spirit of IBIS. This research has generated mixed results as GIS platforms are not designed for users or for a rich diversity of information (Schoder, Putzke, Metaxas, Gloor, & Fischbach, 2014). Certainly, the recognition of wicked problems has greatly influenced GIS technology, but information systems remain generally inept as they forever focus upon discrete variables and a single formulation of a problem (Riechert & Dees, 2014). Among geographers, these projects tend to be most successful when engaging problems that are easily spatialized such as natural disaster planning and crisis management (Wu & Zhang, 2009).

It is possible that the design of GIS has failed to change under this new threat, as information technologies quickly becomes muddled with complexity partly due to market forces. The cost of software replication is negligible, and the diffusion of the software is rapid, thus directing the business value into the software design. While it can be difficult to measure 'good design,' one can quickly quantify 'more design' in terms of more features, more data structures, more applications and more everything. Information technology products are additionally inclined toward complexity because the generation of the IT platform provides an opportunity to develop additional tools or products, whereas the technology functions as an infrastructure for business enterprise beyond customer acquisition (Kahin, 1993).

As a point of entry into creating a new approach for GIS, the issue of materiality has begun to recently receive more attention from within the information systems community and from within Geography. In addition robust areas for deep research concern the socio-materiality of information management systems (such as IBIS) include the political nature in which these systems are created and performed, the role of time, and new methods that can overcome linguistic limitations (Cecez-Kecmanovic, Galliers, Henfridsson, Newell, & Vidgen, 2014). Furthermore, we can learn from Rittel's work within IBIS, as he demonstrated an approach to connecting product level design and large-scale impact through the design of an information system by incrementally stretching multi-stakeholder dialogue over time, and carefully working through an evaluation of its components toward the creation of consensus.

3.3 The emerging threat of geographic disinformation

The scale of disinformation within social media platforms such as Reddit, Twitter, and Facebook have been a common conversation since the American 2016 election. However, the role of disinformation within geographic information systems has been largely ignored, though evidence suggests the problem exists. In 2015, I met Adm. Michael Rogers, the commanding officer in charge of the National Security Agency (NSA) and the US Cyber Command (USCYBERCOM) while participating in some workshops at the National Defense University. When asked "what is the biggest threat," he paused, and said "I worry that the basic data we rely on for day-to-day use is manipulated without us knowing it." Months later it became public information that the U.S. elections had been compromised by disinformation.

Disinformation has continued to sew itself into the most mundane aspects of our lives, such as our maps. In June 2019 millions of business listings of Google Maps data were discovered as intentionally false, perhaps as much as 8% of all Google map data (Copeland and Bindley 2019). In the last year, Chinese hackers have accessed American satellites and utilized machine learning techniques to modify satellite imagery, often the primary source of GIS data (P. Tucker, The Newest AI-Enabled Weapon: 'Deep-Faking' Photos of the Earth 2019). As the problem continues, the National Security Agency (NSA) has expressed concerns that insecurity in satellite systems and data transmission is leading to the manipulation of GIS data, which may potentially conduct great harm upon agriculture and food security (P. Tucker, The NSA Is Studying Satellite Hacking 2019). Government and some private sector companies who rely upon satellite imagery as the source of information for algorithm training, testing, and analysis can no longer trust their models. As algorithms also become a target for manipulation, the problem quickly compounds (Calypso AI 2019).

The use of satellite imagery used to create map data is heavily connected to human labor. In 2009, I oversaw a series of service centers in East Africa that would confirm/reject automated maps from images. Today that same company with whom I was employed sell's its services as a provider of custom labelling for A.I. training data. Yet this strong human element is also insufficient, given the scale of hacking and manipulation of satellites by foreign actors (Menn 2018). If the original source imagery is compromised, then all the resulting geographic data is also flawed. If the satellite manipulation is realized and corrected, the changes may not make their way through the layers of databases, teams, companies, files, hard drives and circulated images. Evidence suggests that geographic data is under threat, influencing quantities of persons and institutions to make decisions with no ability to calibrate the authenticity of the most basic levels of information. Though disinformation in geographic information systems is an emergent problem, it is very real, and the consequences are severe.

3.4 Geographic information systems as domain of product design research

A geographic information system is an assemble of digital data and tools concerning earthly phenomena represented as maps and manipulated through map making. Every GIS relies on an underlying database and discrete rules, properties, and relationships. These data models are translated for users into visual representations through an interface.

The roots of GIS are fragmented, but the largest strand of GIS development in history can be attributed to the work of an architect at North Western University in Chicago, Howard Fisher, in 1963. Relying on graphic overlays, his initial GIS prototype SYMAP, was capable of generating contour maps, overlays, and choropleths. His research soon caught the interest of Harvard University. Harvard procured grants from the Ford Foundation, the National Science Foundation and other federal departments, and Fisher relocated to the Laboratory of Computer Graphics at the Graduate School of Design in December 1965. GIS was developed according to the Cartesian coordinate system and could not produce a completed display. Instead, layers of symbolic data were printed on transparent sheets and arranged by designers to form comprehensive data visualizations (Chrisman, 2006). The interaction between internally constructed images that exist purely in a mental space and physical graphical images such as maps provide opportunities to gain new insights. Partly an asset, and partly a hindrance, the ability for an individual to gain insight from a new image is dependent on the ability to associate that image with familiar images or patterns. Where gaps exist, unexpected discoveries may emerge (Peuquet, 2002, pp. 95-120).

In an increasingly complex world in which large quantities are information are rapidly structured and communicated, mapping plays a fundamental role in the orchestration of information for decision-making. The rise of computation has blurred distinctions between environments and conceptions of realities, giving rise to a demand for new vocabularies, rules, and conceptions of maps. Computing offers opportunities to make these new forms of knowledge broadly accessible, to modify the temporal constructions of knowledge representation, and to shift maps away from 2-dimensional surfaces (Peuquet, 2002, pp. 152--156). By "channeling a human-centered approach to representation in a computing environment" it is possible to better understand how computers as tools can aid in complex problem-solving and offer new problem-solving capabilities.

Mapping with computation redirects the longstanding focus on symbols and abstraction that have dominated cartography as GIS provide greater degrees of freedom to the user through customization. The user of GIS becomes the designer for a body of information and GIS offers the opportunity to integrate, filter, and analyze a diversity of information and to represent that information in a broad palette of colors and graphic outputs. Yet as GIS is created with a series of default settings, by necessity, many of the default settings tend to dominate cartographic design given that many users are not familiar with other possibilities of representation or the means to create alternative forms (Peuquet, 2002, pp. 209-211). The notion of default GIS settings may provide an interesting point of entry for the design and exploration of alternative GIS configurations, as it theoretically possible to

More advanced users may not be restricted by the software but are instead restricted by the experimental nature and massive scale of information databases from which GIS maps are created. Users may not begin a map in search of a question or with the intention to convey a particular message, but rather experiment with the availability of data, and the available options pertaining to graphic language, color, and symbolism. This might be a valuable process for knowledge construction, but given what is understood about the ways in which people organize knowledge through patterns, categories, and mental maps, there is much opportunity to expand the limited capability of GIS and to better order the diffusion of information that affords mapping (Peuquet, 2002, pp. 209-211).

The primary reason that GIS is restricted by information database design is because the "data representation drives the visual representation." Data – raw fragmented observations of the worldly information - attributes and locations are formatted across grid cells and relative or discrete units of measurement and time establish relations. Notably, since the 1970s onward, the formatting and implications of these structures – such as explorations in cognitive representations and representational possibilities- developed without and underlying theoretical framework (Peuquet, 2002, pp. 210-213). Extensive research conducted in the meanwhile concerning GIS has found that the more internal components such as, database formatting and algorithmic constructions, and external components, like interface design and workflow, of GIS mirror cognitive representations, the more efficient and effect human-to-machine communication can become (Peuquet, 2002, p. 218). Current attempts to reconcile this concern focus on crafting a multiplicity of representational schemes.

The front-end of GIS software has also imposed restrictions by relying on the graphic user interface (GUI). The GUI provides visual representation of abstracted data and bounds this abstraction with the physical frame of the GUI hardware. It can, however, synthesis diverse graphic media to formulate new types of representation. More recent research efforts to go expand the limitations of the GUI include virtual reality to insert the user into the information landscape and augmented reality, to project information interfaces into the real world by relying mobile and wearable computers. Thus far, little research has focused upon how these new interfaces, and how the design of information represented by these interface technologies, corresponds to an understanding of human cognition. In contrast, the majority of research on GIS interfaces has been intent to better transfer the experience of paper maps to digital screens. This method is clearly erroneous, because working through an additional degree of abstraction; the research is intent to make a model of a model (Peuquet, 2002, pp. 220-228).

To step away from GIS into the domain of information systems for social change, the limitations of information technologies to motivate and inspire human action have been identified and techniques have been adapted such as user experience design, gamification and crowdsourcing. Open source communities have been identified as robust domains of feedback and interaction between participants to stimulate spontaneous action. Mobilization is also spurred by the alignment between political conditions and information tools, such as Twitter and the Arab spring, or the development of violence mapping system Ushahidi and Kenyan political violence. By extension, explorations in user experience design have identified increased socio-political participation driven by information systems when the design affords enriched experiences, transparency, and high interactivity (Heyleighen, Kostov and Kiemen 2013). Paul Pangero has made similar arguments in the proposal for conversational information systems. According to Pangero, transparency in frames and values must be articulated and exchanged among participants and through technologies to drive collaborative, responsible, and innovative outcomes (Pangero October 2016). Through conversational interaction design, information systems afford immediate feedback in alignment with clear goals. While the limitations of information systems can be overcome through conversational design, the fundamental element is the articulation of the challenge. Ambiguous and poorly defined problems do not afford a technological call to action through feedback, though a defined problem and goal enable stakeholders to best apply the value of their technology, participate, get feedback, and move forward.

3.4.1 The Interface and User Experience Design of Modern GIS Platforms

The design of a majority of GIS systems is limited to single user interactions and a shared database. Historically this software has been built in C languages or Java, ran on a single workstation, only in advanced institutions pulled data from a shared database. This traditional design, including products such as ESRI ArcMap and the open source QGIS, a GUI with various tools and typically an interface for making SQL queries. Over the last ten years, as GIS moved into web environments, complex applications, such as an interface may include tools for the drawing of vectors to designate geometric areas of interest. More advanced and recent tools include the ability to style cloud-based tile maps using an HTML-like markup language or WebGL (See Figure 19 for examples).

These systems run exclusively on highly structured data within table or database schemes, with latitude and longitude coordinates and strict requirements on the design structure.

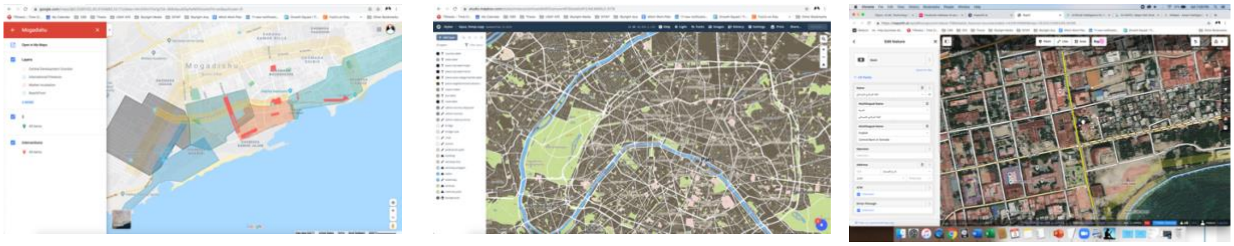


FIGURE 19 (LEFT) CUSTOM DATA LAYERS WITH GOOGLE MY MAPS, (CENTER) CUSTOM MAP STYLING IN MAPBOX USING WEBGL, (RIGHT) FACEBOOK MACHINE LEARNING MAP CONTENT CREATION APPLICATION.

Modern cartography within large scale systems with integrated machine learning tools that are commercially are rare. Among the few solutions on market are a mapping platform by Facebook, that uses human labelled data of satellite imagery to train algorithms (See Figure 19 Right). Notably there is no check for data quality on such maps and the type of data themes currently established for widespread application such as house or road are incredibly generic. Much of the world remains unmapped, and prospectively, vast quantities of human settlements will remain outside of the grasps of the algorithms on account that the training is determined by populations with little ability to assess global human settlements.

If an organization is reliant upon large volumes of poorly structured, the use of standalone applications is readily abandoned for custom enterprise solutions. A more common modern approach for organizations is non-intentional descriptive cartography via dashboards. Such dashboards (AWS Kibana, Quicksight, etc) utilize cloud hosting (AWS S3), with data transformation layers to organize data into SQL and NoSQL solutions (data warehouses and data lakes). These dashboards provide the opportunity to run queries on the data and rapidly visualize the data with stock basemaps and visualization layers such as heatmaps. Likewise, the use of APIs is frequently a key resource in moving the data from storage to visualization. This infrastructure design is sufficiently similar to the design of web-based tools such as Google Maps, though the components are different.

Notably, this cloud based, data-driven approach, forces great design expertise in software architecture to access and manipulate data for visualization, yet does not directly imply a role for design in the act of visualization and engagement. The sophistication of cartographic design is contingent upon the goal of the maker. If utilizing off the shelf plug-n-play components, such as AWS with Kibana to rapidly visualize and map large quantities of data utilizing SQL - the result is highly constrained. A map is created, but it fails to provide any insight into the data as a thing. Likewise, there is little to be done to create a map as a creative artifact. The end product is little more than a defacto and glib representation of narrowly determined locations and tags. For those who lack the technical expertise, various commercial products abound to facilitate cloud-hosted map-based data visualization. All such tools are highly limited in their ability to provide nuanced engagement with the information.

To access this kind of sophisticated treatment of data for cartographic purposes, one must possess niche technical skills in software engineering, have access to others who can provide these skills as a service, or rely upon limited commercial solutions. Market demand for the digital transformation of organizations and applications of data sciences looms large, though cartography is a niche element. A range of business models have emerged to capitalize on this demand, through pure consulting (McKinsey Digital), consulting services with off-the-shelf technology integration (Accenture), and Software and Platform as a service models, and through the creation of internal technology development cost centers. Notably, the ability to create a technology stack for the transformation and visualization of data is not necessarily the same as cartography. Implicit in these services is a raw faith in the data - that this computational representation of the world is a sufficient and real thing that can be twisted and manipulated into insight.

3.4.2 GIS software as a material

Peuquet's concept that human cognition and GIS design must be more integrated is congruent with Suchman's assertion that interactions with technology should not be predetermined by planned use, but rather by design according to situational actions and environments. Abstraction in design should permit us to re-orient ourselves (Suchman L. A., 1994). Design for situated action and cognition in GIS has precedent. Foremost among known examples is Hutchin's account of Micronesian Navigation (Hutchins, 1995). Hutchin's asserts that anthropological methods applied to ship navigation can produce insight into the psychological processes that inform the technology design as conditioned by cultural contexts. In so doing, Hutchin's describes a navigational instrument requiring the user to lay down upon the boat and physically engage the instrument so as to sense the given directions through physical contact.

According to Hutchin's, the Micronesian's cartographic map is the only level of information extraction, his technology operates in relationship to the cartographic map to guide decisions – where in contrast, western navigators rely upon external models such as maps, compasses, and sextants – undermining their own cognitive map formation. Consequently, their geographic decisions require an additional level of abstraction and therefore usurp a greater degree of challenge – and limit – to understand location and place (Hutchins, 1995, pp. 223-225). Another example of material cartography determined by culture is the Inuit wooden carvings of landscapes, highly detailed three-dimensional maps of coastlines used for navigation. These maps are not visual aids but are to be touched with one's hands. The forms appear highly abstracted to the eye, but lend nuanced information to the fingertips, perfectly acceptable for use at night (Papenek, 1995).

In the domain of computation, there has been a large quantity of research to generate tangible and immersive interfaces for GIS. Initial research by Davies and Medyckyj- Scott in the early 90s (during the same era of much research concerning critical cartography) found that GIS should move away from configurations of expert systems and that with standard GIS packages such as ESRI ArcMap, extended training did not prove useful for current users (Davies & Medyckyj-Scott, 1994). Efforts building on this research did little to change the interface or interaction of the user, but influenced by the emergence of the World Wide Web, were concerned with data standards, reliability, and exuberance for immersive virtual reality technologies (Rhyne, 1997).

After more than a decade of research, virtual engagements with data representation have become more sophisticated due to new developments in XHTML, Javascript, and server configurations though user interaction with data as material have not progressed since the 1970s with an overt reliance on archaic SQL queries awkward interface design. The fusion of panoramic video and augmented reality to understand environmental landscapes has proven effective as a means for multi-stakeholder communication on issues of sustainability though such efforts are entirely experimental (Ghadirian & Bishop, 2008). Unexpectedly, new challenge has emerged with such sophisticated interactions as highly detailed renderings and mockups reduce the range of user feedback while interaction with vaguely defined objects elicits greater variance in information across stakeholders (Brandt, 2007). Research in the realm of computer vision has generated interesting breakthroughs for the digital modeling of environments that provides an opportunity to engage the materiality of GIS in a new way, with new user interactions and configurations, yet this research is in its infancy and not common within GIS development among geographers, planners, or information designers (Kamel Boulos, Blanchard, Walker, Monterro, Tripathy, & Guiterrez-Osuna, 2011).

3.4.3 GIS as a social platform

Users of GIS must recognize and understand that GIS is not merely a tool for graphically representing a database, but as a system, is an infrastructure for an organizational culture and way of thinking that informs all decisions. In consequence, new conceptions of GIS demand and instill new ways of thinking and acting. In recognition that GIS shapes political and cultural spaces as much as its users rely upon it to make decisions about the modeling of the physical environment, research that builds upon the social construction of GIS can push the technology into areas that have been previously underexplored with significant social consequence (Shepard, 1995).

Unfortunately, GIS remains an 'expert system' that has thus far been generally complicit within a worldview of expert decisions regarding social policy and planning. Integration of GIS in community processes tends to focus on "middle class politics," a reliance on technical vocabularies and conversations concerning infrastructure, and a workflow based on efficiency rather than social good (Baud, et al. 2015; Lingel and Bishop 2014). Just as frequently, when social researchers apply ethnography to GIS data construction, the quality of data construction is shaped and determined by the ethnographer and creation of qualitative data as layers creates distortions in scale.

The decisions made using expert GIS systems have had large-scale global implications. Historically, many GIS tools that informed the urban planning and development in the United States (and then appropriated elsewhere) were initially funded and developed for military applications. These technologies then influenced urban and community development across multiple sectors, such as transportation, crime, and crisis management (Light, 2003) In more contemporary efforts, the push to create Smart Cities, cities that are first built as large-scale technological solutions for sustainability and technology before being populated, can be attributed to information systems and information system culture. For example, the city of Song Du Korea is constructed entirely using data-driven decisions using building simulation and computational logic, collapsing the role of the citizen within city making (Halpern, 2015). The institutional complement of information systems shaping urban development is exemplified by the dominance of massive corporations such as Siemens and IBM in the push to create global smart cities

(Townsend,2013).

There have been efforts to build and apply GIS within communities as participatory processes for social change. For example, the integration of community participated mental mapping exercises with GIS systems provides opportunities for new power constructions and dialogue (Brennan-Horley, Luckman, Gibson, & Willoughby-Smith, 2010). Furthermore, the fusion of community engagement and ethnography in GIS development and deployment has led to the creation of widely supported social development policy and can give voice to underrepresented groups (Skinner, Matthews and Burton 2005; Bagheri 2015). It has been found that the design of the GIS utilized in participatory methods greatly informs the sustainability of community initiatives, as it is essential that the community can utilize and continue to build upon the GIS after any experts leave the project. Many open source GIS solutions, touted, as friendly and non- expert, are equally prone to failure without expert guidance (Panek & Sobotova, 2014).

Opportunities to modify the conception of GIS in relation to social processes of change are for GIS to embody the shifting terrain of data ecologies (Walker, 2010). This may not necessarily require new organizational schema (such as in relational database architecture) but conceptualizing the inputs and outputs of a GIS system. Embracing the materiality of the information system in relation to the widely distributed technologies that channel the flow of information in society, GIS may be reconfigured for social practice.

A GIS attuned to social practice gives material form to presently abstract social relations, implementing many the assertions by Manzini in how a designer may facilitate "Design, When Everybody Designs" (Manzini, 2015). In this manner the visualization process becomes a tool for community building as the GIS can facilitate ongoing processes for the transformative exchange of knowledge and values. Such processes can amplify unheard voices, create new platforms for narrative construction and sharing, and lead to the reconstruction of community and personal identities through hybrid realities. Affectively, via GIS, information may not only be designed, but tools for others to design their own information and exchange can generate a sense of place (Manzini, 2015). Creating a sense of place through digital culture, even among socio-materially hybrid spaces, inform and construct normative social relations, and the future unfolding of cities (Forlano 2013; Kelliher, Rikakis and Lehrer 2013).

Today, the role of community within geographic information is less ambitious and restricted to the licensing of software and the building of open source communities. The most well-known open source solution is Open Street map, a visual map and database created by crowdsourced efforts and dedicated teams from around the world. OSM has many valuable elements distinct from any solutions within the commercial space. OSM is constantly evolving and frequently updated via humanitarian hackathons, providing a constant stream of refreshed data. Via open source code, OSM maps are highly customizable and the growing user community has created many novel variations of OSM maps including, but not limited to, maps for handicap accessibility, transportation, hiking and other purposes.

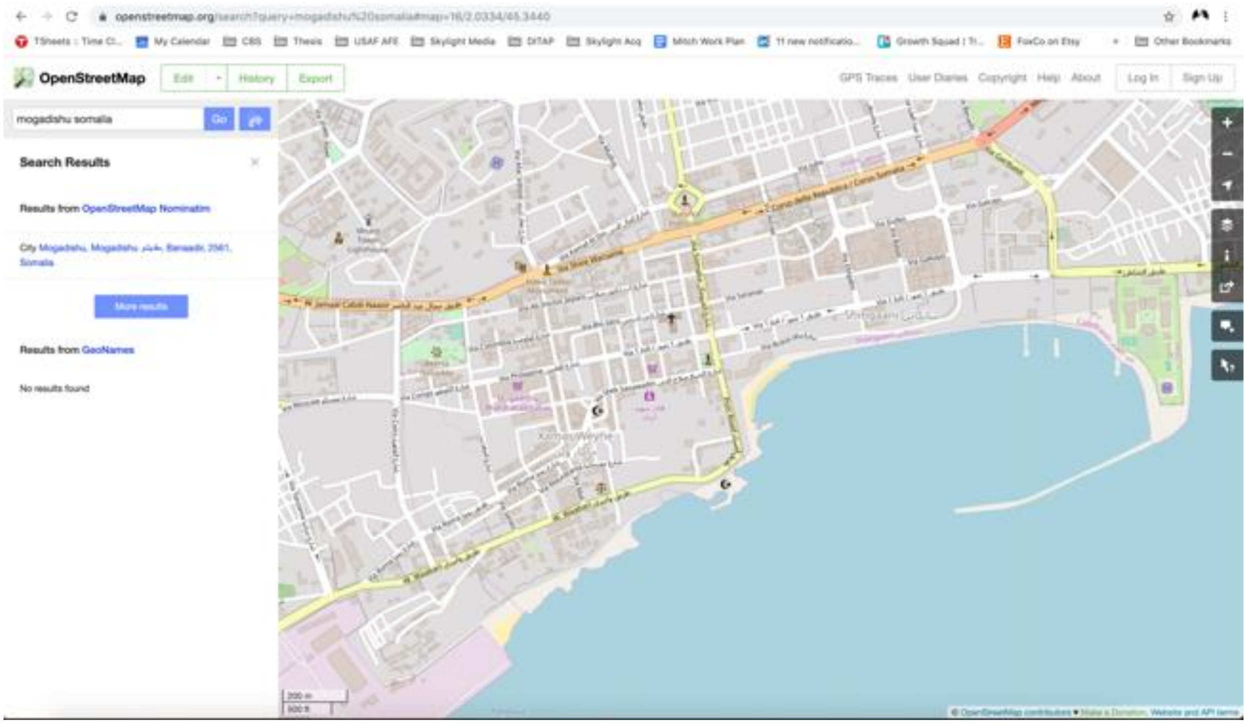


FIGURE 2 OPEN STREET MAP

3.5 Section Summary

While designers within innovation industries are creating products with emerging technologies, the lack of research and insight on disinformation is resulting in the creation of undesirable global consequences with weakened states and fragmented societies. There is a clear demand for design research to take responsibility for this problem and work to develop to new theories and methods on who designers can counter disinformation within their products and organizations. This demand presents an opportunity for action research through venture and product creation.

This section was a literature review on the origins and mechanics of disinformation in modern technology products. As a byproduct of the innovation ecosystem, I have additionally reviewed the state of research literature concerning the role of designers and design processes to counter disinformation through product design. Presently, proposed solutions to disinformation function purely at levels of national policy or granular algorithm engineering, with no research on the relationship of disinformation circulation and workflows, data sourcing, or data analysis. The research and theory on combatting disinformation within design literature is limited to arguments for use of service design methods and human-centered design techniques (Tonkinwise, 2017; Facebook 2017; UX Collective 2019).

The value of design through entrepreneurship to combat disinformation remains completely unexplored. Disinformation is not an area of focus in any design research concerning business innovation or machine learning products. Furthermore, as disinformation is becoming an increasing risk within geographic information systems, this software presents an opportunity for research through the design of new GIS interactions, capabilities, and experiences. This work benefits from insights drawn from Horst Rittel's critique of design methods and from his own experiments in the development issue-based information systems (Kunz and Rittel 1970). Research through design also benefits from the study of design for machine learning through service design and machine learning as a material.

Section 3: The Problem

3.1 Section Abstract

The design process has a proven value for creating products and services. Designers are consistently sought within innovation industries to supply value for strategy and refined execution of goods and services. Entrepreneurship benefits from design processes through better management of ambiguity to satisfy customer needs. Through the imposition of new ideas and values, design entrepreneurship can function as a force of radical social change. Yet most designers are not equipped to succeed as entrepreneurs and many products are designed that do not succeed to provide positive social value. Subject to the push/pull dynamics of innovation ecosystems, designers meet market and consumer demands through their products, with little ability to connect long-term systems thinking with short-term design thinking and production.

Disinformation is a byproduct of designing within the innovation economy. It is the manipulation of materials to create and circulate false information with the intent to cause harm. Disinformation is exacerbated through machine learning products that create insular echo chambers for information consumers. If designers were more adept to design products for systems-scale challenges, disinformation could potentially negate within products. Right now, there is no information within design literature on how to combat disinformation.

Therefore, I ask, how can designers inform the creation of new businesses and use those businesses to create new products with long-term social interests in mind? Through their companies and products, how might designers face the challenge of disinformation, and design their work to mitigate this threat?

3.2 The Research Question

As the companies and products produced by innovation ecosystems have produced the global threat of disinformation, how then may entrepreneurs apply design processes to create ventures and products to counter disinformation and afford more positive consequences?

To research this problem, I have broken it into three components:

3.2.1 Research Component One: How may one design a new venture within the modern innovation ecosystem?

Applications of design processes can help individuals and companies make sense of complex problems, rapidly develop new ideas, and pioneer new solutions. Designers have thus done much to inform a range of strategies for businesses and initiatives for social change (Brown 2009; Bertola and J.C. 2003; Muratovski 2017). The design process can encourage learning through iteration and structured methods, while facilitating new interactions and dialogue (Junginger 2006, J. Forlizzi 2007).

The practice of design to manage ambiguity asserts a clear value for design to entrepreneurship. Yet designers are often ill equipped to develop their work through entrepreneurship, which requires other kinds of knowledge on business conditions such as organizational, financial, and social factors (Nielsen and Christensen 2014). Entrepreneurs quickly must navigate complex decisions on recruitment, legal structure, reporting, communications, processes, and goals. In recent years, design methods have enabled entrepreneurs to focus on customer needs while the use of Lean methods have been heavily adopted to manage these business decisions. A lean approach may be summarized as the fastest way to deliver value to a customer (Ries 201; Batova, Clark and Card 2016; Mansoori and Lackeus 2019; Solaimani, van der Veen, et al. 2019). Reliance on such reflexive methods asserts a significant influence by the innovation ecosystem, regional markets of actors, institutions, resources, and actors who exchange and inform ideas to encourage new models of production (Schumpeter, 1934; Bertola & J.C., 2003; Katz and Wagner 2006; P. Romer 1994) This concept has been appropriated and reproduced as the entrepreneurship ecosystem, the intentional effort to create conditions for innovation to drive economic growth, though it is a difficult model to prove (Katz and Wagner 2006, Nadgrodkiewicz 2013, Krugman 2013).

Research gaps concern how a design process may inform and benefit entrepreneurial ventures within innovation ecosystems. While lean methods may provide the entrepreneur a path deliver the fastest value to the customer, the speed of value is not the same as the best value, the best over time, or the best solution for regional, environmental, or macro-economic conditions. A design process should enable a more strategic approach to entrepreneurship, not only through customer validation, but through consideration of additional factors. How, exactly, a design approach may better manage business decisions is unclear. How, design may be used to solve a problem such as market strategy, purchase price, recruitment, or internal communications is uncertain. Some kind of hybrid approach utilizing design and lean methods is viable, but the nature of that approach is unclear. How then may design inform the development of a new business venture?

Yet the composition and function of the innovation ecosystem is not a component of design methods or the design research discourse. The reviewed literature concerned with business has descriebed design research as concerned with interactions, materials and ecosystems (Junginger 2006, J. Forlizzi 2007, Muratovski 2017). Research and interactions with multiple stakeholders, social institutions, and models of social dialogue have been specific to the domain of design as social planning (Manzini 2014; 2015). The scale of questioning is thus broad, on how may an entrepreneur utilize the theories and methods of design to better leverage and contribute to the innovation ecosystem?

In particular, the relationship between design and lean is well suited to investigation. Lean methods are heavily informed by the composition of the ecosystem, while lean is also the means for most entrepreneurs to better manage the demands of venture creation. Designers are sought by innovation industries, on account of the value they provide to business and product development, but the intersection between the strategic learning value of design and the reflexive feedback driven process of lean is less understood.

3.2.2 Criteria Two: How can design entrepreneurs better engage and manage disinformation in the world?

Theories on the design process within products, complex systems, and businesses have asserted that design can supply clarity, iterative learning, and creative leaps through hybridized rational and non-rational methods. It remains to be understood how design methods can better inform venture creation and how design entrepreneurship through products can affect problems at a systems level. Yet the discourse on design is lacking in the domain of combatting disinformation within design of things, processes, and businesses. How then may designers better counter the threat of disinformation in the world? If they cannot reduce it, can they change their processes or innovate new products to better account for disinformation and manage it within their works?

Disinformation is an urgent concern for designers, as it is a byproduct of innovation economics and design choices. Disinformation and misinformation have a long history, but their effects have been grossly multiplied in the recent era within social information systems and machine learning tools to create echo chambers and social fragmentation (CEPA; Thompson and Lapowsky 2018; Tenove and McKay 2018; Bradshaw, Neudert and Howard 2018). Current efforts concerning content moderation, machine learning, and inoculation strategies have not proven sufficiently effective to remedy the problem (K.-C. Yang, O. Varol and C. A. Davis, et al. 2019; Candogan and Drakopoulos 2017).

As disinformation functions through the manipulation of digital media, information curation, interface and algorithm design, this is a domain ideal for design research. The emerging issue of disinformation within geographic information systems deserves attention, as GIS technologies are a defined link between human action and systems level transformation.

An entrepreneurial approach to this problem is parallel to Manzini's belief that designers must work to reinforce democracy, though participation in the free market is perhaps not what he intended (Manzini 2017). Design entrepreneurship, as a force of radical change, directly addresses Tonkinwise's argument that designers must utilize a hybrid approach of design for services, products, interactions and must also confront the complex power structures of the innovation industries (2017). The entrepreneur, as an agent of Schumpeter's creative destruction, may – in some but not all circumstances – negate the power of the dominant market player and force a transformation of the market.

3.2.3 Criteria Three: How can design entrepreneurs better apply systems-level insights to human-scale product design to mitigate threats such as disinformation?

Designers who supply a structured approach to iterative learning, new models of dialogue through products, and human service experiences are driving social change through business and economics (Forlizzi and Zimmerman 2013; J. Forlizzi 2018). Design entrepreneurship also provides new products and processes but can supply more radical levels of change with the introduction of new solutions, new frames, and new meanings (Hagedoorn, 1996; Roberts, 1998). This is possible through the application of non-rational design processes, based on motivations and dreams which enable the entrepreneur to drive systems level change (Spinosa, Flores and

Dreyfus 2001; Zhang and Van Burg 2019). In this respect, the ability to make bold, creative leaps distinguishess the design entrepeneur from those entrepreneurs trained to derive solutions through concensus or learning processes (Roberts, 1998).

The modern context for design entrepreneurship is the innovation ecosystem, or perhaps more specifically, the entrepreneur ecosystem as discussed by Schumpeter and Romer. The reliance on innovation ecosystems to generate new social and economic opportunities places pressure upon entrepreneurs to drive systems level change (Katz and Wagner 2006). The design entrepreneur, in this context, maintains both an inside and outside status. Designers within institutions are valued for their ability to drive learning and systemic processes. Designers outside of institutions are valued for their ability to inject new ideas and offer new products or services to the market.

It is yet unclear how the design entrepreneur is to leverage the innovation ecosystem to create value through products and services for systems level change. Those products and services must function as multipliers for a particular kind of value or insight, as their adoption and circulation enable the disruption or processes of creative destruction described by Schumpeter. According to Romer, the free circulation of these works, in collision with the works of established industry and the resources of the city, are fundamental for leaps and transformation so that these ideas may grow and take root.

Yet how exactly does the design entrepreneur do this? How does one strategically ensure their work and their effort creates the value multiplier sought? How does one apply these concepts to achieve multiple goals through venture creation, product design, and systems impact?

3.3 Section Summary

As the companies and products produced by innovation ecosystems have actualized the global threat of disinformation, how then may entrepreneurs apply design processes to create ventures and products to counter disinformation and afford more positive consequences? To research this problem, I must understand how design processes may inform new venture creation within the context of innovation ecosystems. I must research how design processes may be leveraged to counter disinformation within products. And then I must draw on those insights to better understand how product-scale design may benefit from systems-level thinking to inform positive downstream repercussions. In the next section I will discuss the methods, the field, and research decisions to examine these questions.

Section 4: Design Research Methodology

4.1 Section Abstract

In this section I articulate how I approach the problem how the design process may be applied create new business ventures, to combat disinformation, and to ensure the products created by these ventures yield positive consequences in the world? This problem is contextualized by the pressures of innovation economics. Research consisted of systematic inquiry through the practice of design to develop insights and new hypothesizes, to add knowledge the field of design.

This research was conducted by making – by design. To design objects and processes is a form of action research on what the world “could” or “should” be. To research by design is to also recognize the value of insights generated through non-rational, creative leaps (N. Cross 2006). Unlike a scientist, a designer is less concerned with what is likely, but is attempting to impose a particular vision into the world, to change the world into something as it *should* be (Buchanon 1985).

The knowledge of design is primarily captured through the artifacts of making. The design products were informed by the unique challenges of disinformation, personal expertise, and the responses of stakeholders throughout the innovation ecosystems. The generated artifacts include a range of software products, a code repository, a legal business entity, an archive of internal business communications, marketing materials, internal strategy documents, extensive sketches, video and photographic records, field notes and a code base located on GitHub with multiple releases of software. The design outcomes were assessed according to the success of the products and processes to influence those stakeholders and conditions engaged throughout the research processes and relative to satisfying the demands of the research questions.

To conduct research, I have identified the Double Diamond framework as the design process most consistent with my approach to designing. The double diamond places emphasis upon divergent exploration and synthesis before the exploration and development of a solution. This framework was selected on account of structural alignments with lean methods to better inform venture creation. Application of the double diamond is a reflection of praxis. Another distinction of design research is that praxis can be considered a path for reflection through action (Crouch and Pearce 2013). To apply the design process, I have described my own framework for conducting divergent design research, built over a decade of reflective practice as the means through which I apply action research.

Research was conducted between 2014-2018 in three different domains. The first domain was an investigation of the Pittsburgh innovation ecosystem and rapid prototyping of GIS products as informed by the engagement with the ecosystem. The second domain was the creation of the company and GIS product Symkala. The third domain was a collaborative software design effort, called Geo4Nonpro, a GIS platform intended to support the global nuclear nonproliferation community.

4.2 Design as a Research Method for Knowledge Production

In the last 100 years, design has radically transformed in definition, scope, scale, and identity. It has become less about aesthetic form and function, and it now constitutes various abilities assembled to resolve ill-defined problems. It has firmly taken root as a means by which individuals and groups can strategically structure themselves by diverse methods to shift the conditions and objects of material and cultural production. While design has long held a foothold in arts, sciences, and cultures of production, the exploration to build meaningful engagements with these domains – outside the expectations of positivism – has situated design as a fusion of experimental thinking and technological culture. Today the role of design is not mere tradecraft or problem-solving for known problems, but to borrow the words of Richard Buchanan, to "combine theory with practice for new productive purposes" (Buchanon 1992).

For over more than half a century, designers have explored various aspects of design as a form of knowledge production. Unlike science, wherein the goal is to utilize a rational framework to understand the natural world, Simon's conception of Design is "the science of the artificial," whereas design is a way to understand and create insight into that which does not exist and can be made to exist (H. Simon 1969). The designer is not entirely an expert into the science of things, but build insights through experimentation with materials, phenomenological interactions, and observation. Through this process, the designer constructs an argument on the composition of a particular, unstructured problem, building on a broad view of the nature of design, its methods, materials, and principles (Buchanon 1992).

The type of knowledge produced is commonly referred to as "tacit knowing," borrowing from Michael Polanyi's assertion that not all knowledge is knowledge that can be codified or communicated (Polanyi 1966). This is not the same as the accumulation of technical knowledge, but described by Schön as knowing-in-action, reflection-in-action, and reflection on reflection-in-action (D. A. Schön 1987). The creation of design expertise is thus the development of expertise through practice, on the ability to move from maintaining the "theory of intervention," to a more creative knowledge, the "theory in action (Argyris and Schorn 1974)." Notably, technical expertise is not the core of knowledge gained through practice. Rather reflection-in-action and "on action," demands that the practitioner can build a new understanding to inform actions while engaged in a problem. This ability to reflect and act, as a means to work through a problem in real time is at the heart of knowledge built through practice (D. Schön 1983).

When engaged with an ill structured or wicked problem, designers do not merely attempt to understand a problem like a social scientist, but designers create processes and generate physical forms that embody their understanding of the world, or a possible world. These observations are ground in value assertions but are worked through physical processes founded on perception. To design is to make sense of something that is perceived. It is a process for sense making fusing perception, action, and experience, and it generates products to inform and make sense for users (Krippendorf 2007). Crafting human perception and value into a physical form can be defined as an act of knowledge production, or at least, it is the production of information that through validation –, through use – then becomes knowledge. Perception is the epistemological root of design if not all forms of knowledge production. Yet the relationship between perception and knowledge creation is not simple.

Human perception has been a philosophical debate since our most primitive times. Sidestepping the philosophical speculations found in the traditions of Plato and Kant, we can argue that the perception of reality is the interweaving of internal biological systems and the external environment (Winnograd and Flores 1986). The ability for a human to perceive an environment is contingent entirely upon the "fit" between the tools of sensory perception and the composition of the environment. It is only reasonable that biological systems are not capable of perceiving an environment completely but leave a deficit of unobservable phenomena.

Upon recognizing the limits of biological and mechanical perception, an epistemological challenge comes to the fore, as all human knowledge is found not on perception but upon an interpretation of the external world. The long-held Cartesian view – the common rationalist framework - that grounds the scientific method contends with this epistemological problem by stating that human cognition is a mental model and this model can be made more robust through empirical and deductive means of observation. The Cartesian model is not sufficient, however, because it remains reliant on the limited biological mechanisms of perception. It does not propose any other system to validate itself. Fortunately, there are other means to engage and understand the world (Winograd and Flores 1986).

To engage the external world by diverse means with the expectation of acquiring information to construct knowledge is to further recognize that the objects which compose the world must contain information. It is therefore feasible that objects which have been crafted with knowledge can contain knowledge. Just as all knowledge is not obtainable by equal means, not all knowledge can be communicated equally. In the words of Michael Polanyi, "we know more than we can tell" (Polanyi 1966). By extension, it is also possible to not understand a problem in its completeness, even when it is clearly visible because it is composed of unknowns that are contained within. Yet we can look at a problem and have a sense about those unknowns, that compulsion – the tacit knowledge - can guide the direction of engagement. Thus, the incommunicable tacit knowledge can guide one toward the discovery of new knowledge through material interactions (Dormer 1994).

For a designer to shift outside purely rational models, to break open new understandings and execute forms as embodied tacit knowledge is a difficult undertaking. It forces designers to "rethink themselves" and their relationship to the conditions in which they work (Manzini 2009). This rethinking is better articulated as a process of frame reflection, wherein the designer does not separate reflection and practice, but rather works reflexively between them. The intent is not to falsify or validate a particular frame, but rather, to understand the normative assumptions of a particular frame, and thus to take ownership of these assumptions when working through the design process. Frames thus function as a parameter to guide the direction of choices and argumentation (D. A. Schön 1995).

The designer thus continually navigates an uncharted path, choosing where to go and how in a systematic fashion according to the information presently available, the catalogued tacit knowledge, methodological assessments, and by building on previous experience amid unstructured problems. In essence, the designer constructs an argument on the composition of a particular, unstructured problem, building on a broad view of the nature of design, its methods, materials, and principles (Buchanon 1992).

Yet it should be clear that design is not merely information synthesis. It is guided by the search for an ‘opportunistic’ resolution. This procedure is not easy but requires risks and commitment for new possibilities to emerge from previously uninvestigated paths. Designers frequently relying upon processes of sketching and diagramming so as to apply spatial reasoning and visual cognition to generate and make use of intuition (N. Cross 2006). Buchanan further claims that the deliberation and construction of argument distinguishes the designer from the scientist, as the designer has the advantage to concern himself with not what is possible but what is probable, and ultimately lay claim to create what is preferable (Buchanon 1985).

To tightly conform to Buchanan’s claim of design as a system of rhetorical argument, however, negates the tactile and visual component that is central to design processes. In contrast, Nigel Cross asserts that to manage unstructured problems, designers must take action through creative material processes to codify abstract phenomena into communicable terms. The essence of this codification provides the impetus for physical processes such as sketching, and object prototyping to embody and convey knowledge (N. Cross 2006). Designing is a complex mental process that cannot be directly observed and therefore drawing serves as a record of that process. Sketching commonly facilitates the synthesis of disparate elements into a cohesive structure or simply can document disconnected observations. Sketches are products of vision and the state of the designer’s mind at that given moment (Arnheim 1993).

Whereas designers are regularly understood to use sketching to give form to abstract ideas, it is lesser understood that designers sketch to synthesize and give conceptual form to ideas in their minds (Goldschmidt 1994). As tangible artifacts, knowledge may be created and stored through this material interaction, allowing the design process to move forward and backward (Ewenstein and Whyte 2007). When combined with supportive notes, the designer uses the sketch to evaluate if the design process is consistent with the current goals and constraints (Seitamaa-Hakkarainen and Hakkarainen 2000). This process is an attempt to cope with the perceived variables of a problem in relation to unknowns and is clarified through iteration (Chia and Hold 2009).

Freed to think outside of linear pathways, designers can choreograph information into new assemblies and interpretations of information, including forms that do not conform to reason. By holding these paths and assemblies in memory through sketching and prototyping, designers can also rely upon previous experiences in undertaking the design process to uncover new design insights (Schon and Wiggins 1992). The design process allows the designer to not only shift personal understandings of the problem, but to shift the relationship to the problem, and thus to build a plausible line of design argument in a space of unknowns (Lawson 2008). More so, this process of synthesis, reframing, codification, and the production of tacit knowledge facilitates the creation of new insights. Consequently, design functions as a system of abductive logic (Kolko 2010). Through design, the designer can systematically generate abductive leaps to create new possibilities to create a new world.

4.3 The Design Research Process

4.3.1 The double diamond framework for innovation

There are many interpretations of the design process. To date, Hugh Dubberly has methodically identified several hundred in his collection of models *How do you design?* (Dubberly 2008). To conduct research through design, the model I have utilized is most consistent with the Double Diamond Framework for Innovation, a the design process model initially developed by the UK Design Council in 2004 (UK Design Council 2020). The diagram was initially designed to show four phases of design research: Discover, Define, Develop, and Deliver. Through iterative development over the last 15 years, the simple diagram of two connecting diamonds has expanded into the form represented in Figure 3.

This framework was adopted on account that it tightly aligns with the Endogenous development theories on innovation by Schumpeter and Romer. In particular, the Design Council asserts that this model is tightly concerned with social processes to share ideas and collaborate. I selected this model on account that it is also similar to lean methods, with a focus on continual feedback loops between stakeholders and the designer throughout the decision and development process.

Distinct from lean, implementation of the insights created through the instantiation of these principles:

- **Explore**: challenges, needs and opportunities
- **Shape:** prototypes, insights and visions
- **Build:** ideas, plans and expertise

Whereas lean does not have a stage for framing or shaping concepts in advance of execution, the selected design model requires framing and reflection in advance of building. This method was adopted on account of the clear value that such a design process may offer to venture creation, given the multitude of incremental decisions necessary to build a business. Furthermore, the UK Design council considers leadership and engagement as considered critical factors to encourage and diffuse innovation in whatever form it takes through the design process, be it the will to experiment, adoption of new ideas, or the sharing and communication of those ideas with others.

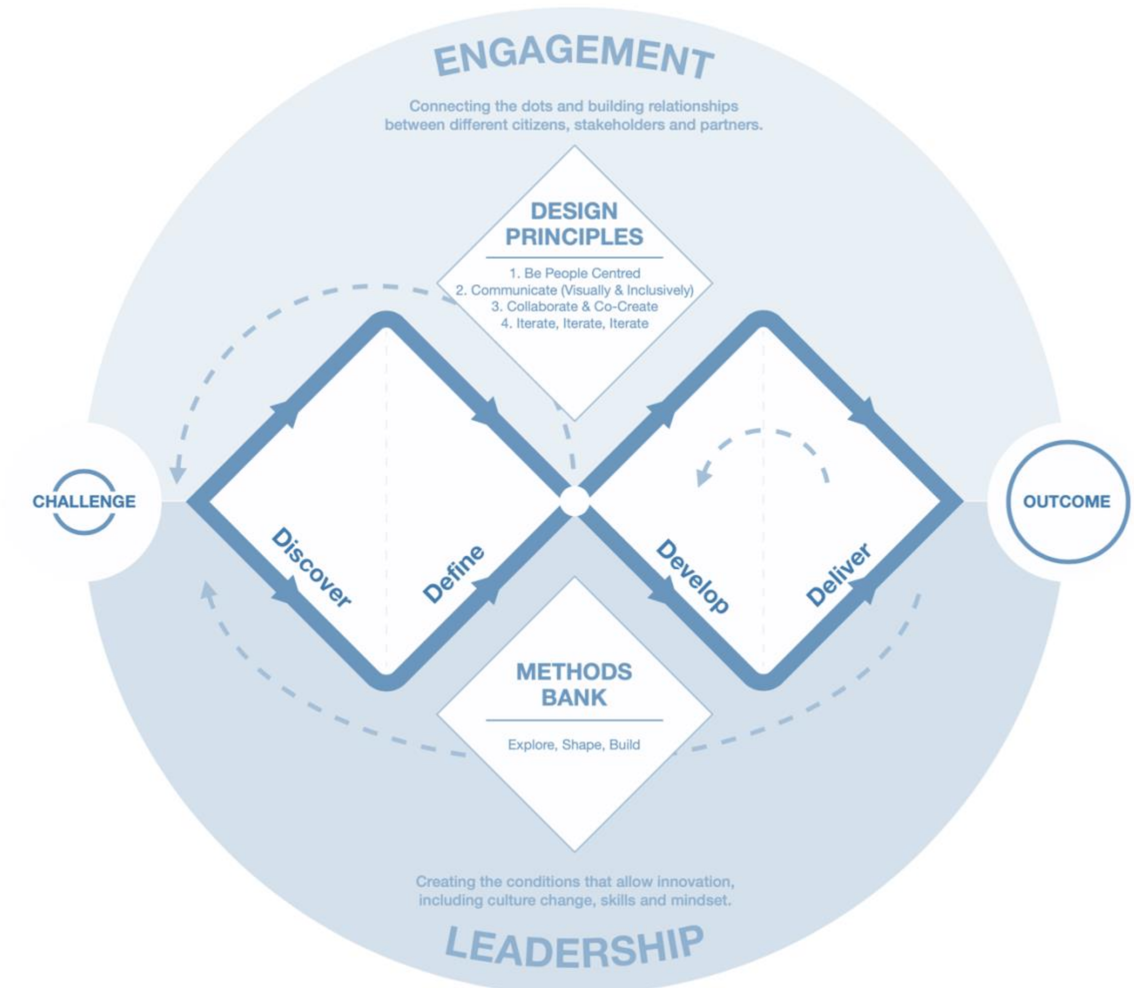


FIGURE 3 THE DOUBLE DIAMOND FRAMEWORK FOR INNOVATION, 2020

4.3.2 A framework for research through design praxis

Design process models such as the Double Diamond and support insights are effective to clarify the overall process of discovery, framing, definition, creation, delivery and assessment. Such process models tend to be vague – and are likely intentionally vague - on the specific methods to be applied within those phases of the design processes. How one conducts design and design research is a reflection of individual praxis, a fusion of thinking and doing. “Praxis allows the researcher to ask questions about the purpose of theory and action (Crouch and Pearce 2013, 43).” Through such a lens, design research is not only action research, but is also an individual investigation about change in personal practice and meaning through interactions over time. Research through the actions of a practitioner is distinct from scientific traditions of research as it is systematic but situational, informed by subjective reflection, and can do much to assert a new hypothesis for investigation and to test the boundaries of the discipline (Archer 1995).

For example, Forlizzi's schematic for product service ecologies in Figure 4 articulates a range of concerns to be identified and addressed by the designer, but such a model is highly abstract, and thus has limitations for interpretation, replication, and validation (J. Forlizzi, 2013). The framework articulates a systematic approach to research and knowledge creation, yet the application of such this design framework cannot be replicated across designers to yield the same result. This framework is not the consequence of clinical trials or similar rigorous instruments of the scientific tradition but has been highly influential in the field of service design.

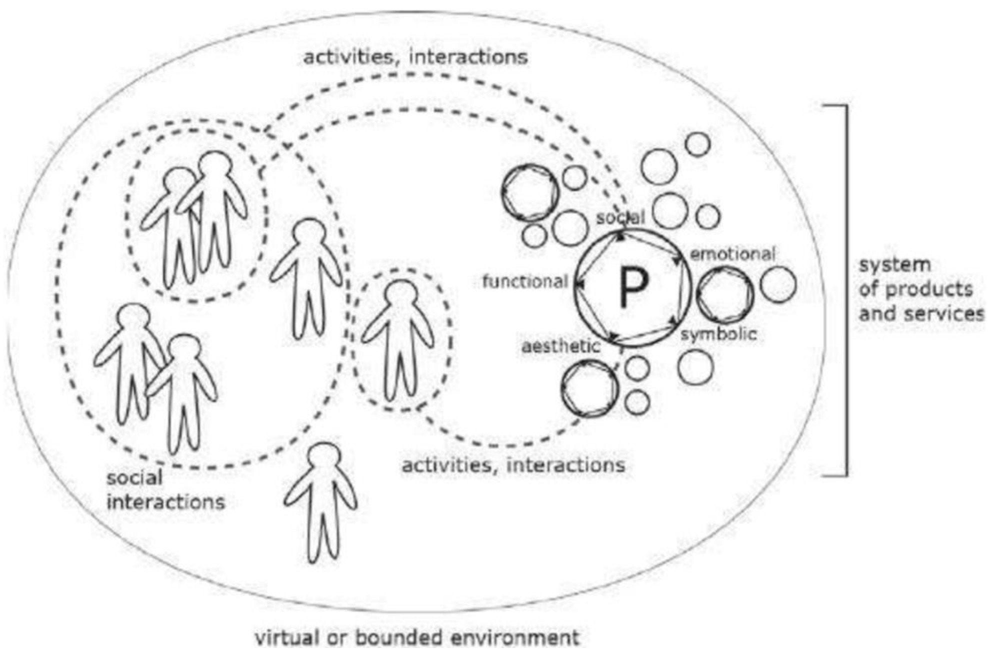


FIGURE 4 THE PRODUCT SERVICE ECOLOGY

My own research is framework is similar, rooted in praxis, developed over a decade, through iterative, systematic, and reflective experiments in entrepreneurship, contracted research services, and academic study in fine arts, architecture, urban planning, and immigration law. This framework was developed through years of practice in refugee camps, conflict cities, and robotics labs. Like Forlizzi's framework for research and design of product-service ecologies, my own approach would not stand scientific scrutiny through replication, but functions as a framework for development of solutions within complex conditions, with many stakeholders and sophisticated technologies.

Represented in Figure 5, this research framework sits on an XY axis, with overlaid circles. The grid describes the intersection of methods (qualitative / quantitative) with a they physical material of those methods (observable, physical vs experimental, phenomenological).

Interwoven is a series of circles that align to the physical form that observations may take, such as imagery, objects, or the development of invisible systems. Within invisible systems, complex dynamic systems take precedent over formally architected systems on account of the volatility and unpredictability that such systems leverage to yield power. All elements of the diagram are scaffolded by people, who carry with them goals, beliefs, needs, expectations, resources, and perceptions of limits. These are similar to the findings of conventional user experience research.

To utilize the framework is simple. One locates a problem, and begins to explore that problem through its text, images, objects, and environments. One seeks and engages with the people who make up or engage with those domains, and through those people the designer seeks to understand individual goals, needs, beliefs, expectations, resources, and perceived limits to the problem. As the designer engages the materials and humans from which the problem is composed, the designer collects data that is evocative of the problem and persons. That data may be qualitative or quantitative, but what more importantly, that data has a range of tactical materiality.

This framework has been developed for two reasons. One, to enable interdisciplinary and exploratory approaches to understanding any given problem. Two, to ensure that the research results in clear, concrete points of decision. The outcome is never an abstract recommendation, but is tied to material things, places, and persons or processes which can be designed to improve the problem.

At a glance, this framework may appear to share some commonalities to Buchanan's Four Orders of (Buchanan 1985; 2008) and Forlizzi's product-service framework, but there are severe differences. First, Buchanan's orders describe how design may affect value through organizations, he was not developing a framework for research. Forlizzi's framework is perhaps more similar, but her framework only identifies the factor of interest, and does not reference tactical methods for research.

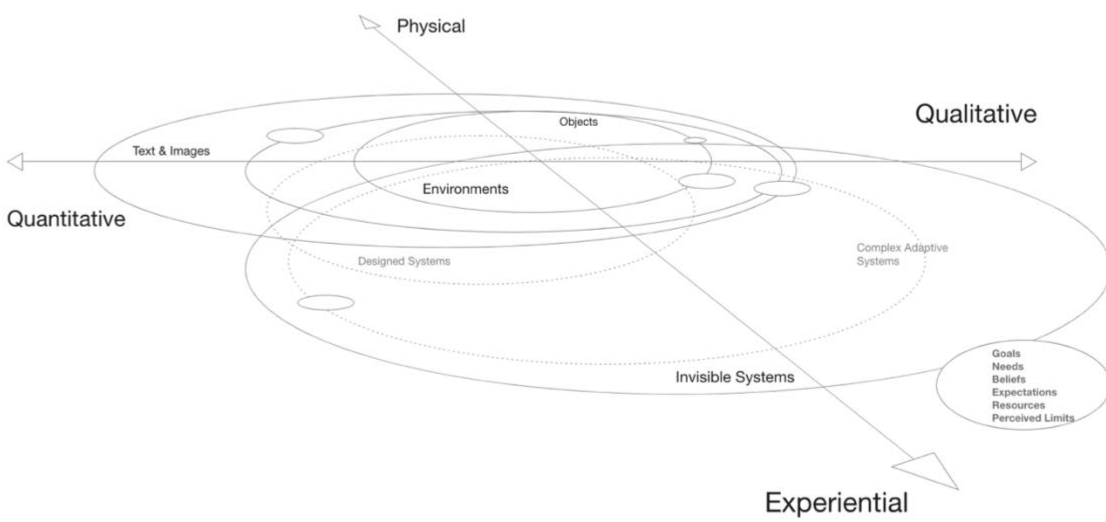


FIGURE 5 TRANSDISCIPLINARY FRAMEWORK FOR DESIGN RESEARCH

To apply this framework for design research, one should recognize that any kind of 'method' should not be considered out-of-bounds but should be determined relative to the demands of a given problem. In this manner, quantitative methods and purely creative artistic practice are considered equally valid as method of design until constrained by the problem. Furthermore, no preference is given to a technique, material, or discipline. Rather, the goal is to utilize the concerns of design disciplines as a means to investigate the social configuration of a problem in relation to its material form. As a problem is better understood and defined in light of its stakeholders and the evidence of those interactions, determinations on how to better experiment and implement change are possible.

4.4 Timeline of Research Activities

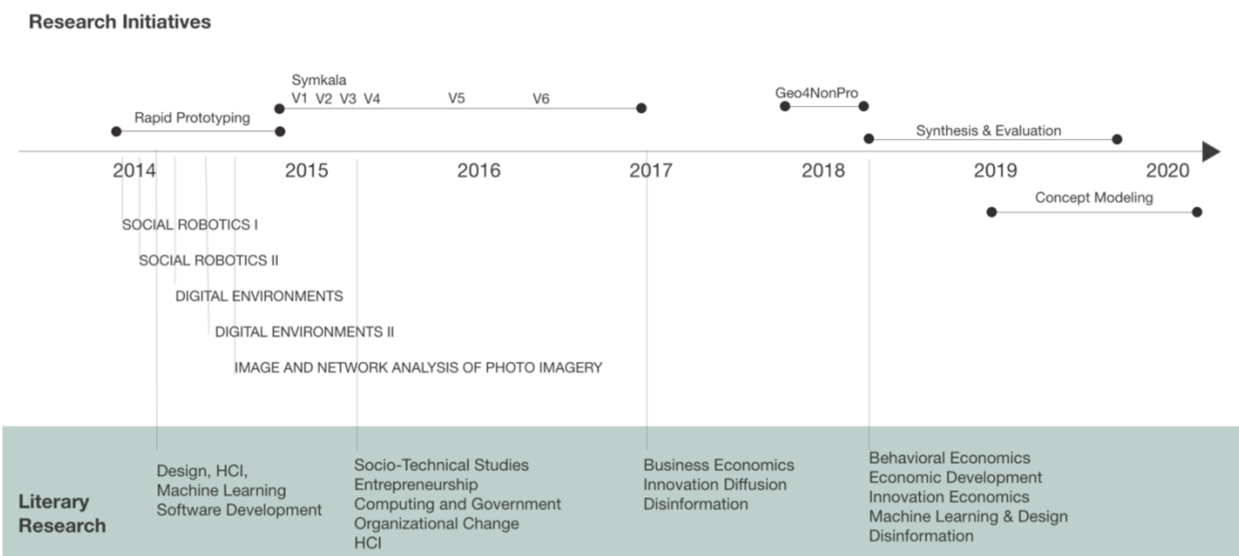


FIGURE 6 THIS RESEARCH TIMELINE CONTAINS THE COMPLETED PROJECTS AND PARALLEL AREAS OF THEORETICAL RESEARCH

Over the last six years, three phases of design research were conducted to explore the role of emerging technologies in countering disinformation to yield economic value. In the above image (Figure 2), these projects are described as rapid prototyping, Symkala, and Geo4NonPro.

The first phase of rapid prototyping consisted of an immersion into the Pittsburgh Innovation Ecosystem, which yielded small projects exploring emerging ideas on design and machine learning to create, engage and transform information. Reflecting upon the theoretical implications of the innovation economy and the findings through contextual inquiry, led to the formulation of Symkala, an information product and a business. Symkala was not sufficiently successful in the marketplace but did generate enough interest that external government actors asked that I provide assistance to a related initiative called Geo4NonPro.

4.4 The Research Setting

This research is informed and contextualized by the Pittsburgh Innovation Ecosystem. This Ecosystem has been defined by the Brooking's Institution as a series of site-specific innovation districts including Oakland, North Shore, Downtown, Lawrenceville, Bakery Square, Almond, and South Side. Institutional strengths are Carnegie Mellon University, University of Pittsburgh, Google, Chatham University, CMU's National Robotics Engineering Center (NREC), the Advanced Robotics Manufacturing hub, CMU's Collaborative Innovation Center, UPMC, and companies such as PNC Bank, Highmark, PPG Industries, and US Steel. With over 1$ billion dollars in university R&D capital, Pittsburgh was ranked 9th among 100 cities for university R&D relative to the size of the city (Andes, Horowitze, et al. 2017). University of Pittsburgh sites resources such as the university library system, the small business development center, and center for research computing (University of Pittsburgh 2020). Carnegie Mellon University specifies the Swartz Center of entrepreneurship, which offers many free events, lectures, access to experts and competitions and showcases for fundraising (Carnegie Mellon University 2020).

4.5 Artifacts

The project Symkala existed as a software and as a company, headquartered in New York City, as a Delaware-registered Limited Liability Corporation, additionally licensed to operate in NY, DC, and PA.

During development, this software was also referred to as a "Card Sort Process for GIS." Versions of Symkala are available on an open source Apache 2.0 license at https://github.com/momomoro/symkalaResearch and at https://github.com/geoffrey-p-morgan/symkala.. Symkala was designed and implemented on an AWS server and built of Python code, with some Java functions running open source Weka machine learning algorithms. In February 2016, the Carnegie Mellon University Office of Technology Transform and Enterprise Creation conducted a legal review and concluded the University has no claim to the intellectual property of this innovation.

Works were produced with support and collaboration by many talented individuals, including Will Milner, Rachel Chang, Geoffrey Morgan, Jeffrey Huang, Yaakov Lyubetsky and Davey Gibian. Earlier prototyping support was also provided by David Bradley and David Fouhey.

I provided design research and design services as a free agent and for free use to Geo4NonPro. The final build was created by Harris and is owned by the James Martin Center for Nonproliferation Studies at the Middlebury Institute of International Studies in Monterrey California. It is accessible, as of December 2019 at https://geo4nonpro.org/.

4.6 Section Summary

Design research is a form of action research to create new hypotheses and to propose new models for how the world could be. Through making processes, objects, and experiences, a designer synthesizes and reflects upon worldly engagement and codifies new knowledge as objects (Buchanon 1992). In this sense, a designed object is a proposal for the form and function of the world. Through the continual act of designing, the designer may build expertise on how to solve a problem in real time. This form of theory in action may be difficult to teach or communicate as tacit knowledge but can be developed over time as a central component of individual practice (Polanyi, 1966; D. Schön 1983).

Within this research I have applied a design process akin to the double diamond design framework developed by the UK Design Council. This process consists of divergent exploration, synthesis, prototyping, and optimization. To apply the double diamond, I have shared my own framework for conducting design research built over a decade of practice working in social science and design disciplines.

To conduct research on the value of a design approach to venture creation, product design for systems scale problems, and countering disinformation, I conducted three multiple research initiatives over six years summarized as four parts of research. Those parts consisted of the following parts:

Part 1 - Divergent exploratory research of the Pittsburgh innovation ecosystem and early stage rapid prototyping

Part 2 – The creation of Symkala LLC

Part 3 – The creation of Symkala the software

Part 4 – The redesign of Geo4NonPro

In conducting this work, part 2 and part 3 were conducted simultaneously.

This research through design generated a collection of artificats, each one as a proposition on how something should or could be. These artifacts include business planning documents, presentation materials, software sketches, lo-fi prototypes, working software, an archive of internal communications, records and field notes of interactions, and a repository of code.

Through review of these artifacts, review of selected artifications, reflection on the actions of design, recognition and reflection on the transformation practice, findings and insights are presented as knowledge. These insights propose new hypotheseses for deeper research and introduce new materia realities and new perspectives to entrenched and complex problems. In this manner, research through making contributes to broader systems of social and economic transformation in the world.

Section 5: Innovation Ecosystems and Exploratory Prototyping

5.1 Section Abstract

This section describes the first iteration of the double diamond process of design research. In this section I conducted divergent research within the Pittsburgh Innovation ecosystem and generated a collection of small prototypes to explore how information and machine learning can inform the material design of geographic information systems to counter disinformation and elicit systems level change.

The first phase of research was to immerse myself into the Pittsburgh innovation ecosystem, to working through the social and institutional relationships that constitute that ecosystem, to and to build capacities to produce exploratory prototypes that utilize machine learning to manipulate and transform information. Research of the ecosystem was directly informed by iterations of prototype development. With the creation of each prototype, I could return to the various social and business events with an object in hand to open new doors and drive new conversations. Through the churning process of social engagement and prototyping across the web institutions, I began to formulate new ideas on how to best approach the intersection of business design, product design, and disinformation.

Within the entrepreneurial ecosystem, there was a lack of awareness by most participants and many stakeholders about the value of design methods or the role of designers within technology industries outside of communications or marketing. Though universities held a strong institutional role, only small numbers of students participate, and there is a general concern about intellectual property licensing that stifles growth. With a strong internal bias toward the power of expensive industrial scale solutions in the domains of robotics, I found ecosystem more of an echo chamber than a support system for growth. Bold visions and communications nonetheless did the most to maximize resources such as recruitment through these events.

Through the prototyping process, experiments were conducted to utilize machine learning to assess imagery and to extrude layers of data for analysis. Through the development these prototypes I learned more about the limitations of current GIS tools, as it became that current GIS solutions do not enable deep exploration of the data as a source. Furthermore, it became clear that the user's interaction patterns modern GIS environment are consistent with the logic of SQL, more than with the end goal of the analysist. This enabled a vision for a new kind of GIS product, in which one leverages rich imagery and diverse data sources and works through a series of interaction patterns to elicit a deeper understanding of the information, not just its relationships. The prototyping and immersion into the innovation ecosystem established a direction to develop a venture, and to combat disinformation, and to design a product as a multiplier.

5.2 The Research Setting: The Pittsburgh Innovation Ecosystem

With this priority, reflective of my training in urban planning, I experimented with approaches to better understand human to environment relationships through computer vision and data analysis.

According to the Pittsburgh Technology Council 2014 study, Pittsburgh's creative industry is growing 14 times the national rate and the 35,000 creatives working within technology are growing at a rate of three times the national average (Stolarick and Musante 2014). Core institutions within the city's innovation ecosystem is Carnegie Mellon University and the Pennsylvania sponsored business development center, Innovation Works. Both organizations arrange local events, competitions, and feature in-house programs to connect entrepreneurs with funding and advising. The city also hosts technology offices of many large corporations including Google, Microsoft, Uber, and several large organizations that are not usually considered technology producers but do have major innovation demands such as PNC Bank, UPMC, Bayer, Heinz, and BNY Mellon. The city ranks number nine the top ten producers of R&D research in fields such as robotics, software, and artificial intelligence.

The city has over 500 startups yet has failed to generate many high growth startups. While the city performs at 225% above the national average in computer science research, employment in the software industry is 36% less than the national average. By and large, local populations are apart from the technology industry, and many of the resources available for technology entrepreneurs are not evenly distributed (Andes, Horowitz, et al. 2017). Outside of Carnegie Mellon University and Innovation Works, the primary resources in place consist of 12 coworking facilities, 6 community groups, about 10 venture capital firms (StartNow Pittsburgh 2019). Yet according to Linda Rottenberg, CEO of Endeavor – a firm committed to growing urban technology hubs and entrepreneur ecosystems around the world – a city only requires one major success story to transform.[1] Within Pittsburgh, two of the earlier success stories were the creation of the Lycos search engine in the 1990s and the work of Henry Hilman, who backed Silicon Valley venture capital firm Kleiner Perkins. More recent success stories include the 1-Billion-dollar valuation of Duo-Lingo, a language learning software founded by a CMU alumnus Loui Von Ahn; a $93 million-dollar investment into artificial intelligence company Petuum, and the $1 billion-dollar acquisition and investment of autonomous car company Argo by Ford. While these examples are remarkable, they constitute less than 1% of the total city innovation ecosystem. Also, consistent with Krugman's critique, these anecdotes, are not sufficiently evident that the ecosystem is a catalyst for successful business creation (Krugman 2013).

As the central node of city's innovation ecosystem, the CMU Swartz Center offers a range of free services for entrepreneurial students such as access to legal advice, limited office space, a lecture series on company formation, and promotion of local events for startups. I made a point to attend events including startup bootcamps, lectures by local leaders, technology showcase events, and smaller boutique services such as legal and accounting seminars. Through this

[1] Hoffman, Reid. "The Next Silicon Valley is…?" Masters of Scale, Podcast Episode 10, Episode Transcript, Accessed 2/21/2018 at https://mastersofscale.com/wp-content/uploads/2017/12/9.-the-next-silicon-valley-is...-formatted.pdf

program, I was able to participate in a shared non-credit course with Stanford University that featured a range of well-known speakers sharing their own experience.

Seeking and attending events, I visited the offices of many companies throughout the city including Bosch, Uber, Google, Autodesk. I made a point to make repeat visits to the growth incubators operated by Innovation Works. Furthermore, I sought out and spent time at city co-working spaces such as Alloy 26 and Beauty Shop. Within these events I attempted to quickly understand who was interested in building companies and how these organizations facilitated local entrepreneurship.

Within all settings, I openly engaged persons to repeatedly hold the same conversation. I stated that I was new to Pittsburgh, had just returned to America after many years of living abroad, and was seeking to start a company. This social action was reinforced by cold emailing individuals expressing an interest in their work and inviting them to share a coffee. My goal was to have one meeting every day, and in that meeting, to also ask the individual to identify and introduce me to others who do related work.

Consistent with endogenous growth theory, I directly injected myself into the Pittsburgh innovation ecosystem with the expectation that endogenous resources would inform the development of a novel technology concept. No doubt, experiments were informed by my own situated expertise, yet otherwise entirely dependent upon chance encounters, open conversations, and fluid relationships. Given that Romer's own New Growth Theory is rooted in the increased investment into technical research and development with incentives for entrepreneurship, I sought to associate myself with any resource that provided such incentivization, in expectation that I could find like-minded persons to share and align resources (P. Romer 1994). As Romer stated, the more persons involved in "discovery activity," with aligned institutional polices, the more quickly one can enable the creation of products that generate socio-economic value (Matsangou 2019). According to the theory, if Pittsburgh appeared has this set of conditions, my social immersion should yield products that eventually produce economic value. I would observe this value through immediate financial return, new forms of participation within the ecosystem, and via externalities such as the rise of competition (J. Schumpeter 1934, 1942; P. Romer 1994).

Initially I made the mistake to approach engagement with the innovation as a participatory mindset. Within a participatory model, the designer is a coordinator, who surfaces the perspectives of a group and supplies design expertise to help consolidate those perspectives (Manzini 2014, 2015). Yet the notion of co-design within an entrepreneurial ecosystem yielded only chaos. Consistent with the literature, participants in the innovation ecosystem may be owners and researchers of problems, but many are not, many are merely seeking opportunities to advance business interests (Batova, Clark and Card 2016).

As a design process the early phase of discovery was very chaotic. Oscillation between stakeholder views with lean and design mindsets supplied no clear direction or opportunity. Though I attempted to understand the microeconomics of venture creation in the ecosystem as advised by Gans, Hsu and Stern 2002, the findings were inconsistent. It was mentally challenging to move through constant interactions with little attachment to a given idea, but to build a mental model of the system as a whole and understand how the mechanics of that system can inform development of a product. In this manner, product development was more appended to push and pull factors for market transformation, often tied subjective stories and beliefs more than concrete actions. Working closely with the innovation ecosystem to build a venture was not effective.

The research shifted toward an ethnography of fragmented future visions or anomalous observations on the present tense, held by a technically informed population. There was no intention to consolidate those visions, to discern a problem, or apply a method. There was a clear and discernable population, but if there was any certain expectation, it was merely to better understand the ecosystem, to meet people, and to eventually have a more defined goal, expressed through the making of things. In this capacity, design and design artifacts served as a means for goal formation and articulation, consistent with Rittel's identified demands for those working on problems of general planning (Rittel and Weber 1973).

5.3 The Research Process

5.3.1 Observations of the Pittsburgh innovation ecosystem pertaining to venture creation

Through continued field research and engagements, several key factors were identified that defined the success and limitations of Pittsburgh as an entrepreneurial hub. Furthermore, an array of obstacles was discovered to access this hub, build a community, and prototype experiments in computational information creation and management.

- While Carnegie Mellon does hold a role within the local ecosystem, this role is far more defined by the image and actions of the institution than by the student population. Based on turn out, I was surprised to discover that in general, many students at CMU do not have any interest in entrepreneurship but are far more interested in obtaining an industry position at a major technology corporation. Over dozens of meetings and spontaneous visits to research labs, it was clear that most doctoral candidates had a determined plan in academia and were not remotely willing to explore entrepreneurial pursuits. Some students pursuing undergraduate degrees were frequently interested in collaborating, but their lack of experience led to little contribution, as they were easily overwhelmed by story, my goals, and requests. Students pursuing a master's degree in computer sciences, were harder to find, often had a fair amount of expertise to contribute, were open to exploration but had little time available.

- Accessible opportunities for initial seed funding are misaligned to the downstream interests of the entrepreneur. Venture capital relationships facilitated through the CMU network often propose only $50,000 dollars in exchange for 10% - 20% of company equity. When company is merely an idea with no ascribed market value, the $50,000 dollars may seem like a good value, but such a low amount of funding will require excess demands from any staff members and only covers operational expenses. When factored with the future dilution of equities during additional funding rounds, the investors will have severely underpaid and the founders will see the least return. By comparison, in West Coast markets, a 10-20% equity share is equivalent to $500,000 or more, at the same stage of development.

- It is difficult to build a customer base in Pittsburgh, as the largest companies with the most flexibility in spending have conservative operations and cultures. Organizations such as BNY Mellon or UPMC are less inclined to experiment in their purchase of technology solutions with upstart companies on account that these organizations also maintain high levels of risk in their work. While there is a sizeable industry to demand benefits of endogenous innovation, the culture of those industries may not align with the culture of the innovation ecosystem.

- Many startups in Pittsburgh must also build footing in external markets. Frequently taking advantage of regional markets such as Detroit, Columbus, or Washington DC, early stage startups extensive time and money into travelling to participate in the entrepreneurial assets of other cities, such as Detroit Tech Stars, to gain early customers and regional visibility. This trend extends beyond technology firms, but includes other business models as well, such as local distilleries and breweries. Companies such as Wiggle Whiskey and King Fly spirits hold various personal relationships to technology community but have relied upon external resources such as investment derived by partnerships with external firms or persons in locations such as New York City.

- The highest density of technology entrepreneurship is located in the Strip District, unofficially dubbed Robotics Row, a former industrial riverfront with large cheap warehouse space available. However, with the explosive growth of the technology sector in the last ten years, and the new developments by Google and Uber in Pittsburgh, local developers have been quick to cater to the technology sector. Having visited over 20 independent sites in Pittsburgh to build a company, I discovered one can readily access sparse warehouses, large-scale finished spaces abandoned by failed companies, or ready-to-occupy but costly facilities. Yet the market is already highly saturated, and few options exist for budding startups. While CMU Swartz center offers a space for some startups, this space is outside the proximity of other companies. Consequently, the expertise and logistical support may be in place, the rapidly real estate market can force entrepreneurs toward asset-light business models.

- For those entrepreneurs who can obtain market entry and initial funding, late stage capital is frequently available, yet the mid-level funding rounds are the most difficult.

- The resources and attitudes embedded within Pittsburgh and the CMU community skewed to favor young, inexperienced entrepreneurs who had excess time to volunteer. For more experienced entrepreneurs, conditions were best suited for a "lab to market," approach, with coaching on federal finding opportunities to commercialize university sponsored research. For those who may be older to have additional responsibilities such as the demands of family and debt, the resources in place did little to garner sufficient funding or material support.

- Carnegie Mellon University states that it has a gold standard in the support of sharing and licensing commercialized research. In summary, any student or faculty who utilizes more than $10,000 of resources provided by the university in their research pursuit or develops novel solutions by means of CMU research funding entitles CMU to own the license of the technology with a sharing of rights and 50% on returns. Over the last 15 years, this policy has generated $150 million dollars in revenue by means of 2,299 agreements for the university via 152 companies (Carnegie Mellon University, 2019). Averaging 65,000 USD per agreement and $10 million dollars per company (setting each company revenue at an average of $20 million dollars).

While few individuals voiced criticism of this policy, it establishes an inequitable regulatory burden upon the CMU entrepreneur to sacrifice 50% of prospective earnings. No doubt, the university is entitled to downstream returns for provision of facilities and expertise over the years. Yet as MIT's Technology Licensing Office demonstrates, there are additional arrangements that can be made such as joint partnerships, equity management, conversion notes (in which shares are established later), in addition to royalties. Notably, MIT's own royalty fee is only 7.5% on future returns (MIT 2019).

- Through immersion into the Pittsburgh innovation ecosystem, the bulk of my encounters were with persons who were employed by a large technology firm. Secondly, I met other "founder" types, persons like myself dedicated to building a company and seeking to recruit interests or talent. Neither of these were helpful to inform product development. Founders specifically were already invested in a given idea.

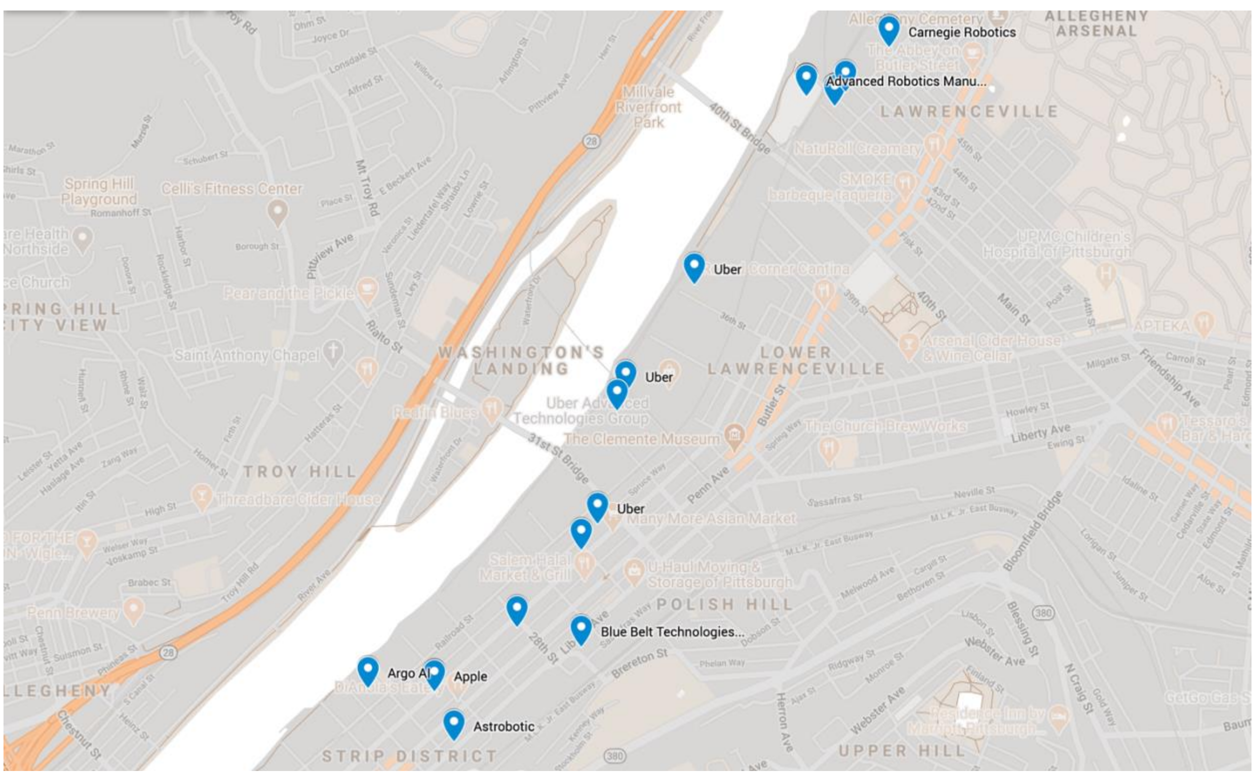


FIGURE 7 PITTSBURGH ROBOTICS ROW 2018

5.3.2 Rapid prototyping products to inform new venture creation

Informed by the range of lectures attended throughout the city on computer vision, it was clear that many computational processes existed, especially in the domain of computer vision, to create additional data assets from imagery. While an Autodesk event, local computer vision researchers were showcased, many of whom worked for Disney, or Caterpillar, and all of them had Carnegie Mellon associations with the Robotics Institute. Many of them demonstrated capabilities in modelling environments from imagery or printing 3D scans of the human body.

Collaborating with David Fouhey of the Robotics Institute, we developed an approach to better elicit information about human to environment interactions. My reasoning, was that such measures could inform new processes downstream to distinguish false images and videos from real, based on spatial patterns and object trajectories. More so, in the domain of GIS, that one could create validation layers for GIS data from photographs if background algorithms could extract meaningful data from the imagery to run a test. We set to task to create a prototype; wherein everyday mobile phones could surface information about how a space was used by a person, enabling new conceptual representations of geographic data (Peuquet, 2002).

Seeking an environment with lower complexity, I emptied the PhD. Design shared office of its furniture. With the assistance of another doctoral student, Deepa Butoliya, I created two sets of photographic imagery. The images were shot in rapid sequence, documenting my movement through the space. Each set of imagery consisted of thirty consecutive photos, one from each corner of the room (Figure 8)

Supplying the data to David, we explored the range of possible uses for that data through drawing. Studying the range of consistent and inconsistent variables, we focused on my body as a unique object, the shape of the light diffusion across the floor, and the intersections of physical planes. Fusing the object view with the scene segmentation from both sets of photos, an overhead view of the space could be spliced together, with a heat map applied to document human activity across environment.

The overall result was beautiful but less than insightful (Figure 9). The diffusion of light enabled the means to create a reconstruction of the environment. The heat map ultimately revealed the amount of time spent at each location by the human actor, with no additional information into the activity. Notably, distinct from the point cloud experiment, this endeavor removed the role of the initial sensor, bringing attention exclusively to the person in view. One could not infer from the imagery if a person or a stationary camera was used to collect the data. This amount of information suggests a baseline of necessary data to build projected simulations on how spatial activity may shift if the space is modified. Immediately, I began to consider the design implications for architecture and urban design, to forecast traffic and human occupation patterns.

Beginning to grasp the statistical relationships between sensing, human behavior, and environmental context, I began to question how a collection of unrelated images may generate insight into a large-scale environment. With additional research into agent-based modelling, I began to question how machine learning may do more than generate insight environmental form or human interactions, but how a sufficiently large dataset may render new kinds of insights into complex environments.

I suspected at the time that there might some commercial application of this spatial analysis. The greatest limitation is that the analysis was not self-contained as a software, but dependent on the cost prohibitive MATLAB. A more fundamental problem was that I was uncertain exactly how such information could create value within any particular market. The field of urban planning veers toward the low-tech in the daily practice of most planners, and so I thought that crowd and traffic analysis from low tech sensors – specifically common mobile phones – could be of value.

Equipped with this protype for an application, I returned to the ecosystem, sharing this imagery with anyone willing to look and listen. As someone with no background in engineering, I found it exciting and compelling, but the response varied. By and large, individuals mentioned the work of larger corporations in the computer vision space. Conversations focused on the novelty of the technology, and there was little coherent thought on value of application. I that the Pittsburgh ecosystem was a constant feedback loop on value propositions, conducted by a highly skilled population, yet detached from demand.

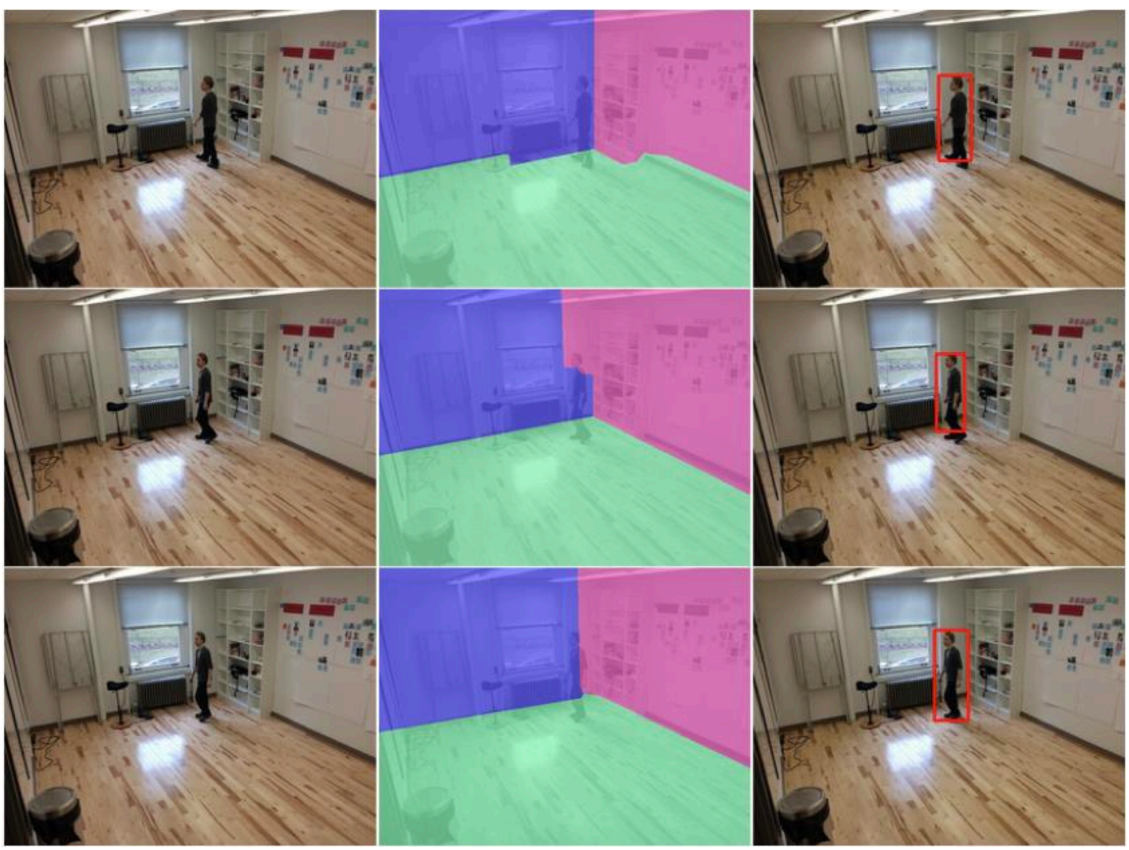


FIGURE 8 HUMAN TO ENVIRONMENT MAPPING

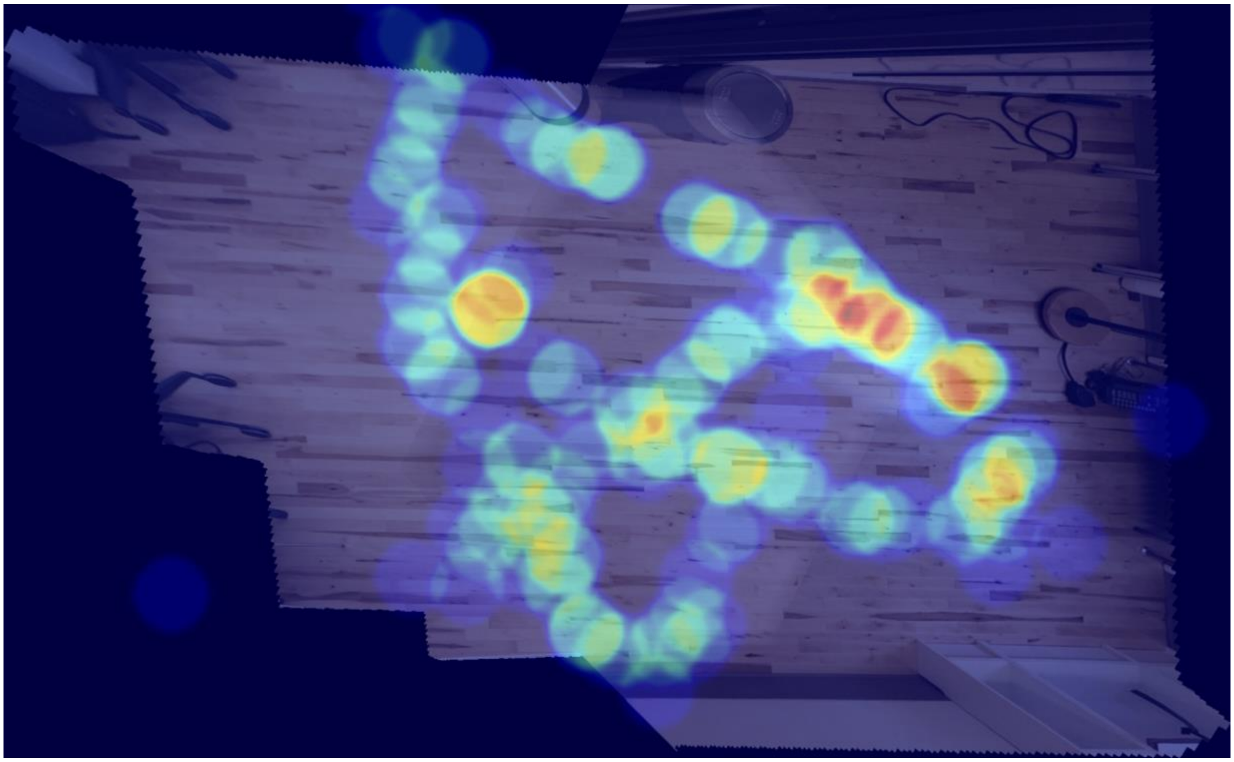


FIGURE 9 A PATH ANALYSIS OF HUMAN TO ENVIRONMENT INTERACTION

5.3.3 Reflection on product and venture design

Finding the innovation ecosystem may be more of an echo-chamber for isolated engineering research, populated by similar individuals with little connection to issues, I sought to bring my expertise on urban problems into the process. Unlike lean methods, which demand an identified customer, what if I could be the problem owner? Could I inject my demand upon the constituents of the innovation economy, and with enough persistence, the ecosystem of actors, funds, and institutions would propose a solution back to me?

My immediate point of reference was my last major urban planning initiative was the mapping of Mogadishu, Somalia with mobile phones. I relied upon dozens of mobile devices to create the world's highest quality map of this conflict city and utilized that data to drive significant economic changes (Rogers 2014). Over those years of working in Mogadishu as a city planner, I had accumulated 10,000 images collected in Mogadishu, Somalia from the years 2011 to 2013. Over 7,000 of those images contain time stamps and location data. Although that work had concluded in August of 2014, the memory of the experience and the challenges remained fresh, when my work was disrupted by violent circumstances. Surely, if information can facilitate the stability, growth, and management of a city, there must be a safer way to collect that information at a lower cost, and with greater speed. Inspired by the recent spatial analysis product, I set out to engage Pittsburgh's innovation ecosystem with this problem. Is there a faster, better way to get verified ground truth information?

Again, I discovered the same echo-chamber. Dozens of roboticists would respond to my challenge with an industrial scale response, suggesting one simply hire an expensive engineering firm to apply laser scanners to document an environment. This was absurd. One does not find such firms in battleground cities such as Mogadishu, Sanaa, or Tripoli. There might be a local engineering contractor, who is onsite to do such work, but there is no sufficient infrastructure in place to support it. Limited security, lack of stable electricity, poor internet connections, and the simple public spectacle of this activity are all sufficient to invalidate the approach.

The innovation echo chamber repeatedly pushed me toward expensive, highly technical hardware solutions for my proposed problem. The Swartz center pointed me toward AlphaLabGear, an innovation incubator for hardware firms. Meetings with their current companies and leadership continually surfaced reliance upon a lab to market model. As an individual outside of the research lab, with no grants in hand, no support could be offered. The deep bias of the community failed to meet the challenge I brought to it. The ecosystem was best aligned to those commercializing technical research and entrepreneurs who had a clear product proposal. It was not responsive to a designer with a problem in seek of a solution. It only responded to an entrepreneur with a product concept seeking to grow it.

Stepping outside the endogenous feedback chamber, I specifically sought out persons who could help me stretch computational information as a material. Who might understand my yearning to extract new kinds of meaning from my database of Mogadishu imagery, in hope that some curious anomaly will arise and point toward new methods of mapping complex environments? I had, by this time, formulated a rough set of heuristics to help me find collaborators:

- I found Engineers who had begun their careers in a non-engineering discipline held “go to” mental models on what kinds of computational tooling might be valuable. Such individuals demonstrated a bias toward one kind of approach or another for some reason other than technical difficulty. I found this bias refreshing, as it drove the conversations forward.

- I found that highly technical persons who created any kind of web presence – a website, a video about their work, a blog – were consistently better communicators. These individuals – for the most part – seemed to value communication as an art form and worked a little harder to share information for others.

- Highly skilled engineers and scientists usually were very forward about their understanding of design, and how design can influence their work. When I asked, “how do you think about design in your work?” those who simply said the word “marketing” were going to prompt failed collaborations.

No doubt, these are not scientific statements and should not be treated as such. But in navigating the innovation ecosystem, it became necessary as a designer to formulate heuristics to more quickly isolate key individuals, to prospect opportunities for collaboration, and within social engagements manage the inherit bias within the system toward sophisticated hardware solutions detached from actual problems or market demand.

5.3.4 Experimental prototypes to combat disinformation in geographic information systems

My experimental software with David Fouhey raised questions on how machine learning can create new forms of information from an original source. It became clear to me that one can pursue a sequence of abstractions for many kinds of information, relying upon computation to interpret and reinterpret a fragment of information in new ways. A digital image can generate text descriptions, text descriptions can be assessed and scored by sentiment, sentiments can be graphed and clustered relative to engagement. In this manner, one can take a paragraph, an image, or a video and stretch it, and bend it, creating new levels of dimensionality, forcing new forms of distortion or depth.

By comparison, the tools GIS have changed so little over the decades, dependent upon vector files and spread sheets. With another collaborator, Geoffrey Morgan, I sought design a new kind of approach to GIS – perhaps something with a new workflow, based off the new capabilities of computer vision, rather than by the limitations of SQL (which is the primary mode of managing information within commercial GIS solutions). Seeking a point to experiment, Geoffrey proposed first duplicating the construction of a common GIS system.

The design logic was to understand an existing technical system and then innovate through small deviations. Geoffrey from the NASA open source World Wind Project, https://worldwind.arc.nasa.gov/java/, to create a stand-alone GIS software product (Figure 12). At my request, we used the location metadata from the previous prototype to locate the 3D environment reconstruction and human activity heatmap.

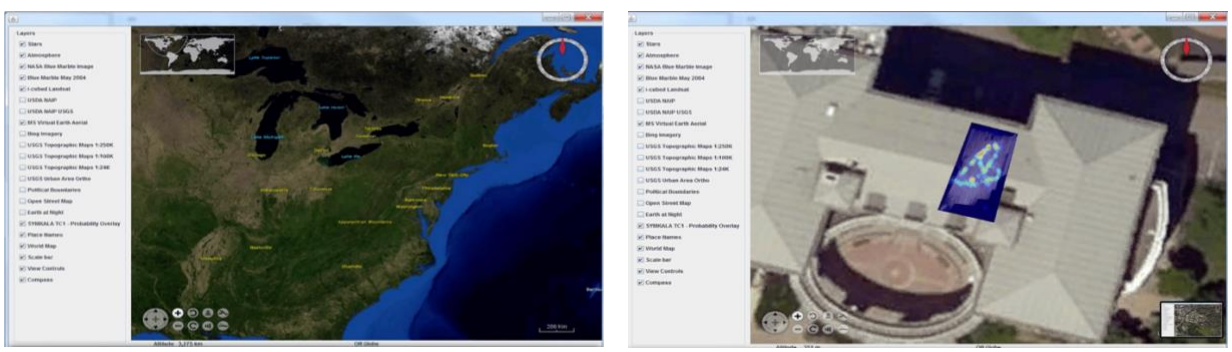


FIGURE 10 NASA WHIRLWIND GIS DEVELOPMENT KIT

Sequential work continued to explore how digital imagery can be used to better understand the human experience of environments through a GIS interface. The starting point for most GIS data is reliant upon a satellite image. While satellite imagery is sufficient to map out systems components and thus describe characteristics of a human experience, the manner in which an individual engages the world through ongoing sequential interactions over time.

Moving beyond the conventions of the NASA GIS, we experimented with introducing imagery as physical assets within a 3-dimensional space (Figure 10). Seeking to push my understanding of how temporal sequencing of information can shape human emotions, and expectations, I translated the spatial path of movement through image assets within virtual space into a video of emerging figure ground relationships (Figure 14). In the most minimal form, void of any context and at an accelerated pace, the constant barrage of white forms upon the viewer creates feelings of high anxiety, as it the battery negates the viewer the opportunity to make sense of what is seen.

Although this protype held little remarkable value at the time of creation, it went on to inform future design choices in the countering of disinformation. While satellite images may be hacked and manipulated, local-level information may be collected and embedded within the imagery. Extrapolations of data can be created from those images and applied. Experimenting with 3D and 4D video (Figures 11 and 12), I began to recognize that the interaction design of GIS may also avail a sense making and information qualifying process that is currently absent within social media software, designed for constant consumption rather than validation.

Thinking through how to combat disinformation, how to build products as multipliers, and how to build a new venture, two new questions came to mind?

What if a software was created to generate and qualify information through continually extruding layers of data and comparing those layers?

What if a GIS software was created so that the user workflow started with rich media, rather than CSV tables or SQL databases?

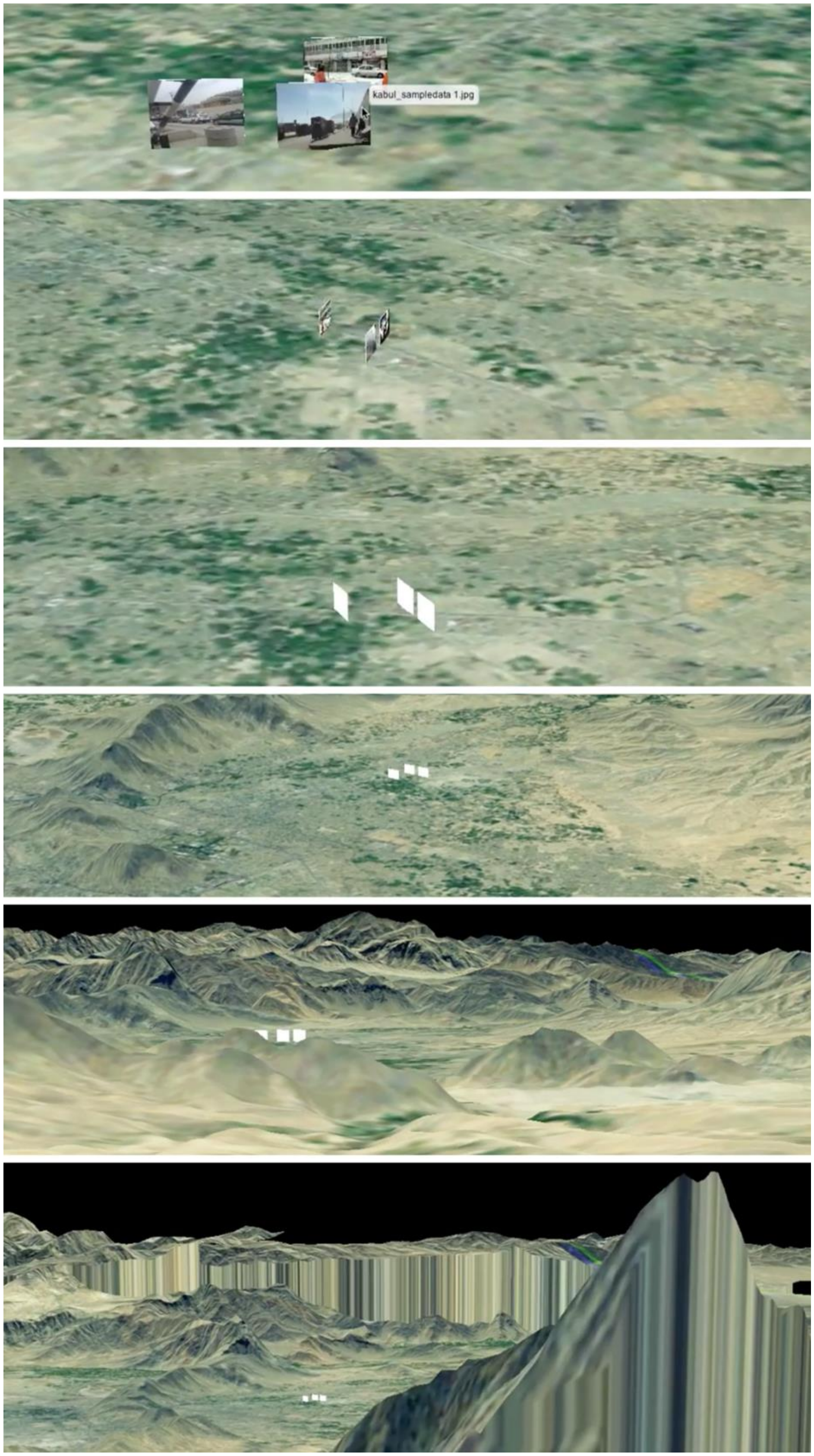


FIGURE 11 GEOLOCATED IMAGES IN KABUL WITH NASA WORLD WIND

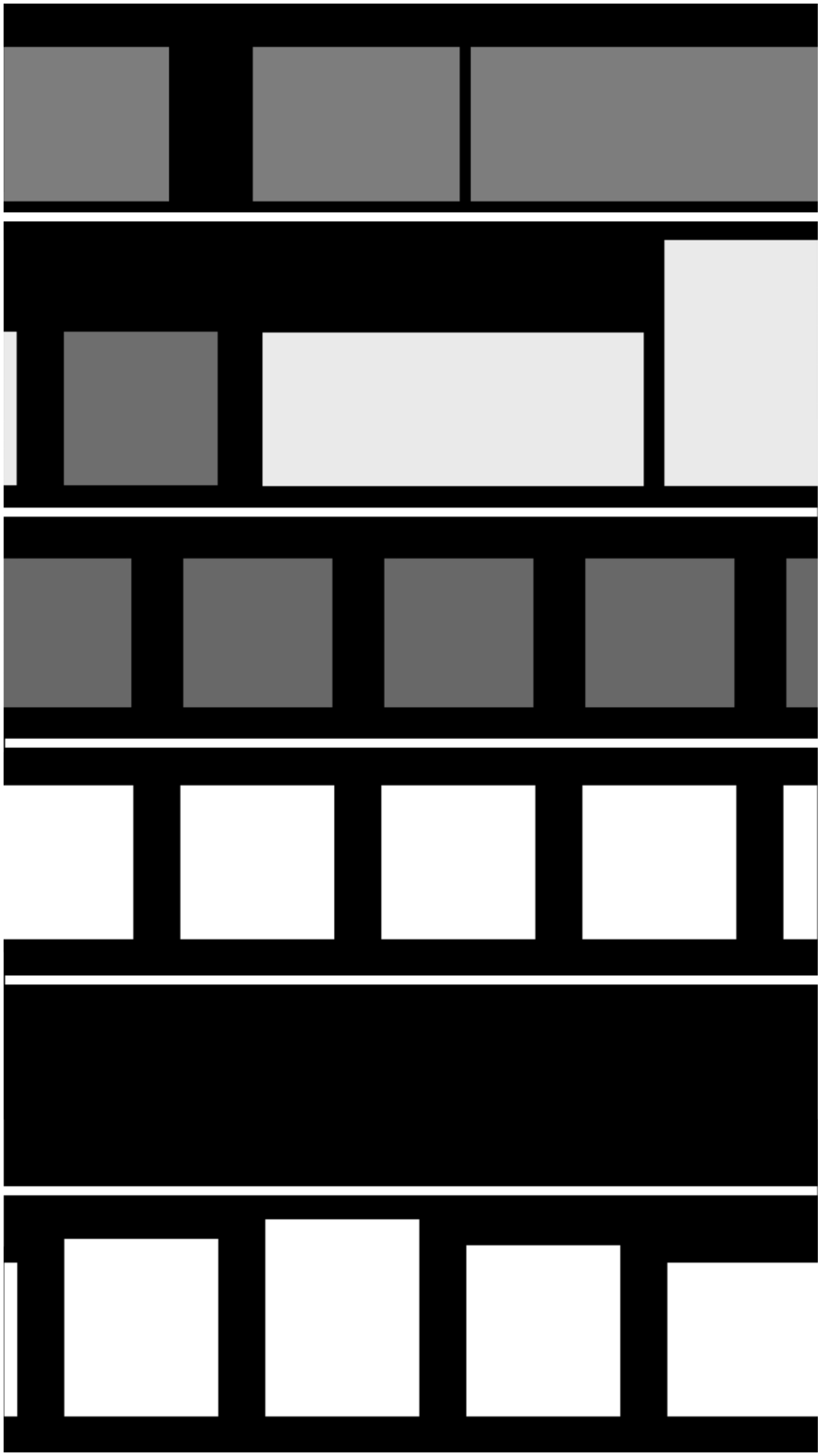


Figure 12 Frames from Sequenced Interaction

Figure 13 Photo of street corner in Mogadishu, Somalia 2012

Figure 14 Heat map analysis of Building using MIT CAFÉ, Places Scene Recognition Library to label image as "slum"

Figure 15 Sample of 12,994 images used as training data to generate the label of "slum"

Building on these insights, I pursued another prototyping initiative to validate my ideas within a GIS environment. The goal was to determine if the data pulled from images through machine learning was of possible value within a GIS environment. My collaborator, Geoffrey and I used the MIT Places Library that runs on the Caffe deep neural network.[2] This library predicted characteristics of the environment with labels including indoor/outdoor, scene categories (slum, embassy, construction), scene attributes (man-made, open area) and so on. (See figures 13 – 16). In the example below, the heat map reflects the imagery analysis for the label "slum."

The result of "slum," is not entirely inaccurate. The image captures an extremely poor, dense urban environment. The building is riddled with bullet holes and decay. The individuals in the image do not give any indicators of wealth. With a moment of additional attention there are other important elements to understand this image. The building has fresh concrete installed on the doors and windows to the right, demonstrating some effort toward property management. To the left is a security barrier, thin power lines crisscross the air, and the upper right steel scaffolding contains a mobile phone transmitter. Some goats wander in the back – and averaging a cost of $70 dollars

[2] At time of research between 2014 and 2018, this library was accessible at , http://places.csail.mit.edu/downloadCNN.html, however this library is no longer supported and has been replaced with a new version, available at http://places2.csail.mit.edu/index.html as of time of writing at December 2019.

USD within the world's most dangerous and impoverished nation, a sufficient level of physical and economic security must be in place to justify the presence of these animals in the open. To be fair, it is easy to miss these significant indicators

Notably, while the CAFÉ scene recognition algorithm failed to provide a nuanced reading of the image, this image library contains over ten-million images to generate thousands of label combinations. A rapid inspection of the data set for slum (Figures 16) contain an array of polarizing and typical images of aid workers, journalists, unclothed children, rusted sheds of corrugated steel, and dark-skinned persons. Yes, much of this can be found in the world's slums, and yet, this label also fails to convey the qualities of economic transformation, family life, technological and social change that are also widespread.

FIGURE 16 A RANDOM SAMPLE OF THE PLACES LIBRARY FOR THE LABEL "S_SLUM 12994," IMAGES ARE LOW RESOLUTION AND BLUR IS NATIVE

Given the failures of the labeling, I thought that other opportunities may be possible within the analysis, building off of my own labeling. Separating the same images into distinct categories such as types of health care, it was possible to sort the images into homogenous groups, and then utilize the image EXIF data to map it against the city utilizing a Manhattan analysis, wherein nodes are connected based on 1/3 of mile of walkability. This type of analysis was selected as the goal was to better understand what layers of information may be accessible within visualization. For presentation purposes, I crafted dark base map rendered using the commercial cartographic design tool, Mapbox (See Figure 17).

Notably, the resulting visualization is not only aesthetically striking but raised compelling questions as an area expert. Mapping core urban infrastructures, I was not surprised to see the high density of over lapping layers in the in their particular locations, as the spatial patterns represent the population and business settlement patterns of the city. However, the shapes of the edges between the nodes is evocative of the market boundary for each high-density market. Furthermore, the patterns overlay with tribal settlements in surprising ways. For example, the blue lines, representative of health care infrastructure, roughly correlates to the settlement patterns of a single tribal group, suggesting a monopolization of services.

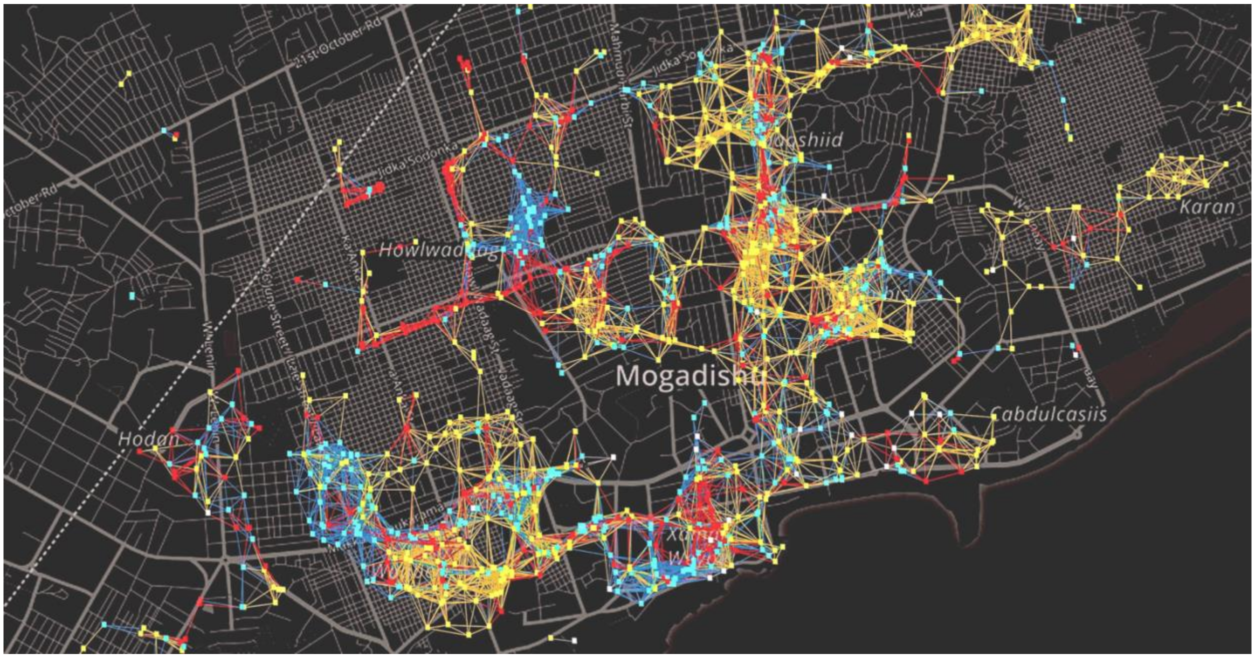


FIGURE 17 NETWORK ANALYSIS OF MOGADISHU INFRASTRUCTURE ASSETS

Through these experiments I concluded that photographic imagery is heavily underutilized when combined with advanced computation. The small size and high quality of modern image capture techniques unlocks expanded opportunities for information capture, with new perspectives and value. Direct infusion imagery to simulated digital environments has perhaps some of the most limited value. Of greater value to design, the creation of training data and label conventions is among the greatest weaknesses of machine learning, as a massive gap exists between the generic learning of machines and the situational learning of human. Often the discussion veers into issues of algorithmic bias, which is legitimate, yet I find the notion of "learning" to be painfully discrete and limited. Unique Opportunities may exist at the gap between text and environments, whereas the object-type extrusion exercises rendered the lowest amount of insight, yet text to environment (such as the network analysis) provoked new questions and insights.

More remarkably, the introduction of these GIS experiments back into the local innovation economy again failed to elicit traction. Directly informed by the strengths and limitations of the innovation ecosystem, I brought the locally held expertise in robotics and engineering together to propose methods for extracting greater levels of information within poorly mapped and dangerous cities. I utilized understood technologies and introduced iterative modifications. Following the advice of the local advisors and guided by the entrepreneurial culture, I expected to see my work inform the ecosystem in some manner. I did not expect to suddenly create jobs and new markets, but I did expect to access a new level of that ecosystem. Perhaps meetings with hard to access and influential persons? Or possibly an opportunity to pilot these technologies with the city planning department? Yet what I discovered, in great contrast, that this ecosystem is not stratified. Perhaps, I was simply misaligned. I thus took steps to elevate my work, beyond prototypes, but to formulate a business, with a product, to combat disinformation.

5.4 Section Summary

In this section I described the first iteration of the double diamond process of design research. I attended extensive events, networked, and participated in the offerings of the Pittsburgh Innovation ecosystem. My goal was to determine a path for venture creation through design. Through interaction and participation with the ecosystem, I built to facilitate the creation of small prototypes to understand opportunities and limitations for machine learning to manipulate digital information. Through recursive actions of prototyping and constant engagement with ecosystem, stakeholders, I began to identify opportunity paths for embedded validation processes within geographic information systems.

Following this process of immersion, engagement, making, and reflection, I began to consolidate a vision for a new venture. This new venture is a company and software for the creation of geographic information systems that deviates away from the traditional design of commercial GIS solutions with a focus on SQL-driven queries. Rather, through design research I began to craft a proposal for a new kind of GIS, informed by the capabilities of computer vision and new kinds of workflows to carefully, almost forensically, let an analyst study and enhance the information to be analyzed downstream.

Section 6: Design Entrepreneurship for Complex Information Systems

6.1 Section Abstract

To better understand how the design process may inform new business ventures, to combat disinformation, and to ensure the products created by these ventures yield positive consequences in the world, in this section I focused on the building a venture and the building of cartographic tools to counter disinformation. I built the company Symkala, a GIS product called Symkala, and provided support for the development of a crowdsourced GIS solution called Geo4NonPro.

To build a company through design, I built the company through the production of artifacts. The creation of software products, marketing materials, and presentation decks and guided the company development in response to feedback from prospective clients or investors. The product and company were oriented toward the demands of federal agencies in Washington DC. Through continual development and feedback, the identity of the company, it's story, and its process became increasingly tied to biographical experiences, beliefs, and arguments and less about novel technologies.

The venture of Symkala was created through design process. The making of artifacts, in particular the pitch deck, drove most of the decisions on organizational structure, pricing, channels, and the organizational narrative. The deck experienced over 28 iterations, repeatedly improved through the study of other decks and feedback and observations from presentations with possible clients and investors. Through iteration, the company drifted further away from lean, customer-based methods and from proving a novel technology design, toward creating bold visions founded on biographical experiences.

The software of Symkala introduced a new model for GIS. The workflow for data management was designed for careful curation, investigation, and comparison of imagery and text to render geographic visualizations. The workflow enabled one collect information from multiple sources, such as imagery and text files, and map those assets for geographic analysis. It did not directly combat disinformation but illuminated how fragments of information inform argument construction over time.

The second software design initiative, Geo4Nonpro, was intended to more directly combat disinformation. Geo4nonpro is a GIS software for individuals to label satellite images of nuclear research facilities around the world. The labeling activity is intended to train algorithms for automated image analysis. This product is intended to enable independent analysis of global nuclear issues to achieve similar as federal agencies, to thus inspire more trust in government messaging. The challenges to achieve an impact on disinformation were tied less to software design, but far more a matter of data policy and organizational transparency.

From these works, the identified contribution of design to venture creation is to supply a coherent and distinct vision and value proposition, and to utilize stages of artifact creation as the process to resolve many organizational needs. A designed venture achieves rapid clarity in its mission and

its organizational design. It may supersede the capacity to deliver on that vision through technology, but the research suggests that execution of the product may not be a necessary first step to build a successful venture through the creation of resources, acquisition of capital or the acquisition of stakeholders. Unlike lean, the vision and the story are more important than the execution of the business in the initial stages of founding. Lean methods became less useful or important as I built an independent vision through the design process. In the domain of products to counter disinformation and achieve impact at scale appear less concerned with technology design, but highly contingent on the design of organizational policies and efforts to be transparent, to allocate resources to a greater value, and to directly engage new communities.

6.2 Symkala: A Business Venture and Geographic Information System

FIGURE 18 THE SUMMARY PRODUCT PROPOSAL FOR SYMKALA

Symkala was a created to provide enriched understanding and source confidence to geographic information systems. With a design-based approach to venture creation, I built Symkala through the production of artifacts – products, presentation materials, branding and web materials. It was through the making of things that I was continually confronted with the decisions of entrepreneurship that often fall into the domain of the business planning and strategy such as team composition, communications standards, market entry strategy. Each object required exploration, reflection, synthesis and iterative production. Consistent with the double diamond design process, it also required vision, leadership, and cooperation to succeed. Therefore, I will discuss Symkala accordingly, by first discussing the products of Symkala before the abstractions of venture creation.

6.2.1 Symkala the product

The invention of Symkala was directly informed by the prototypes of section 5. In the investigation to combat disinformation, how to build products as multipliers, and how to build a new venture, two new questions came to mind I became aware of the limitations of modern GIS systems. What if a software was created to generate and qualify information through continually extruding layers of data and comparing those layers? What if a GIS software was created so that the user workflow started with rich media, rather than CSV tables or SQL databases?

Experimentation through design required stepping away from the GIS interface and engaging with physical materials. I intentionally created piles of photos, books, and paper notes with no order to test processes for pulling them out, sorting them, and making sense of them. Sharing these experiments with my colleague, we discussed card sorting as a process for gaining insight into the relationships between individuals and groups, a long established design method for information architecture and sense making processes (J. Nielson 1995) (M. J. Harper 2003).

Researchers have found that the physical distance between piles of cards can be used to construct a matrix of concept relationships by distance, creating an observable network model of a person's conceptual *mental model* (Diebel and Anderson 2005; Steiger and Steiger 2008). *Graph visualizations of* card sorts can reveal new insights about the topics not often accessible through typical card sort exercises (Paul 2014). Grasping the structure of a person's mental model using spatial proximities in card sorting made intuitive sense. Concurrently, researchers were finding that we navigate the world by spatially aligning our neurons in our brains to create miniature replicas of the physical world (Ravassard, et al. 2013; BJ, et al. 2015). Each neuron takes care of a single space, so every time you walk through your front door, the same neuron fires at that place and not at any other time. Though unproven, I posited that the spatial proximities of card sorting to manage information might correlate to our mental models of spatial phenomena, and thus card sorting could function as the window to new GIS workflows. In other studies, researchers have found that the processes of computational card sorting exercises are as reliable as physical materials for research needs (Bussolon, Russi and Missier 2006; Chaparro, Hinkle and Riley 2008).

In the images below, Figure 19, I created a portfolio of poorly structured information, with variations in reliability in the validity of the information. In sequential images, I sorted the information into piles, counted the content of each pile, and drew edges between each. Removing the imagery, I was left with a graph representation of the card sort exercise. This graph model has clear limitations if applied as an abstraction. However, if each node of the graph is annotated with attributes, then the card sort interface has unlocked a human experience for data management distinct from the logic of a SQL query. In the backend, the database structured could remain the same, though each record is now appended with rich meta data on the location of the data on the card sort interface.

Conceptualizing the formation of an argument as a set of relations between shared points of evidence over time, one could describe any given concept as a network map of evidence points and tangential relations. In this manner, Symkala could store the mental model abstracted from the card sort UI and build a map of underlying relations across different sets of analysis. One day one, an analyst has a particular understanding of a problem, but as a new point of evidence is surfaced, the mental model of the problem shifts. When working in a team, the divergence of views slowly become more and more alike over time. The convergence of views can be reflected graphically.

The card process was also a gate way to explore how the insight of Rittel's Issue Based Information Systems (IBIS) could function within a GIS environment. Rittel argued that understanding the problem provides a path toward taming it (Werner & Rittel, 1970). IBIS mapped dialogue and rated arguments over time by multiple stakeholders to enable problem definition and process decisions by diverse groups (Conklin, 2006). In the way that IBIS organized the flow of argumentation across a group of stakeholders, the card sort UI enabled the analyst to organize the flow of data points across sets of information and rank the confidence in that data through association. Data that is isolated becomes areas for investigation, wherein the analyst may discover value by working between the material object and the context (Ingram, Shove, & Watson, 2007).

Once the card sorting process for data management was realized, the ability to construct a meaningful workflow was aggressively simplified. As GIS workstations tend to have a frustrating user experience, I sought to utilize the card sort interface as the primary interaction of the software. The experience of creating, sorting, and storing card assortments was the central interaction for the use. Working with my team, we developed a hierarchical approach to card sorting in which one can fluidly assign data to "cards" and then on the GUI stack cards into "piles" to render different kinds of analysis. The pile process was intended to statistically weight the data through its spatial distribution. Figures 20 and 24 demonstrate design prototypes, working through the UI design for the card sorting process. The intention of this model was to make sure to not treat all information equally. Furthermore, by creating coherent groups – data ontologies – one can quickly establish links between different kinds of knowledge, permitting holistic assessments from otherwise fragmented inputs utilizing automated reasoning.

Rather than force the user to think through analytical functions, I sought to build a GIS that enabled nuanced consideration of the information as an artifact. GIS solutions generally fail to recognize the practices that inform information capture. There is little consideration of encoding and the highly textured insight that GIS can generate (Sheppard, 2001). I sought through Symkala to give form to Dourish's conception of digital ethnography, "to sift through these multiple meanings and extract a particular registration of the world that is effective for whatever purposes are at hand (Dourish, 2001, p. 144)." The goal was not to elevate the user toward some moment of existential realization, but to remove obstructions for the user to move through the world with fewer hindrances.

I posited the software could offer analytical types best suited to the type of data available, and thus the user needs to only think about the information relationships, not the software management. In Figure 23, the prototype contains a list of sample analytical outputs available to the user. This approach was retained over multiple iterations of development and can be identified in Figure 24.

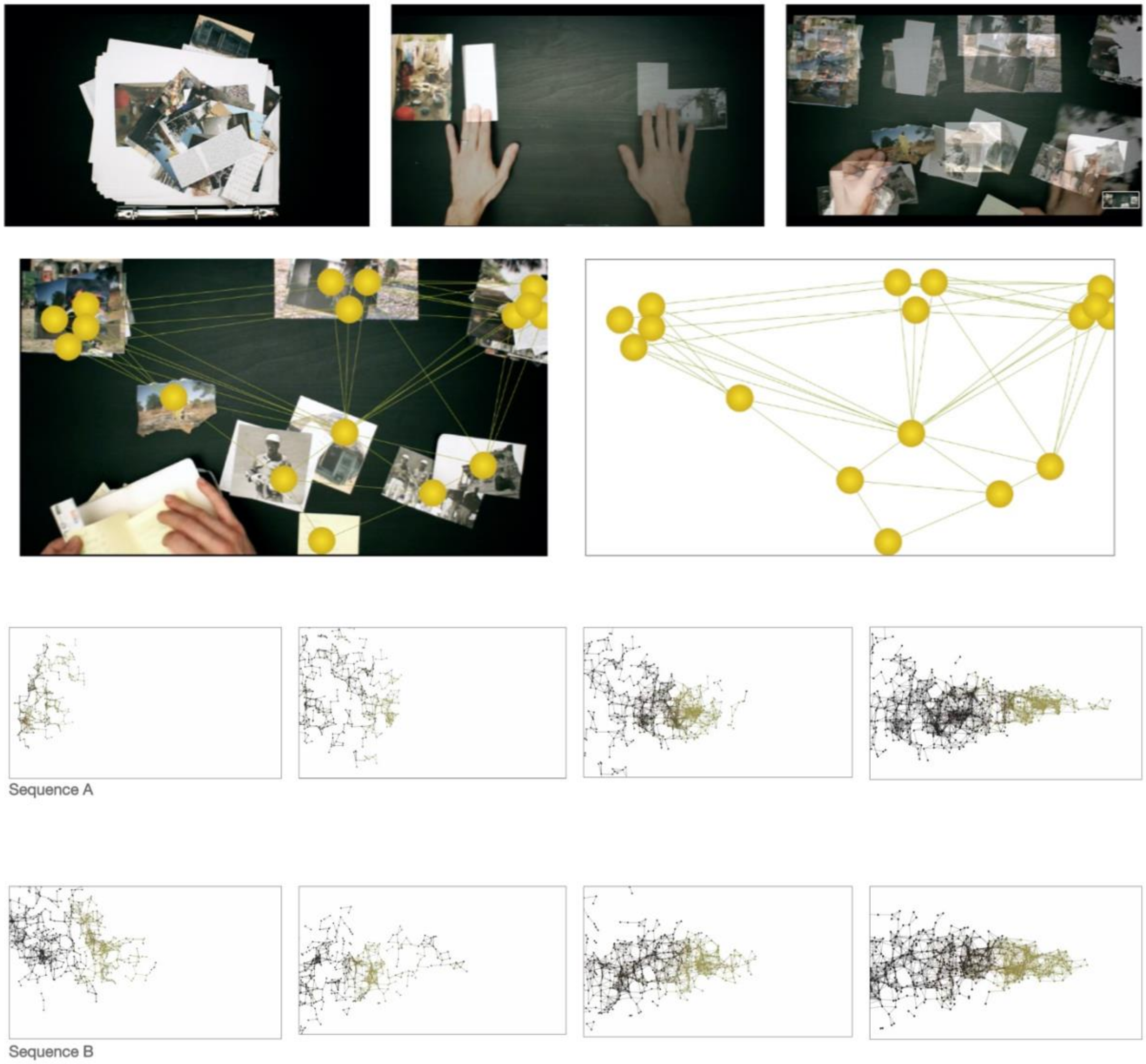


FIGURE 19 CONSTRUCTING A KNOWLEDGE GRAPH OVER TIME FROM CARD SORT PROCESSES

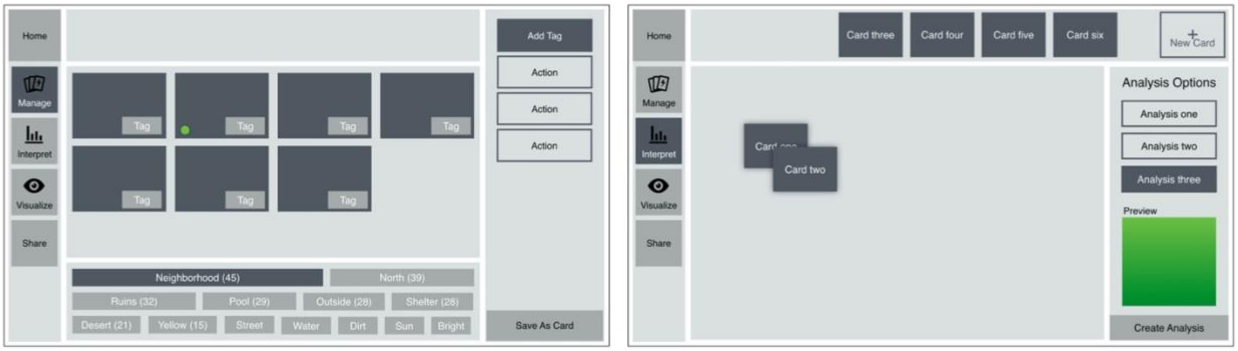


FIGURE 20 DATA ON LEFT UI IS ASSIGNED TO A CARD (RIGHT) VIA TAGS

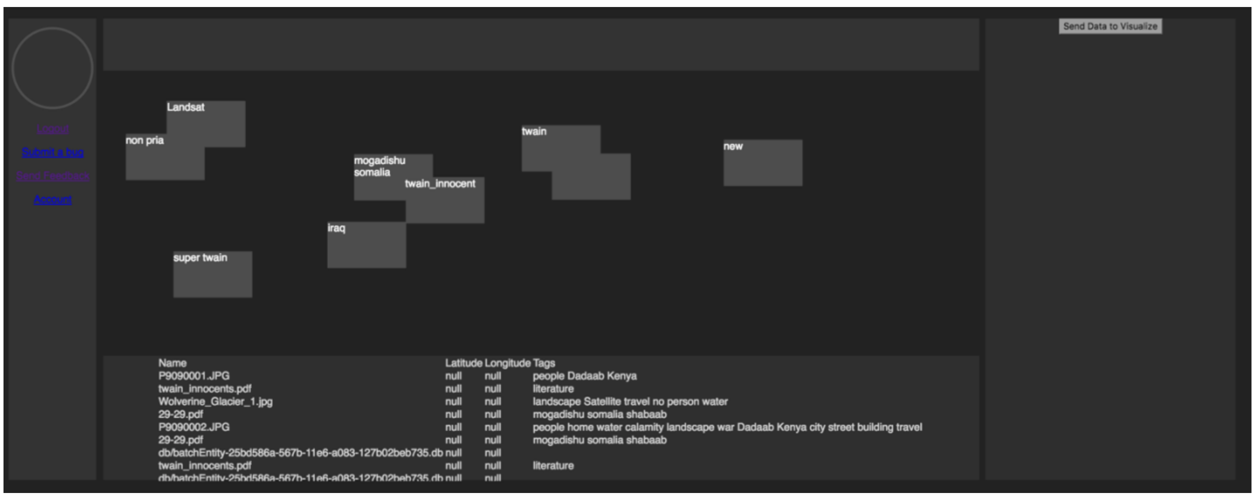


FIGURE 21 WORKING SOFTWARE OF CARD SORT UI

The notion of how to organize unstructured data with a card sort application was further informed by a photo included in a press release from DARPA on the visual management of unstructured media to extract key data points (Conant 2015) Figure 22. The image below is small and slightly blurred as are all copies of this image circulating on the internet. Though my efforts to learn more about this project from DARPA and the US Army Research Laboratory were unsuccessful, I did accidentally stumble upon a large version of the poster-size image in the lobby of DARPA headquarters in Arlington VA in early 2016. Studying the image, it became clear to me that the clustering of media files holds many similarities to the card sorting exercise, though metadata is graphed on the sides to permit rapid sorting and reconfiguring of the UI, consistent with my own goals. Though the DARPA research was not available to the public, I found the illustration highly illuminative in how it broke data into clusters and provided broader meta-management tools at the margins.

FIGURE 22 THE UI FROM DARPA FOR SORTING VISUAL MEDIA

I then constructed a four-phase workflow (Figure 23), in which each phase provides a unique UI unencumbered by the tasks of another. An incentive of this model is to also permit group-based problem solving, wherein tasks such as data management or simulation work may be delegated to specific team members, or one person may work through the entire sequence. This approach is also reactionary to many existing commercial solutions such as Tableau, wherein the UI contains and overwhelming quantity of features, or ESRI products in which all the tooling is consistent with the logic of SQL more than the logic of a user attempting to conduct a task.

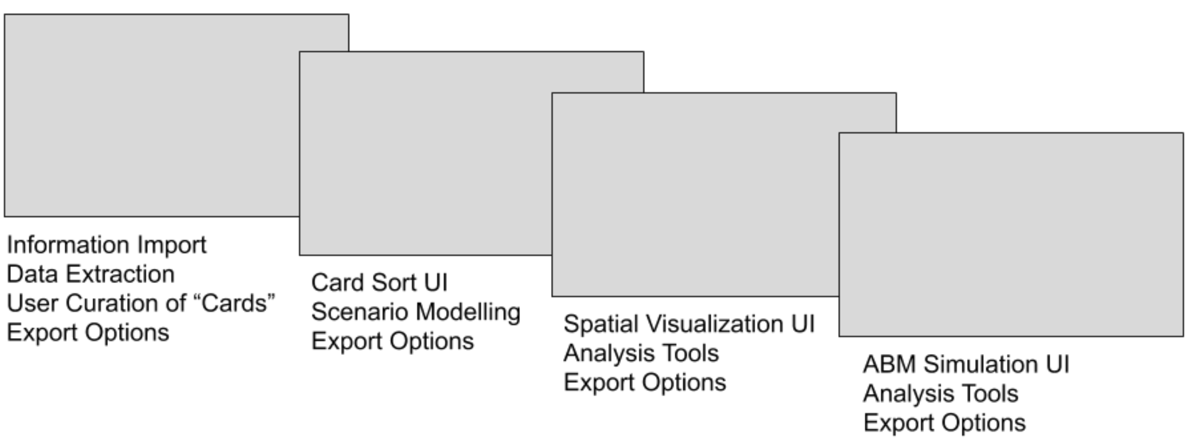


FIGURE 23 A FOUR-PART WORKFLOW

The challenge is that such a simplified workflow is also somewhat impossible when one begins to investigate the all the possible subroutines necessary to execute the overall tasks such as:

1. Uploading information
2. Investigation of unique elements in pdf, image, or video form
3. Modification of information through correction or augmentation
4. Extrapolation of data
5. Labelling
6. Ranking
7. Sorting
8. Curating card creation,
9. Card management
10. Card manipulation for visualization,
11. Parameter modification for card manipulation
12. Visualization modification
13. Editing
14. Sharing of visualizations entire projects for distributed teams
15. Distributed teams also suggest the need for unique user profiles, profile management tools and sharing permissions management

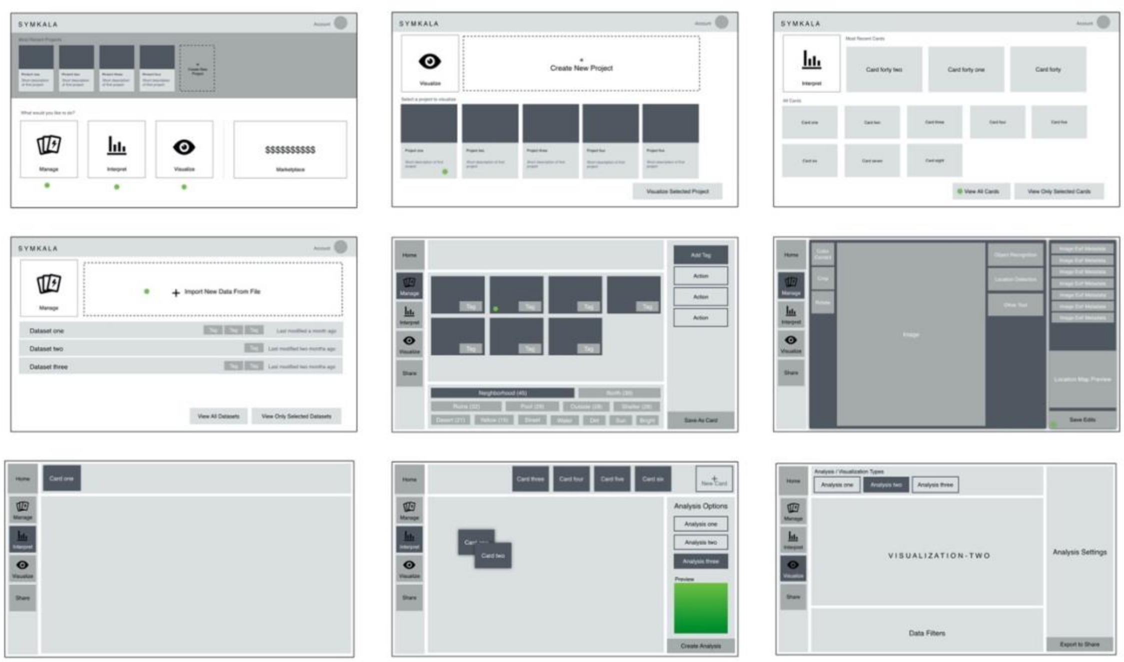


FIGURE 24 FULL-PRODUCT WORKFLOW PROTOTYPE

6.2.2 Building a product for systems-level change

Though lean startup methods advocate that one should build the absolute minimal product, I found this advice often in conflict with the demand of investors or to get prospective clients who want to see a fully functional software suite. In an attempt to assuage this challenge, I initially explored the development of a full spectrum clickable prototype with Yaakov Lyubetsky of HCII using the software Keynote (Figure 24). Development of the full-scale prototype was complex and generated an arrange of possible workflows, UI configurations, and techniques for prompting the user toward certain behaviors. Most powerfully, by means of this exercise it was possible to better identify and prioritize the key mechanisms and interactions necessary to construct the central workflow

The creation of the software beyond non-functional prototyping created a mass of challenges. I was fortunate when a CMU engineering alumnus, Will Milner, was able to lead primary development efforts and guide me on fundamental engineering issues such as database and API design. Yet the engineering constraints always undermined our ability to deploy the software at a high level of quality sought in the prototyping.

- The first release of Symkala provided nothing than the ability to sort photos, assign text as tags and sort by tags. One experiment was to adjust the size of the tag filter relative to the quantity of images with that tag (located in the bottom of Figure 25), so that the tag filters functioned as a visual graph for rapid assessment of the image inventory. This proved the capability of the product to do certain tasks but did not prove the product as a means to better understand information, to counter disinformation, or provide a superior approach to GIS.

- The second release provided a basic but complete workflow from import, classify to sort, and visualize (Figure 26). The UI for the data management continually changed across multiple iterations, as it was hard to communicate the value of the analysis to the engineer. While my collaborators were a data scientist and engineer who understood my designs, his engineering skills were limited to Java and C-based languages, but we were building software with Python on AWS, both of which were outside his comfort zone. With focus, the two engineers could work together and accomplish much, but it was difficult to always get this collaboration in place and on a reliable schedule. Consequently, the UI frequently contained outlandish visual decisions that were made impulsively (Figure 27). Over time I was able to better define and communicate patterns for development.

- By the third release, Symkala was beginning to achieve some level of utility (Figure 28). At this point, a little more than a year had passed to get the software in place. A balance had been found within the team between the desires for UI design and technical ability to deliver that design and the analytical offerings were beginning to make sense, enough that I could reach out and engage others in the market. I was not confident, however, that the product had managed to fully solve the problem of countering disinformation in geographic data.

- As we achieved the final release, we accomplished a benchmark, the ability to upload a document and export a map (Figure 31). I considered this a plausible example of how information can be translated into different mediums through the GIS tool, so that continual comparisons can test and validate data through use. In the image below, a PDF copy of Mark Twain's "Innocents Abroad, A Pilgrim's Progress" has been uploaded to Symkala, and it has rendered a map of all the places visited by Mark Twain on his documented journey around the world. Utilizing a co-occurrent network analysis option, it was then possible to organize clusters by walk ability, mapping Twain's bar crawl in France. This demo – I believed - opened a clear market opportunity, in which large organizations with massive archives of text-based reports could now translate that archive into graphics for rapid mapping and analysis of data trends.

- Figures 30 and 31 demonstrates the most advanced stages of development. Photo and PDF texts could be imported en masse. Images would be assigned text descriptions via machine learning algorithms. Text would be parsed by person, place, and a GPS location assigned to place names. All images and text would have an associated database file. One could group selections of information and assign them to a card for the card sorting window. Within the card sort, different visualizations and analysis tools would become available based on the composition of the card sort and the data contained within. Visualization tools included heat maps and network graphs.

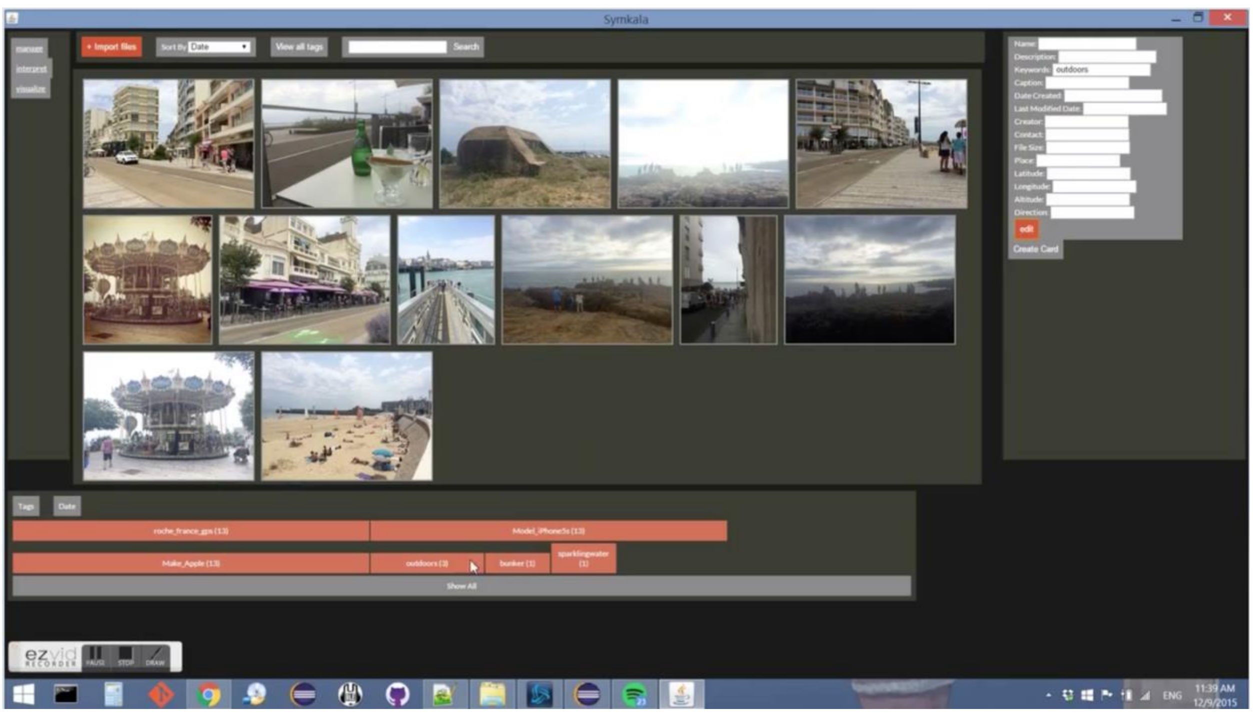


FIGURE 25THE FIRST RELEASE OF SYMKALA

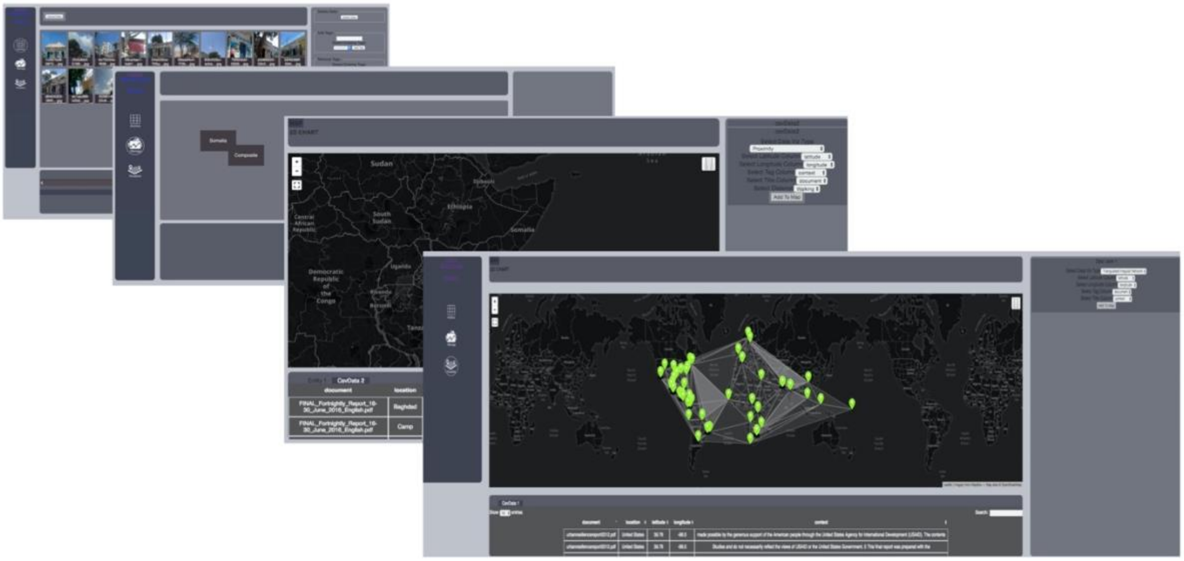


Figure 26The third release of Symkala contained the full workflow through phases of data Management, Card Sorting, Visualization and Analysis

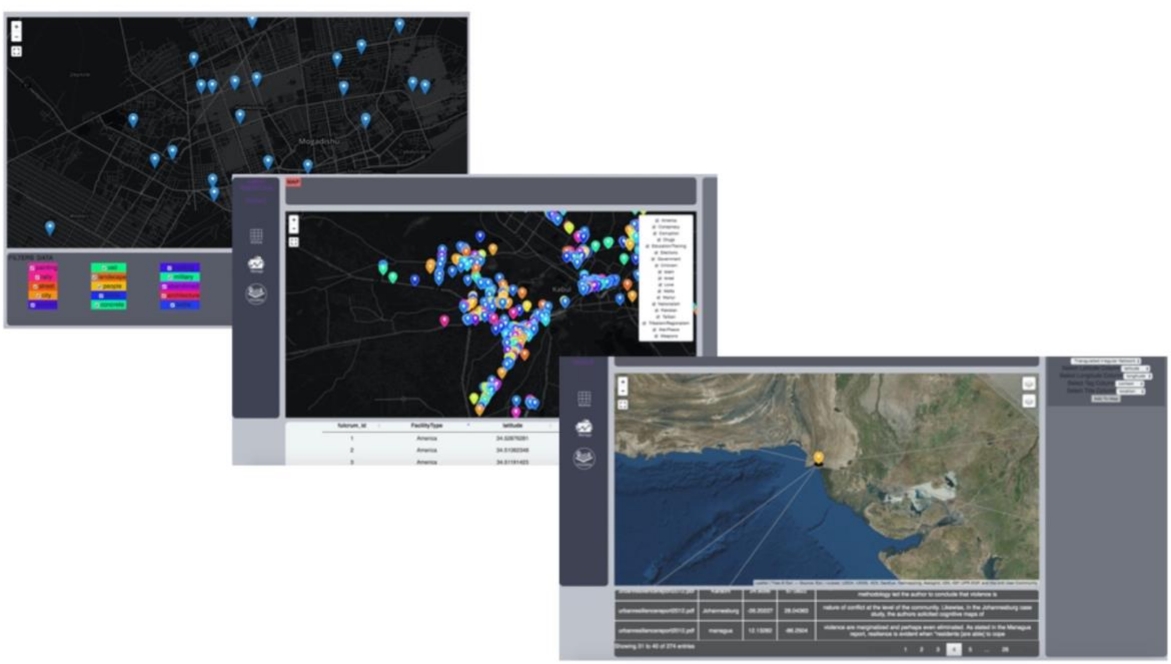


Figure 27 Internally communicating interaction design requirements data visualization proved a constant challenge

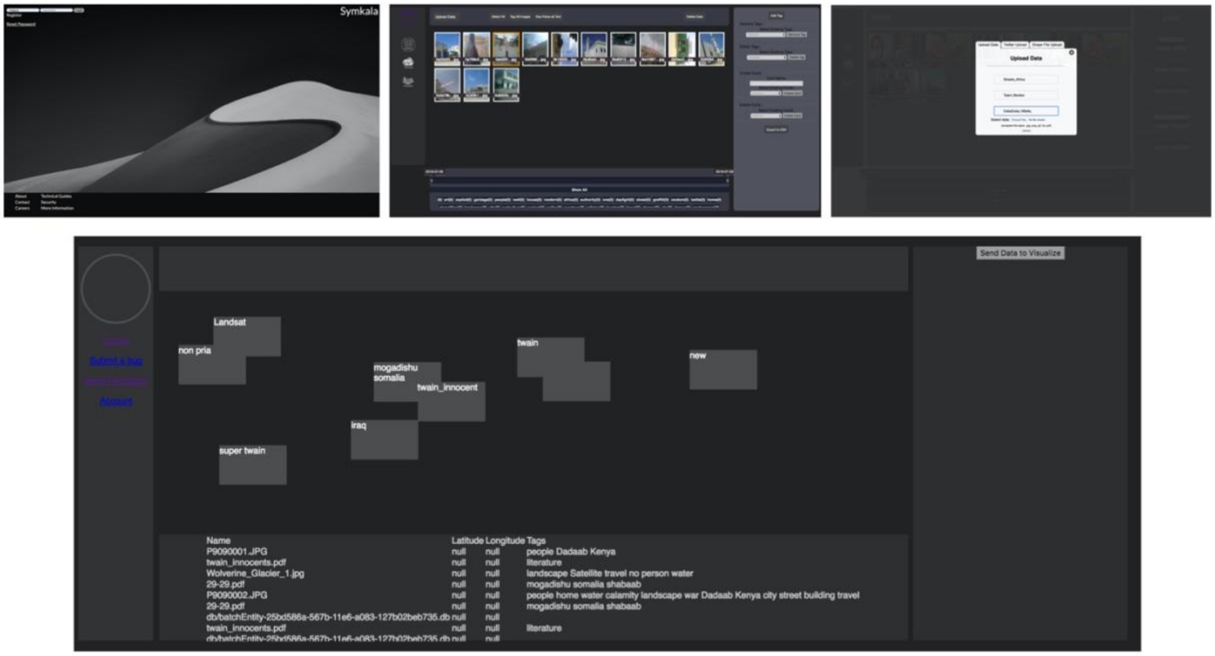


FIGURE 28 THE FIFTH VERSION OF SYMKALA SHIFTED TOWARD A DARK UI BUT ENGINEERING LIMITATIONS UNDERMINED COHERENCE ACROSS SCREENS, WITH WIDE VARIATIONS IN VISUAL DESIGN, TEXT, AND FEATURE DEVELOPMENT

FIGURE 29 LEFT, ALL LOCATIONS REFERENCED IN MARK TWAIN'S "INNOCENTS ABROAD," CENTER, ZOOMING IN ON ONE LOCATION REVEALS A NETWORK ANALYSIS OF SMALLER AREAS VISITED BY TWAIN WHILE IN FRANCE. RIGHT, FILTERING THAT DATA REVEALS MARK TWAIN'S BAR CRAWL ON A SINGLE EVENING

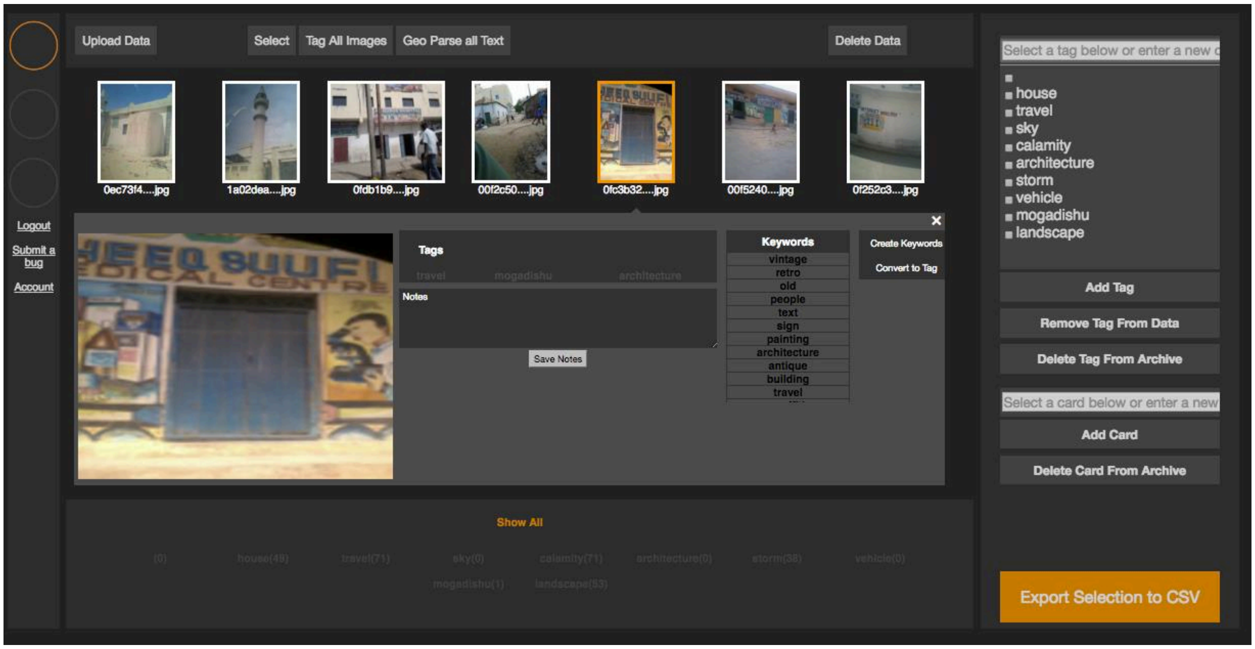


FIGURE 30 THE FINAL RELEASE OF SYMKALA FEATURED HIGHER LEVELS OF INTERACTIVITY, INTEGRATING QUALITATIVE NOTATION WITH MACHINE LEARNING APIS TO RAPIDLY CLASSIFY IMAGERY AND TO GEOPARSE PDFS INTO SPREADSHEETS. IT ALSO BETTER RECONCILED TECHNICAL DESIGN LIMITATIONS WITH UI/UX EXPECTATION

FIGURE 31 A COLLECTION OF VISUALIZATIONS PRODUCED FROM TEXT, PHOTO, AND TRADITIONAL STRUCTURED DATA GENERATED IN SYMKALA IN JULY 2016. IMAGE TOP LEFT MAPS TRAVEL ACTIVITY BETWEEN BALTIMORE AND WASHINGTON DC VIA PHOTOGRAPHS, IMAGE BOTTOM LEFT MAPS ECONOMIC ACTIVITY FROM A QUALITATIVE REPORT, IMAGE AT RIGHT UTILIZES THE ACLED CONFLICT DATASET TO MAP THE DENSITIES AND GEOMETRIC PROXIMITIES OF CONFLICT ACROSS AFRICA.

6.2.3 Designing a new business venture

Informed by the research prototypes, I sought to build a more complex and comprehensive software to explore the qualification of data. My intent was to synthesize the findings of the prototype research into a linear workflow for a data analyst. The heart of many modern startups is the pitch deck, a brief presentation. of the concept, the team, product, the market opportunity, the strategy to capture market value, prospective growth and requests for funding. For the modern company, the pitch deck is the vehicle for engaging lawyers, investors, and prospective clients. In my work, the pitch deck was the business plan. It established the story, the market proposition, succinctly communicated the methods, sales channels, and value derived. Over the entire lifespan of Symkala, I built over 28 iterations of the pitch deck, with a series of smaller versions (version 1.2, 1.3 etc.) along the way. Initial drafts were informed by commercial templates, later informed by the decks of successful companies such as Airbnb, and later by direct feedback. See Figure 32 for a sample of decks that reflect the evolution of content over time.

Over the 28 different versions of the deck, the narrative shifted aggressively from an application that that does verified mapping for cities to serving as a tool for intelligence analysts. In the meanwhile, big companies like Palantir and ESRI had become juggernauts for government agencies, who were not entirely thrilled with those tools and had money to seek out new solutions. Through this process, it also clarified my own sense of mission, that by building a technology on a certain moral premise, that I could instantiate these values into government agencies. In other words, I hoped to change intelligence agencies by changing their technologies to align with different values and theories.

Another observation of the transformation within these decks is that the "pitch" – and thus the company - became far more autobiographical. Within the first dozen iterations, the argument for the technology was purely technological – look at machine learning! Yet by version 28 the argument shifted into a story, the story that I am building this company because I have had a unique set of experiences that have led to an insight into information systems, and therefore I am sharing this insight through building this company and product. This simple narrative generated far more interest and support from possible clients, investors, and potential technology users. The three examples selected from 28 iterations of pitch decks in Figure 19 also demonstrate continual changes in branding, message, and communications design. The company message and identity shifted over the deck away from a focus on the tool and onto leadership, teams, external validation, and simple processes.

Another example artifact is a booklight designed for customers that featured possible use cases, provided information about the company team and our approach. Sample pages from this book are also within Figure 34. The hypothesis was that sales interactions should have a material component, and that the exchange of the material is a means to continue conversations and enable transactions. I also sought for these materials to be circulated throughout organizations. Creating these artifacts required a shift in perspective, from that of entrepreneur to the customer, with specific expectations, beliefs, and needs.

Over the course of two years, I had approximately 50 meetings with prospective clients and investors. As a business model, I sought to provide bespoke services to companies which could be enhardened in the product development. This model is consistent with the teaching of lean entrepreneurship. Yet this path was not welcome by companies. They either hired specialists or the bought new things but rarely did they welcome an outsider into their organization to then create a market solution. Lean feedback methods were not possible.

FIGURE 32 ITERATIONS OF THE PRESENTATION DECK, VERSIONS 1, 13, AND 28 FOR THE SAME CONTENT SECTIONS

FIGURE 33 A DIGITAL BOOK OF MARKETING MATERIALS FOR CIRCULATION

Throughout this process, I never secured a paying client or any capital. I spent over a year immersed in the Pittsburgh innovation ecosystem but discovered it best served recruitment, not customer acquisition. Possible customers were not participating in these events and had to be found outside. After relocating to Washington DC, I then worked through a very different innovation system, built on federal demand for robust solutions. I found my business venture was too underdeveloped to compete succeed in government IT product acquisitions.

Through the venture I did have a range of unique and unusual encounters that I consider successes. I sought government funds through DARPA, Homeland Security, the US Navy, and the National Geospatial Intelligence Agency. I met with two private intelligence contractors, three different DARPA program offices and two offices at the CIA, and one with the Directorate of National Intelligence. I engaged international NGOs and corporations like the Aspen Institute, FHI360, and AECOM. I also managed to get into the offices of New York City millionaires, a Texas billionaire, and presented to the board of the Latin American Development Bank. Many of these engagements resulted in a second meeting but none ever resulted in a transaction.

A constant hardship was to distill the range of feedback from the various stakeholders into actions, as the sequential interactions and extreme variations in perspective did more to push the product development across a range of incongruent paths. Engagement with prospective companies and investors drove the development path of the software. The methods imbued by lean startup, agile, and user centered design insisted that user needs should drive the direction of the product. Through this process it became transparent that the "lean" frameworks for design and entrepreneurship are excellent when a solution path has already been developed, but in this instance failed to generate a market proposal at the outset.

Over time, to develop the business within the ecosystems, I came to rely less on the software under development but found that greater traction took place through creation of a bold vision and circulating that vision through conversations. The product – the software – was somehow a distraction to the business, except among government offices who simply wanted to see a demonstration of "capabilities." Over and again I discussed the value of design processes, working closely with end users or integrating with existing infrastructures, and this often was stated as an impossibility.

FIGURE 34 A FOUND PAINTING FROM FUNCTIONED AS AN ARTIFACT OF INSPIRATION AND TEAM MOTIVATION. AS THE "BEST PERFORMER AWARD" AT THE CONCLUSION OF EACH COMPLETED SPRINT COMPLETION, THE RECIPIENT HAD THE OPPORTUNITY TO CONTRIBUTE TO TRANSFORMING THE PAINTING THROUGH A CREATIVE ACT.

Taking Symkala outside of business circles and into the domains of research and academia, I found a completely different response. Presenting this work to geographers, urban planners and government officials with deep backgrounds in geography (such as a meeting with the Presidentially appointed *Geographer of the United States of America*, at the US Department of State) would enthusiastically respond. These communities had not considered how the process to design something establishes opportunities and limits on the user experience and for the ability for a user to accomplish a particular set of goals. They found the approach refreshing and welcomed.

For internal management, I continued to rely upon an artifact driven approach. Through materializing values, expectations, plans and processes, I could better motivate and lead the team through phases of venture formation and early growth. Several of our processes were borrowed from existing industry standards, such as the use of a two-week sprint. However, I continually sought material forms to inspire and drive collaboration and performance. For example, in Figure 34, the presented abstract painting represents an award system utilized to inform higher performance by the team and to foster a culture of creativity. The painting was initially created in the 1970s, purchased for only few dollars and depicted a woman sitting in a garden. At the conclusion of each sprint, we would internally vote for the person who created the greatest contribution to our goals. Once that person was identified, the painting was provided to that person to keep for the duration of the next sprint. That person tasked to modify the painting in some form toward the invention of a new artwork.

The painting in Figure 34 received continuous modifications for approximately 8 months by each member of the team. To receive the object was a distinction of merit, and the more outlandish the modifications, the more the greater the admiration of the team. Initially my colleagues found this practice to be strange and their modifications were highly reserved, but over time, it became central to our process, part of our identity as a team, and the changes were far bolder.

6.2.4 Discussion

All efforts in product design and venture creation was initially influenced by lean methods. For Symkala, I was constantly in search of the "minimal viable product," and to learn from users to create that product. This is the common wisdom of the modern innovation industry. Many design communities have additionally coopted these methods, with a focus on Lean UX or Lean Design Sprints, to rapidly create the minimal value through design with a tight feedback loop with problem owners (Ries, 2011).

FIGURE 35 THE EVENTUAL MINIMAL VIABLE PRODUCT DID NOT REQUIRE THE FULL COMPLEX WORKFLOW, BUT PROVIDED A ONE BUTTON INTERACTION TO TRANSLATE AN IMAGE OR PDF DOCUMENT INTO A CSV OF GEOLOCATED DATA

Over time I did realize a minimal product. The narrow capabilities of machine learning are not necessarily improved through complexity but make it more difficult to account for the short comings and limitation of the overall software. By contrast, a simple algorithm with a simple UI would yield a more useable output. As an experiment, a quick and simple parallel effort for Symkala consisted of a single upload button (Figure 35). With this UI, a user can drag a pdf to upload and then automatically download a CSV document that parsed the document with identified all actors, proximate locations, provided lat/long coordinates for each location, and a confidence ranking in the relationship between the person and the place.

Yet more deeply, Symkala did manage to satisfy some of the greater demands to build a product for systems-level change. I was able to channels systems level insights into the product, work through user scenarios, and adapt the solution to meet broad user expectations (Myerson 2017; Buchanan 2019; Weller 2019). The workflow in which the user works through vast qualities of data and utilize human and machine labeling systems to build arguments. Symkala is most effective to reconcile conflicts in incoming information, in terms of origin, values, or depth of insight about a given worldly scenario. Through constant investigation, augmentation, sorting, consolidation, and reconsolidation of individual data elements, the overall bias of argument that underlies the data is able to change and redirect over time and use. The analytical outcomes are constant and fluid, providing a structural approach to information management for the needs of a complex world.

It became clear through this work that Symkala offered a malleable approach to the creation of training data, an approach to manage Rittel's priority for equities, enabling the opportunity for less biased models, though the approach was not specifically "human centered" as ascribed by UX Collective (2019). Rather by reflecting on information as a material as described by Dourish, Zimmerman, Yang, and Forlizzi, I was able to capture and translate rich interpretations of the world into granular data for analysis, a process more typically informed by ethnography.

To effectively utilize Symkala, it is essential that the analyst work toward a defined problem. Not all software's require a clearly defined problem for use, such as Facebook. Conventional GIS software requires a far more structured approach to problem definition to for any type of use. The mixing and movement of information will render a meaningless analysis, but nothing more.

Rittel's third expectation of socio-technical planning professionals, expertise in goal formation, is far more ambiguous. Goal formation subject to normative theories on how the world should be. Symkala does not directly impose a process of goal formation. Some software products, such as community messaging boards, may facilitate a particular goal, in this case, a more integrated community. Symkala does have the opportunity to make use of divergent analysis across users, thus enabling better team coordination, but this function was never fully built, and I believe reflects more of a problem than a goal. The outputs of Symkala could be used to support nefarious purposes. Either way, the product is enabling systems-scale repercussions.

Through this process, I came to more deeply understand and recognize the constraints of lean within design, and how design can better inform new venture creation. No doubt, there is much improvisation in entrepreneurship (Shepherd, Souitaris and Gruber 2020). Yet reflecting further upon the experience of engaging innovation economies to build a product, it has become clear that lean is in many ways counter-intuitive to creative problem solving. The Mansoori & Lackeus articulated lean as a means for discovery and to as a means to manage uncertainty, I found this is only true of the engaged customer audience and resource pools are homogenous.

If there is high differentiation across interactions, then lean methods will pull the entrpeneur in countless directions. Whereas the making of artifacts ground the business. To design the business through process design, branding, narrative construction and team creation is strategic and bold. It may have a high chance of failure, yet this process of making goes beyond the claims of Batova, Clark, & Card, (2016), that design only enables customer discovery. Rather design enables the substantiation of the venture from idea into material form. To make design and lean methods fit together, the focus is usually on the phases and artifacts to be produced. The creation of UX artifacts such as user personas and journey maps are effective. Yet the deeper focus is the creation of human relationships, the creation of value, and the exchange of value.

Nielsen & Christensen discussed design process as valuable to provide ideation and direction, but were less certain on how a design process may shape business decisions. I have found that the effectiveness of a design process is contingent upon the type of artifact that can be produced to solve a given problem. The traditional business plans have been replaced by value frameworks, and industry pitch decks. Such artifacts are far more emenable to the exploratory and iterative value of design. Through service design, one may also design client engagment models, transaction models, and communication systems. Such artifacts do maintain bias toward "as it should be," (S. Sarasvathy 2009), but within a learning mindset, such designs can adapt to the benefit of the business.

6.3 Symkala Summary

In this section, I conducted research through the design of a new venture, Symkala, and through the creation of a GIS product, a product designed for systems-scale problems.

The company, Symkala, was designed through the recursive development of the pitch deck. This artifact provided a scaffolding for business strategy, team organization, sales models, and value proposition. Initially the company promoted a novel technology solution to general analytical needs. By the 28th iteration, the company promoted the team, an organizational structure, and a vision and a transactional model to realize that vision more than a specific product.

The product, Symkala, relied upon a novel workflow to enable an analyst to collect information from multiple sources, such as imagery and text files, and map those assets for geographic analysis. These works were conducted to investigate how the design process can inform new business creation, and to explore how product design may achieve systems level impact.

Though Symkala explored the function of information in GIS, it did not directly set out to combat disinformation. It provided a means for product users to think critically about the information and the source of that information for analysis. Therefore, my next case study, Geo4Nonpro, was intended to more directly combat disinformation.

6.4 A GIS product to counter disinformation across systems

6.4.1 Background

While working as a Presidential Innovation Fellow throughout 2016 and 2017, I was detailed to the US Department of State in 2017 to work with the Bureau of Arms Verification and Compliance. This office ensures that countries around the world are upholding nuclear weapons treaties, tracking infringements, and building evidence on compliance to pursue diplomatic measures for treaty management. Overseen by the Undersecretary for International Security, who reports directly to the Secretary of State (then Rex Tillerson), the bureau collaborates with the intelligence community (IC) to obtain information on violations and to influence the direction of IC investigations. Furthermore, the Office of Verification, Planning and Outreach managed a fund known as the V-Fund, to provide over 1 million dollars toward novel concepts and innovations in the private sector for the use by AVC.

I was also asked to develop an action-based approach to countering disinformation. A realization had emerged within AVC that disinformation can undermine nuclear security, not just by directly propagating the world with false information, but by reducing public trust in government. The decided course of action was to assist non-government institutions with any kind of technology, funding or expertise to enable those organizations to better do their work. Ideally, with more resources, these independent agencies would generate more public interest through their work, and if their resources align to the views of the US government, the network of information would enable public trust.

No doubt, this strategy is complicated, as independent bodies should not accept the resources of the US Government. Consequently, these efforts were limited, ad hoc, and "soft" in nature. As I approached the end my detail to the State Department, I was offered the opportunity to advise a team of academics at the James Martin Center of Nonproliferation Studies on the development of a geographic information system called Geo4NonPro.

Geo4NonPro is considered a "debunking website," a platform that enables citizen participation in the operations of global nuclear security (Lee and Pilutti 2017). Through this platform, everyday citizens have the opportunity to see unique imagery of global research sites that are violating, or at least of suspicion, within the violation of international arms agreements. Global citizens may add their personal knowledge to this site, which is fundamentally a geographic information system, which may enable analysts, support research, and possibly be used as evidence in international regulatory systems.

Geo4NonPro is intended to create training data with the help of non-experts around the world to identify nuclear weapons sites around the world and possible treaty violations. Satellite images are uploaded online with some basic tool for individuals to view and label the images. The expressed goal was that anyone can participate, offering their unique knowledge, "so if you are an HVAC repairman, and you see a specific HVAC unit you can identify, then you can share that information to the wider non-proliferation community."

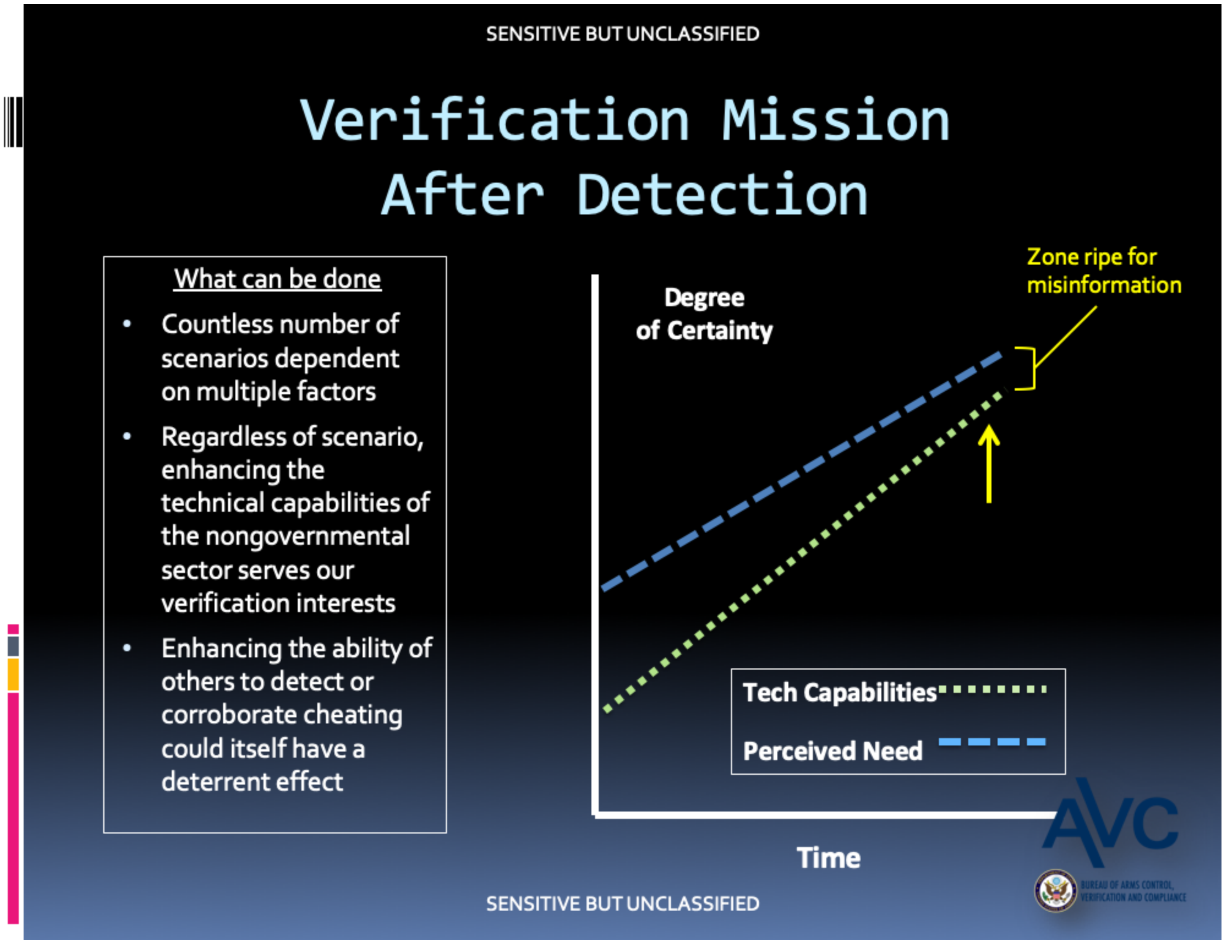


FIGURE 36 STATE DEPARTMENT PRESENTATION ON THE THREAT OF DISINFORMATION 2016

Geo4NonPro was launched in 2016 and was not a success. Commercial satellite imagery was provided by GeoGlobe, one of the few licensed providers of high-resolution satellite imagery. The website was designed by nuclear policy experts in a series of round table workshops and built by a contracted developer. Seven initial sites of interest were provided including North Korea's Punggye-ri and Myanmar's DDI facilities (Hanham 2016). Yet aside from a social media campaign and 526 direct email invitations, the "crowd" of users consisted of only three people.

The product was used by the expert team who created it, but the failure to *crowdsource* undermined the broad utility. The experts were surprised by the low participation, especially because they felt that the satellite imagery of rare sites would be compelling and mysterious. Within the final report, no reason is identified for the low participation. I was asked to transform Geo4NonPro, to overhaul the software design to make it useful toward the goal of creating training data for rich analysis to enable better compliance.

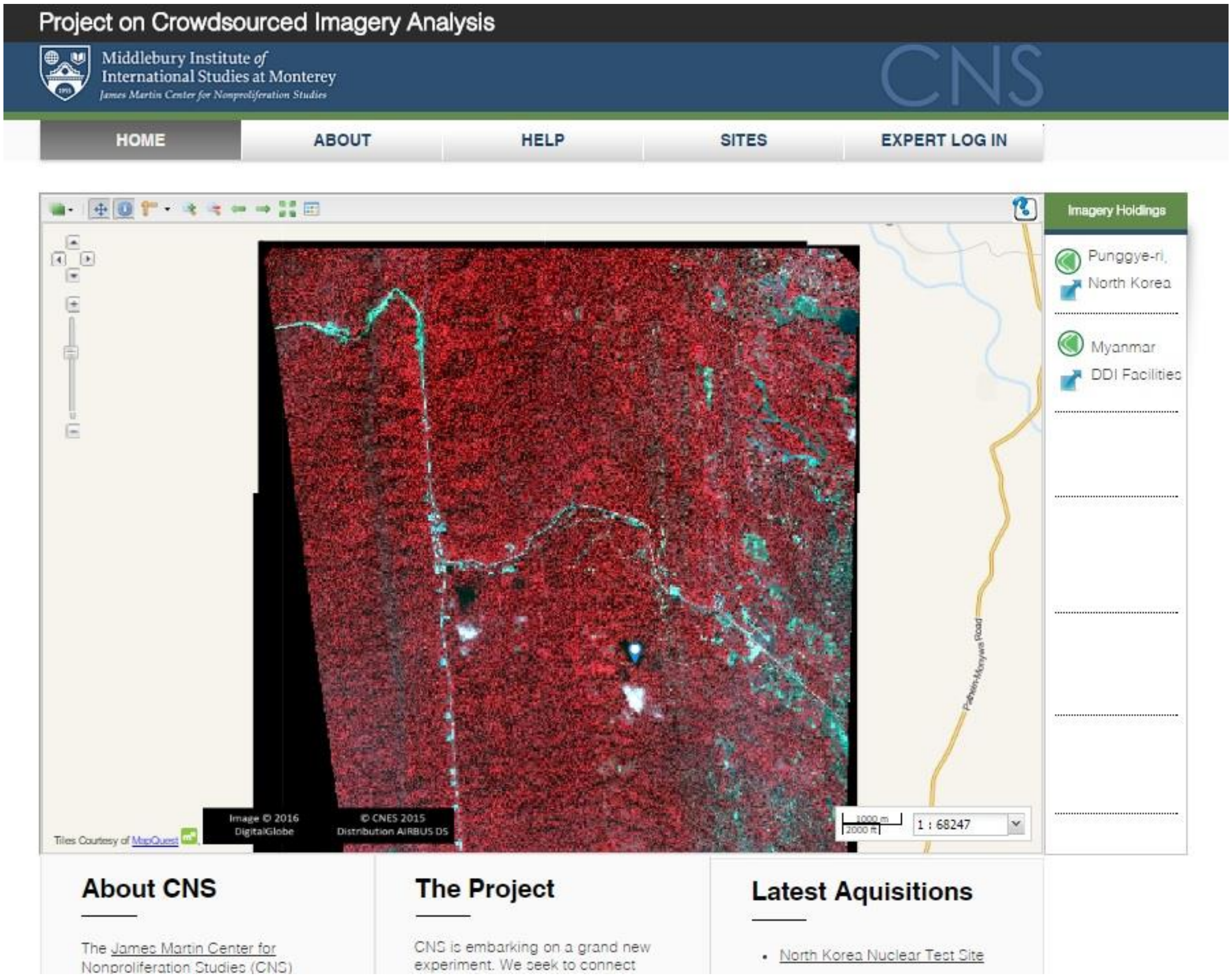


FIGURE 37 SCREENSHOT OF GEO4NONPRO VERSION 1 FROM 2016

6.4.1 Divergent research and synthesis, the first diamond of design research

To better understand the workings and design opportunities for Geo4Nonpro, I approached the problem utilizing the double diamond design process, informed by my own framework for design research.

- I initiated this project by meeting and interacting with a range of direct and indirect stakeholders. I held meetings with the acting Undersecretary, active and retired intelligence agents, State Department Staff and the academics that created Geo4NonPro. Several meetings were about the bigger picture of nuclear security efforts, yet I always made a point to discuss Geo4NonPro.

- Tasked to refine the Geo4NonPro product, I reviewed all documentation on the product, studied the underlying architecture relative to the goals of the stakeholders, generated an account and used the product for intended and non-intended purposes, and made detailed notes on the failures of the product and prospective opportunities for a better user experience and design.

- While tasked to envision a new design for Geo4NonPro, the insights gathered through social engagement revealed that this project – or others – may also be a service design problem. If Geo4NonPro failed to achieve its goals, why would any similar effort with non-government agencies succeed? With that in mind, I began to reach out widely startups whose products may be of value the AVC's mission and directly tested the ability for collaborations to take place.

- Using findings from the above research, I crafted a new prototype of Geo4NonPro. I provided a movie file of the prototype in action, a collection of digital assets to build it, a map of the system, a generic mockup of the software architecture, and a collection of unique screen shots. Furthermore, I provided council on implementation such as development, hiring, marketing, and the use of performance metrics.

6.4.3 Preliminary findings & discussion

Reaching out to engage the professional non-proliferation community, the responses to the release of Geo4NonPro were mixed. While the academics were excited about future prospects, other stakeholders were not impressed or satisfied with current levels of success. The effort was considered to be a great cost for little value. I learned that the focus on crowdsourcing was also strongly tied to the thoughts and aspirations of the former Undersecretary, Frank Rose, a nonproliferation thought leader under the Obama administration. Now with new leadership in place, it was difficult to define the policy stance of the Bureau, undermining the ability to support experimental initiatives.

Furthermore, it became clear that the mental models of organizational processes to resolve problems recognized that the non-linear nature of the Bureau but failed to capture the strong influence of antiquated technologies or processes such as IT acquisition or product design. Illustration 41 articulates how solutions was regularly conceptualized, while illustration 42 describes a more accurate representation of how decisions were created emergently and in tandem with the technical systems in place. For example, I was shocked to discover that nuclear treaties – and all other treaties – are written through a very painful process of sharing word documents by email across hundreds of stakeholders distributed across multiple countries. Throughout this process, the track changes feature is relied upon. As MS Word was never designed for such a function, the documents become bloated and are prone to crashing. Furthermore, the constant exchange results in non-similar documents and often multiple versions of the document are in circulation with little relationship. It was widely accepted that this manner of treaty production adds years to the development time for a multilateral treaty.

When I introduced concepts such as the version control model used by Gitlab or the design of a blockchain ledger system, individuals were quick to jump to buzzwords like *blockchain*, although any proposal in experimentation quickly lost steam. Geo4NonPro was held as an example of how things should be done – by committee, extensive planning, extensive report writing, and as singular pieces of technology that can be dropped into a problem to unleash a new *capability*.

This focus on technologies as capabilities is completely void of consideration for the persons, processes, or problem composition. Rather a capability is defined by the beliefs, expectations, and needs of the technology user. Notably, there are multiple users in these kinds of complex problems such as nuclear non-compliance identification and verification. Commonly identification is similar to the work of Geo4NonPro – human or machine analysis of sensor data, collected through large, expensive and rare technologies. A good example is a global Nuclear Detonation Detection System, the global network of seismic sensors that can monitor vibrations in the earth's crust, separate nuclear explosions from shifting tectonics, and triangulate the location of those explosions for human review. In this case, the users are the immediate scientists, the technical specialists of partner agencies collecting parallel data, and then the hierarchy of organizations who will distill and produce decisions through this information. While the capability may be intact – to locate nuclear activity within seconds, anywhere in the world – the bigger ability to leverage this asset is quickly diluted through human disagreements and the normal chaos of complex organizations. Consider how an aging long-form technology such as email functions within the process, and it is clear that the transformation from observed problem to real-world solution is a socio-technical nightmare.

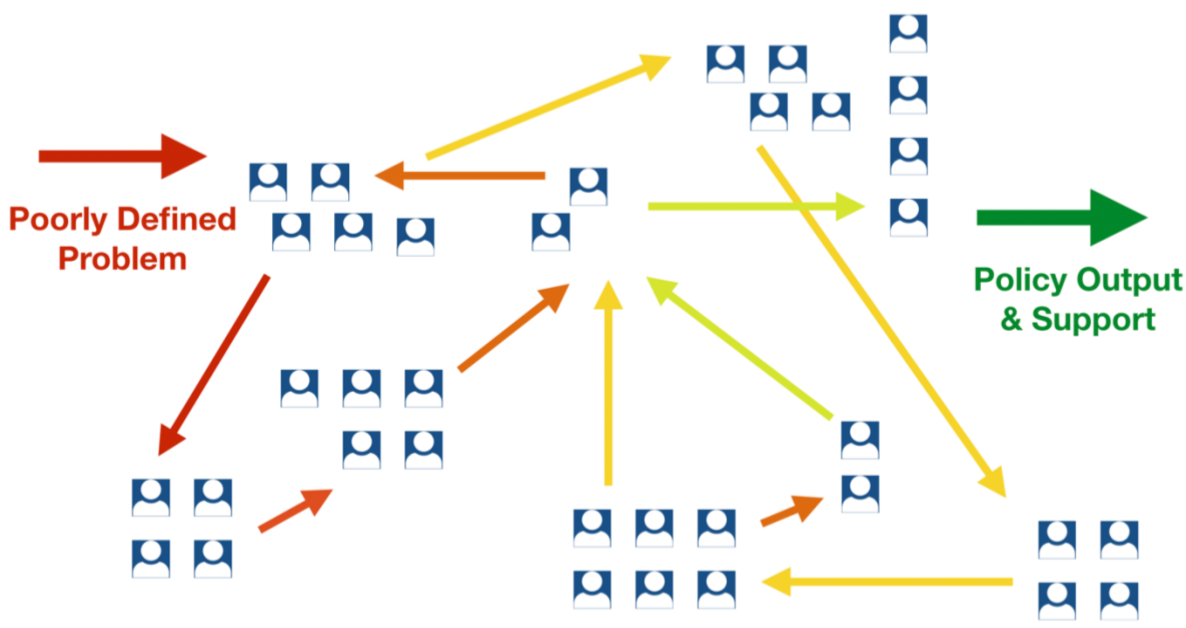


FIGURE 38 ILLUSTRATION OF A COMMONLY SHARED MENTAL MODEL ON INFORMATION TRANSFORMATION TASK EXECUTION WITHIN THE BUREAU

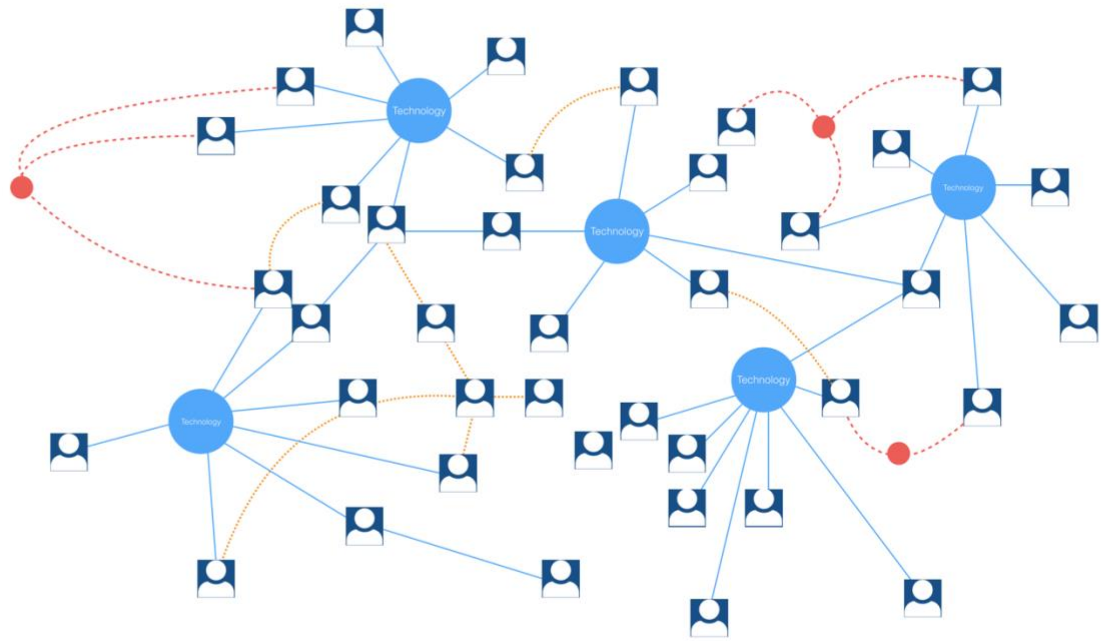


FIGURE 39 RENDERING OF HOW TECHNOLOGIES ARE WOVEN INTO THE ORGANIZATION, AND SHORT CUTS CREATED (RED) TO CIRCUMNAVIGATE TECHNICAL LIMITS UNTIL A SOLUTION OR DECISION IS CREATED FROM THE SYSTEM, CREATING A MORE ACCURATE REPRESENTATION OF HOW WORK IS MANAGED

The design of the Geo4NonPro was of poor quality. As a designer and experienced GIS analyst, multiple attempts were necessary for me to conduct the most basic function. I struggled to understand what analytical tools were available, but I struggled even more to interact with the map. Living in a time when most humans regularly engage with maps on a mobile device, the fact that the software required radically different patterns of interaction made it nearly impossible to use. Additional fundamental UI/UX design failures include:

a) No clear workflow. It was not apparent what tasks I should do or in what order.

b) Difficult to interpret the satellite images: An experimental scanning technique was used to create the satellite images, yielding outlandish colors and harsh shadows.

c) No error prevention mechanisms: If you do something not intended, like misspell and save a label on the image, there was no way to go back and correct it.

d) No clear data policy: Who owns this data? Where does it go?

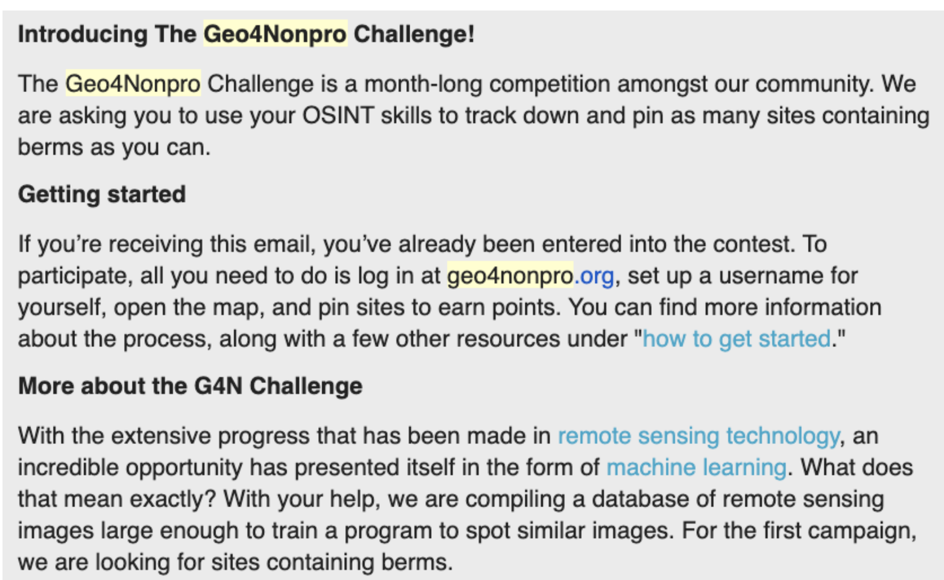
e) Black Box Design: A user cannot see what data was created, by whom, or their own data. They can't pull up a separate non-geographic index. They have no idea how the technology can or should work.

f) No return value for users: A user labels an element on the satellite image, and the label disappears into the black box. Why use it then? The act of creating a label is not a reward in-itself.

g) Confusing Non-Standard Layout: GIS maps all tend to look the same and therefore people can quickly understand and use one with a little practice. This UI had no relation to conventions, but not in a manner that improved the experience. Rather, the UI was organized – at best guess – like a stack of manila envelopes, pulled out of file cabinet and layered on a table in a stack with the tabs sticking on the side. I suspect this is how analysists would normally work across physical photos, sorting through files and pulling out paper images to examine with a magnifying glass. Yet the digital equivalent, was confusing and failed to align with the real-world expectation.

h) No Demarcation of Progress or Completion: One can create labels and switch sites, but there was no sense of progress or completion. Rather, a user stops labelling data after getting bored or realizing there is no reward of value for the user. Instead, the software owner is taking information and simply giving nothing back.

The most critical flaw, however, is not rooted in the mere heuristics of user experience but situated within the broader design of the product and its value offering at large. In summary, the stakeholders of Geo4NonPro believe this product will train machine learning algorithms to identify nuclear sites. They believe the divergent labelling information collected from around the world will be sufficient to create this training data. More fundamentally, they also believe that automated machine-driven detection tactics will be superior and effective for the needs of the international community. This belief is perpetuated today, as evidenced by this email snippet from July 03, 2019 proposing a competition for individuals to label the most berms, long human-made embankments of soil (Figure 4). The winner received a mobile phone charger and some Geo4NonPro themed merchandise.



Introducing The Geo4Nonpro Challenge!

The Geo4Nonpro Challenge is a month-long competition amongst our community. We are asking you to use your OSINT skills to track down and pin as many sites containing berms as you can.

Getting started

If you're receiving this email, you've already been entered into the contest. To participate, all you need to do is log in at geo4nonpro.org, set up a username for yourself, open the map, and pin sites to earn points. You can find more information about the process, along with a few other resources under "how to get started."

More about the G4N Challenge

With the extensive progress that has been made in remote sensing technology, an incredible opportunity has presented itself in the form of machine learning. What does that mean exactly? With your help, we are compiling a database of remote sensing images large enough to train a program to spot similar images. For the first campaign, we are looking for sites containing berms.

Figure 40 Email campaign for a data labelling competition

There are several problems with this model. Foremost, while some features – like berms - may be leading indicators of nuclear non-treaty regulated activities, if human's can already find the berms in supplied satellite data, with low error, why is a machine better? Nuclear research projects are grand, expensive, and very difficult to hide. A suspicious site usually a blank spot on the satellite image or non-descript buildings in a remote location yet accessed by large paved roads with trucks moving large, heavy construction materials. Rarely due rural areas need or contain such roads, and less often do those roads suddenly stop at the side of a mountain or a giant hole in the ground. Building this kind of infrastructure is a large, industrial undertaking that happens over months and years, yet a machine learning classifier could only recognize an indicator within discrete states. Humans already seeking such activity at a regional level are inclined to have a tacit expertise of regional dynamics. There are many different kinds of indicators that equal the idea of a suspicious site, and they are mostly very slow and subtle.

Assuming they are correct that machine learning is an appropriate solution and not just a fad of interest, it wasn't clear to me how their product would generate training data. Users log some text into a SQL database, with an associated longitude/latitude point. But the images were hosted on a server with the commercial supplier, and so it was not possible to link the image and the text by the location. In the end they only had a small list of points, and if there were duplicate locations, they also had a massive amount of variance in information per point. The ability to write free text at any location was the downfall as much as the isolation of the list from the imagery. What could they do with this?

Uncertain if they adopted any of my architecture suggestions, I have found evidence that the organization has taken steps to mitigate this problem. For example, the July 03, 2019 berm competition created a dedicated effort to collect information on one kind of visual feature (Figure 44). According to a Twitter statement, the competition generated over 3 labels, that were getting manually cleaned. Notably, they shared examples of fake information generated, such as "aliens."

FIGURE 41 GEO4NONPRO BAD DATA

6.4.4 Prototype design and optimization, the second diamond of design research

I crafted a new prototype of Geo4NonPro from the social research efforts, product analysis, and in parallel to the service design exercise. I provided a video file of the prototype in action, a collection of digital assets to build it, a map of the system, a generic mockup of the software architecture, and a collection of unique screen shots. Furthermore, I provided council on implementation such as development, hiring, marketing, and the use of performance metrics.

Within the design of the new product, I advocated to pull away from a crowdsourcing model, but a focus on expert users in the community. The evidence compiled form the first release suggested that only experts were interested in the product, so we should provide something really strong for that community. If we are working with experts, we can also go outside the limits of satellite imagery but reimagine the platform as an open source solution to share different kinds of evidence, such as text documents or photographs, which maintain their own unique workflows. I suggested the stakeholders also select a different name to match the new expert tool, and suggested *Crowd Zero* on account that it is for experts, and the goal of many experts in the nonproliferation space is to achieve "global zero," a world with no nuclear armaments.

To enhance usability, I shifted the design to a card-based layout, wherein users may easily explore current sets of imagery (Figure 42). Once a card is selected, the user is presented with three different options for research, one with satellite imagery, one with photographic imagery, and one with a spreadsheet of all data currently created. The subject of data transparency was hotly debated at the time I shared this prototype, as the academic community wants all the data alone. I argued that an individual should at least see her/his own historical data record if not all the data. A fast workflow to create and download point data is the greatest asset for using this platform, currently only achievable with Google My Maps or more advanced mapping platforms like QGIS. I received very strong resistance to these proposals, and they have not been implemented.

In addition to satellite analysis, an interface mockup for photograph analysis was provided. Rooted in the divergent, broad social research, I discovered how much of the world's most powerful work is tied to photographs. For example, the Middlebury arms control expert Dr. Jeffrey Lewis is renowned for his ability to study photographic evidence and map insightful arms control behaviors on the actions of countries around the world. Figure 44 demonstrates how Lewis matched the uses of trucks manufactured North Korea at one location were painted white to the same trucks used in another image, but painted green, to move nuclear missiles. This kind of intelligence informs an understanding about the size and complexity of the North Korean supply chain and logistics infrastructure for nuclear operations. Yet this kind of expert insight is rare, and Jeffrey Lewis is perhaps the world's leading private sector expert in this kind of analysis. In this instance, to develop computational tools to support other's efforts, or to bring their work to someone like Dr. Lewis through good design could yield more, high quality findings. Unfortunately, none of this has been developed or deployed.

Other aspects of these proposals have been implemented. Geo4NonPro in its current form does feature a card-based interface to review current sites. Upon selecting a site, the user may add or subtract layers of satellite data, permitting different views of the same site. The user also needs to simply click a location to view a pop-up window for details. In addition to writing or using an existing tag for the site, the user may write an attribution or link the site to another known views, such as a YouTube handle. As analysts regularly view video of missile launches, this aspect is particularly helpful.

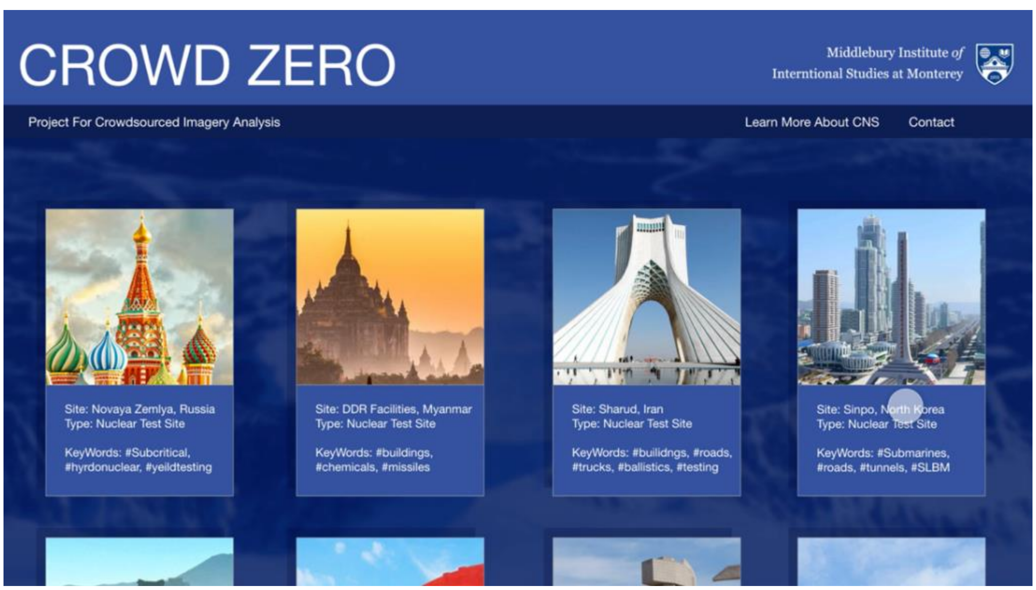


FIGURE 42 NEW CARD SORT LAYOUT

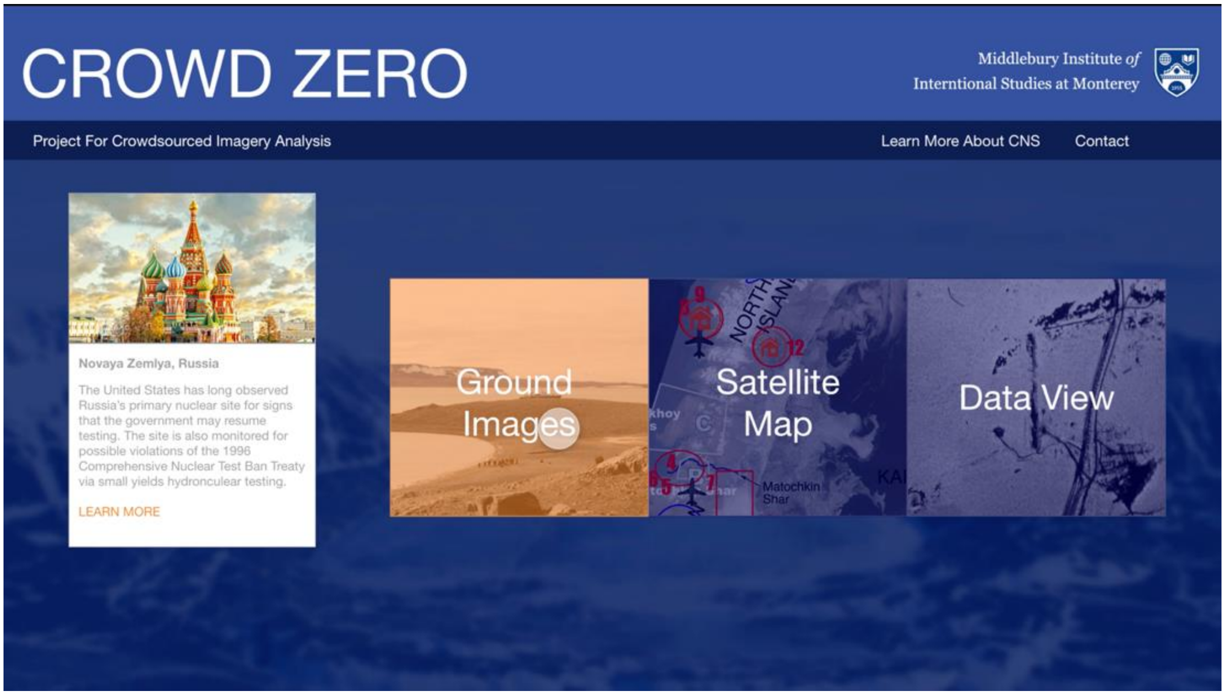


FIGURE 43 IN THIS SCREENSHOT THE USER HAS MULTIPLE PATHS TO CONDUCT RESEARCH ON A SITE

FIGURE 44 LEWIS'S TWITTER FEED MATCHING STATE PROPAGANDA INITIATIVES ACROSS IMAGES

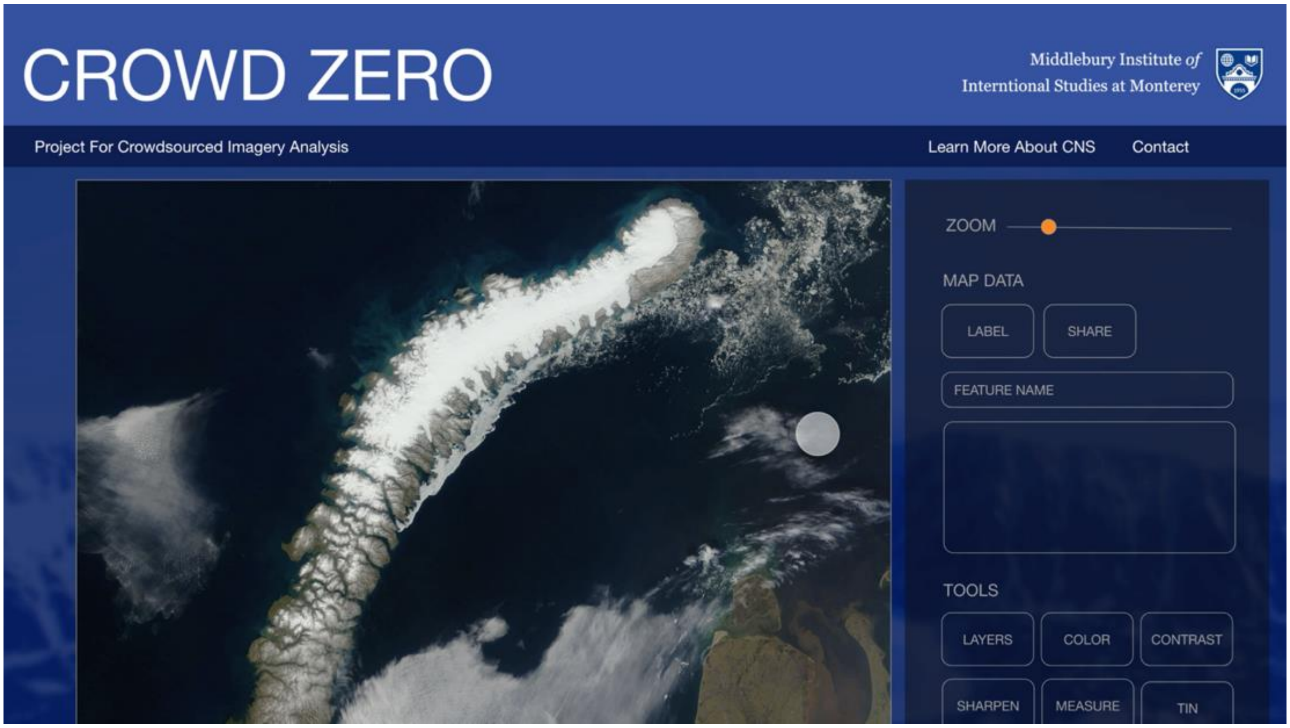


FIGURE 45 SATELLITE IMAGERY LABELING

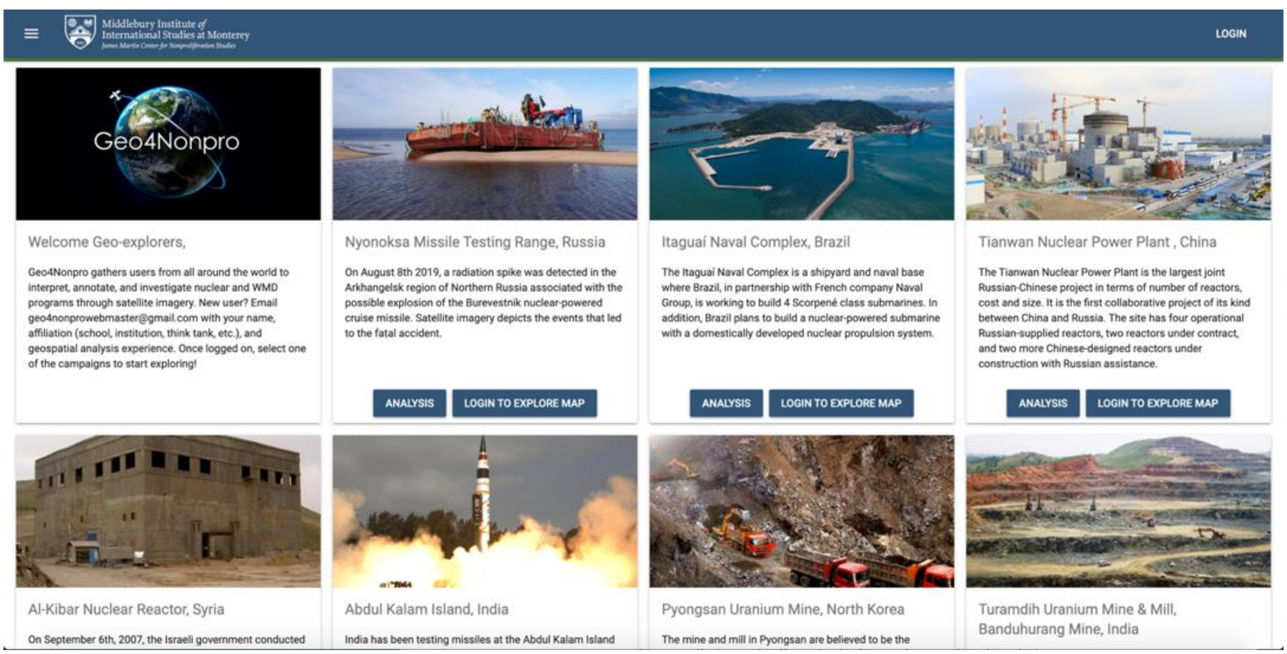


FIGURE 46 THE DEPLOYED SOLUTION OF GEO4NONPRO

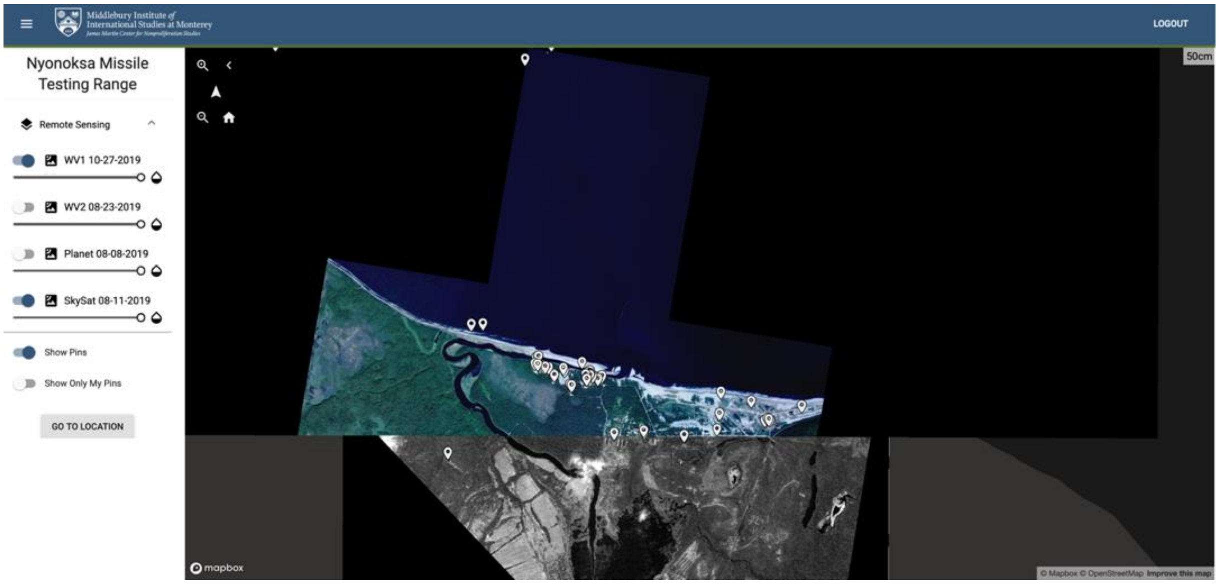


FIGURE 47 ABILITY TO LAYER AND MANIPULATE SATELLITE IMAGES

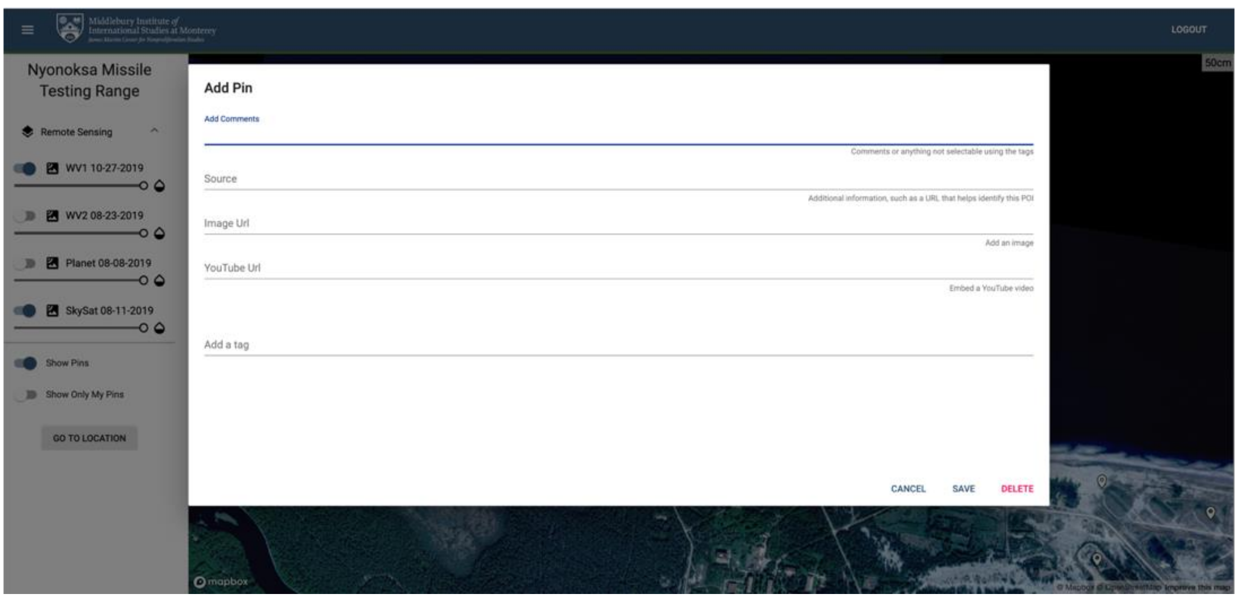


FIGURE 48 A BETTER UI FOR DATA CREATION INCLUDING ATTRIBUTION

6.4.5 Discussion of a GIS product to counter disinformation across systems

The work conducted to upgrade Geo4NonPro was in many ways effective for their needs. The product will better function to provide training data. Working with multiple layers of satellite data frees the restrictions from the exotic GeoGlobe imagery and permits storage of unique satellite tiles along with the location and tag data. One may compare layers of satellite imager to assess the change of the landscape over time. More importantly, the use of attribution builds the narrative of the site, as data aggregates over time, the provenance of the data informs the reliability of any future algorithms. Furthermore, the provenance opens a window into experiments with the data, wherein additional layers of insight may be pulled out like threads, to weave competing or compatible ontologies. This product will maintain at risk of disinformation but has some assurances to better manage that risk. This product is also better designed to create validated information into the world. At a minimum, Geo4NonPro possibility of opening layers of debate and dialogue on nuclear security with reliable information at hand.

Geo4NonPro is a better product now, but I do not believe those debates will be realized, though it may partially achieve its goal to create training data for ML models. Geo4NonPro continues to contain polarizing design flaws, that restrict free and open use. Though someone may be curious to see the satellite imagery, there is no incentive to create and log information. Individual's may now see previous entries, one at a time, on the screen – but not as a list or table. Individual's may not download their own data entries in bulk. The product remains a black box. The code is not open source so no community can improve it or make it more secure and the product was developed by Harris, a massive American military contracting company. Whereas the State Department hoped to see initiatives like Geo4Nonpro flourish as independent entities in the threat of disinformation, the large Harris emblem on the front of the page says otherwise.

For Geo4NonPro to succeed, it must be a platform of trust. The product mission to secure a safer world with the help of machine learning isn't terrible, but it also doesn't seem necessary. This project reflects the value of information as determined by the confidence of stakeholders and not the quality of information itself (Macauley 2005). The greater failure of Geo4NonPro is that participation is simply to put data into the black box. It only reinforces Broumas' argument that design is an instrument of power (2013). How that power functions, given the clear relationship with Harris, may not align to the ethics or interests of the individuals sought to participate.

To be effective, Geo4NonPro does not need to completely transparent, but it does need to be conversational. By embracing greater levels of dialogue through the application, Geo4NonPro could enable users to engage with their own information, to allow users to engage with each other through the software, or to permit users to collaborate in learning and creating new kinds of knowledge. At present, the software fails to uphold Manzini's expectation that we design new technologies as a hybrid, physical and digital space," for individuals to converse, share perspectives, and to collaborate.

Geo4NonPro could function as a tool for social change by the supply of iterative opportunities for learning through the product (Junginger, 2008). In light of Rittel's critique, though this community was able to establish a goal and achieve problem definition, their failure to consider equities within the product negates its value (Rittel and Weber 1973). It is possible that the aggregation of data from across the public could satisfy the consideration of equities, but the afterlife of data is unclear and not necessarily in the interest of the participant.

Geo4NonPro is an idea to incur significant changes upon global diplomacy and citizen participation in nuclear security. Yet before execution, the idea is inhibited by the insistence on black box design. Upon implementation, it is constrained by the contradicting and inscrutable beliefs and expectations of its primary stakeholders. Realized as a digital software and released into the wild, it has had nearly zero success, because it offers no direct transactional for a prospective non-expert user. Geo4NonPro was meant to supply an object for global scale impact through the transformation and qualification of information. It does not.

6.5 Section Summary

This section described the processes undertaken to research the contribution of design to new venture creation, the design of a product to effect systems level change, and the design of a product to counter disinformation.

Design to enable venture creation described the continuous and iterative production of artifacts as the primary means to formulate the venture. These artifacts consisted of case studies, internal design briefs, marketing materials, and the pitch deck for raising capital. Through the constant production of artifacts, it was essential to formulate a coherent business - to identify customers and channels of access, and to establish a coherent value proposition and sales strategy. Through constant feedback while seeking clients and investors, it became clear to me that the design of the product was the least important aspect of building the business. Rather, the success of the venture depended on having a unique point of view, drawn on a unique biographic experience, codified through the creation of an effective team and process.

Design to counter disinformation the processes and products described the creation of Symkala and Geo4NonPro. Within Symkala, the information management process was broken into a series of more granular interactions for augmentation and curation of data for downstream analysis, forcing the analyst to reflect upon the ontology of the data and the argument created through assemblage of the data to achieve an analytical output. Within Geo4NonPro, I designed a simplified user workflow to compare multiple layers of satellite images, on-the-ground images, while quickly labeling features for future use as a research and validation tool on the development of global nuclear research facilities. Yet as my recommendations on data use, access, and organizational transparency were not adopted, the technology was unlikely to achieve widespread adoption or reliability.

From the development of Symkala, the business and the technology, and design of Geo4Nonpro, it became clear that products design for impact at systems scale are heavily informed and dependent upon organizational design and the design of the value proposition. Both Symkala and Geo4NonPro offered overly complex value propositions. Furthermore, the organizational structure of both entities needed to be simple and transparent, so that adoption of the technology does not incur a mental barrier toward adoption. The product itself is more likely to succeed if it provides an immediate return on labor for the user while the aggregation of product activities positions the organization to hold large-scale systems influence.

The process of building Symkala as a company, the product, and Geo4NonPro demanded ongoing processes of reflection-in-action, and reflection-on-action (D. Schön, The reflective practitioner 1983). Through this research my design expertise shifted dramatically, from the disciplinary domain of urban planning to interaction design and entrepreneurship. In the sequential section, I describe this journey of practice transformation.

Section 7: The Path of Practice Transformation

7.1 Section Abstract

This research was conducted as a structured and systematic approach to better understand how the design process may inform new business ventures, to combat disinformation, and to ensure the products created by these ventures yield positive consequences in the world. It was conducted through design as action research, distinct from scientific research on account of subjective and situational insights, however, valid as a process for discovery, hypothesis creation, testing, and analysis.

To conduct research through the practice of design is to methodically question theories that inform practice and the nature of practice itself. To conduct research through design does not separate the practitioner, but functions as a process for reflection, through which the practitioner and the practice is changed. In this section I share the journey of practice transformation.

In this section I articulate how my understanding of my own design practice changed. I discuss some of the context of those changes, the journey of entrepreneurship and heuristics developed to inform my practice in the future. I describe decisions and actions to share and disseminate this research through writing and speaking. I further describe the relationship between practice and teaching and share some of the insights from teaching that have informed my understanding of venture creation, product design for systems-change, and countering disinformation by design.

7.1 Closing the Gap between Social Systems and Objects

The doctoral research process drove a radical transformation in the nature of my practice across scales and categories. Prior to initiating the program, I foremost identified as an urban planner who dabbled in in the use of technologies to pursue novel planning initiatives with complex environments. My attraction to doctoral design research was to use design as a process of invention and knowledge creation, rather than build expertise in technical analysis. A long practitioner of participatory action research methods, I viewed the greatest strength of design as a path to create something from nothing. Consequently, my doctoral education in design required the early and fast absorption of some fundamentals.

Upon arrival to Carnegie Mellon University, my intent was to create a software business as a research process for an unidentified social benefit. The aggressive engagement with stakeholders throughout the Pittsburgh Innovation Ecosystem demanded rapid acquisition of new ideas, vocabularies, and processes. Concerted efforts to master business formation, product management, lean and agile development methods are just a few among the many requirements to maximize the resources and expertise of the at hand.

Within Figure 50, I have mapped the domains wherein I dedicated my utmost time and effort to learn since 2014. This timeline demonstrates a focus on the fundamentals of user experience design and design methods within the first phase, the fundamental of engineering management and technical systems in the second, the mechanics of business formation and innovation studies in the third, and finalized the a narrowed focus on creating machine learning products while trying to grasp at and articulate how these products function within our information society.

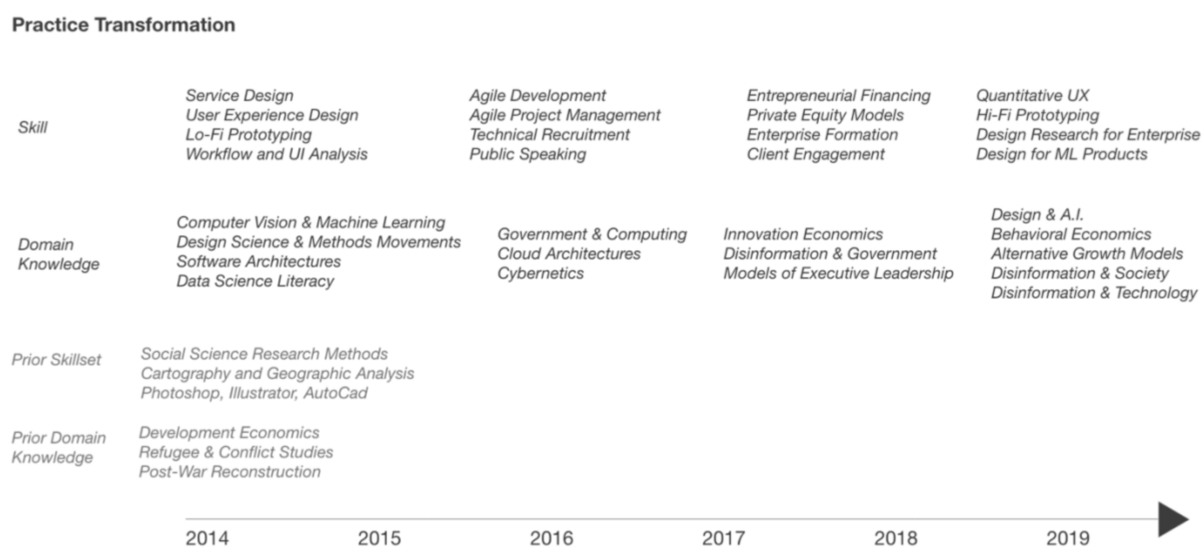


FIGURE 49 THE SHIFTS IN LEARNING PRIORITIES OVER THE COURSE OF RESEARCH

This path of research also forced the development of knowledge not easily accessible within a textbook. For example, the recruitment and hiring of an electrical engineer is not typically part of a design curriculum or found in design literature. In the last 6 years, I have now recruited and interviewed roughly sixty or seventy engineers, and for various endeavors, have hired about a dozen.

Business creation is very hard to do. Aside from the hype of Silicon Valley or the praise of expensive MBA programs, entrepreneurship is a convoluted blend of aspiration, calculation, frustration, rage, and fear. It is never static. Like winning a video game level to encounter new, harder, and unexpected bad guys, every success yields greater hardships.

Yet through the churn of entrepreneurial efforts, I have entirely reconfigured my idea of my practice. Six years ago, I defined my work as the ability to weave myself into the social fabric of any community in the world, wherein I could apply ethnographic and statistical methods to translate complex phenomena into meaningful geographic data. I considered this expertise as the heart of my practice as an urban planner working in the developing world, where no data was hard to come by and the problems were sprawling.

Today, I build and grow organizations. To do this, I create visions to I attract others. I build processes for others to follow for the production of goods and services. Through mistakes, I have also learned how to think about problems with a financial logic – something completely lacking in

Symkala. A good business problem is not a novel alternative to the status quo, it is the realization and exploitation of a market efficiency by offering a finite solution.

Yet one aspect of my practice has gone unchanged – working to transforming large-scale, systems problems. While I might now create products for direct user interaction, these products exist within elaborate architectures, with multiple interfaces for multiple stakeholders to generate and move data across organizations. Through products I can compress organizations, force them to function faster and more effectively relative their internal goals. Equipped to be more effective, these organization are more adept to accomplish their mission.

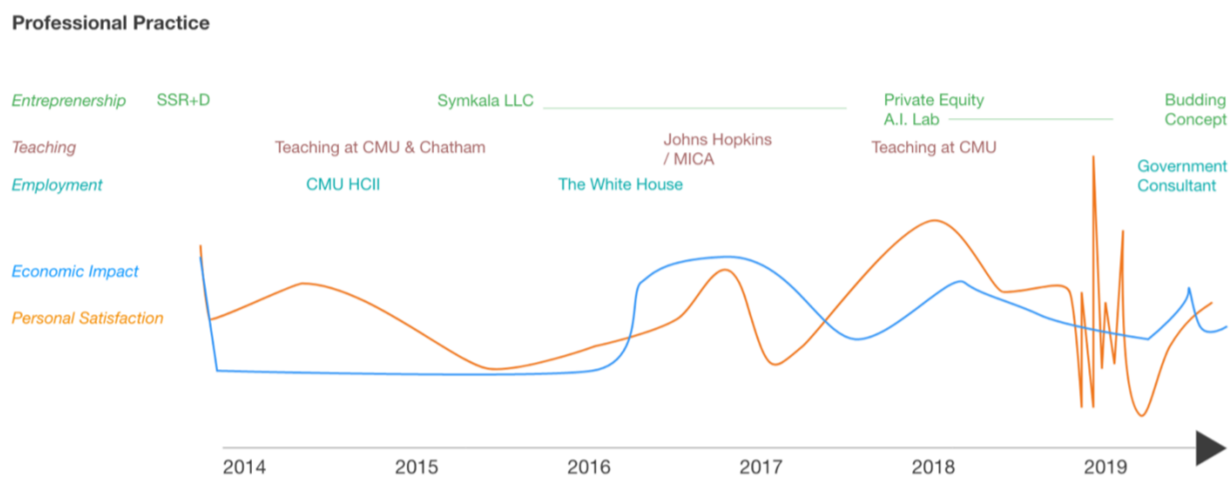


FIGURE 50 TIMELINE OF SHIFTS IN PROFESSIONAL PRACTICE OVER COURSE OF DOCTORAL RESEARCH

7.1.1 The span of works completed outside doctoral research

The extreme shift in practice was developed through an aggressive pace of production. Initially trained as an artist, I maintain a belief that I hold a studio practice, and that to be influential I must be prolific. I have now built or transformed multiple organizations over the last six years through combined dissertation research and parallel initiatives.

From 2014-2015, the priority of my research was to build rapid prototypes, building a personal understanding of how emerging computational technologies can capture, transform, and communicate information between environments and individuals or teams. The insights of these works were channeled into the development of Symkala, from 2015-2017. Symkala, as a company and as a technology, built an understanding the digital mediation of information to construct arguments.

As the topic of disinformation slowly came to public recognition in early 2017, I realized that Symkala was somehow, perhaps, a glimmer of a solution. Thus, I brought Symkala to leadership and intake analysts at the US Navy, the Central Intelligence Agency (CIA), Defense Advanced Research Projects Agency (DARPA), and National Geospatial Intelligence Agency (NGA). I also had meetings with private sector non-government agencies and contractors including AECOM, FHI360, and the American Association for Advancement of Sciences office of Human Rights Technology.

Only a few months after concluding Symkala, I went from building a tech startup with no money, to starting an investment fund to channel that investment into other people's technology products. I partnered with someone to craft a "new model of venture." We called the initiative *Spinglass*. Working through venture as a service design initiative, I was able to generate novel models for financing companies, yet untested, new models were not of deep interest to prospective investors.

Through continued effort to develop another company, I crossed paths with a self-made billionaire who wanted to build an applied research and development lab to enable growth within a portfolio of private equity investments. I built this lab from the ground up over the next two years. Managing a large team and a portfolio of clients, I oversaw the delivery of multiple, simultaneous projects that were a hybrid of design, data science and engineering.

Today I am the principle investigator on two government contacts with the US Air Force with former colleagues at White House Presidential Innovation Fellows. Again, I am holding multiple roles to grow this company through digital delivery to generate systemic results in the world.

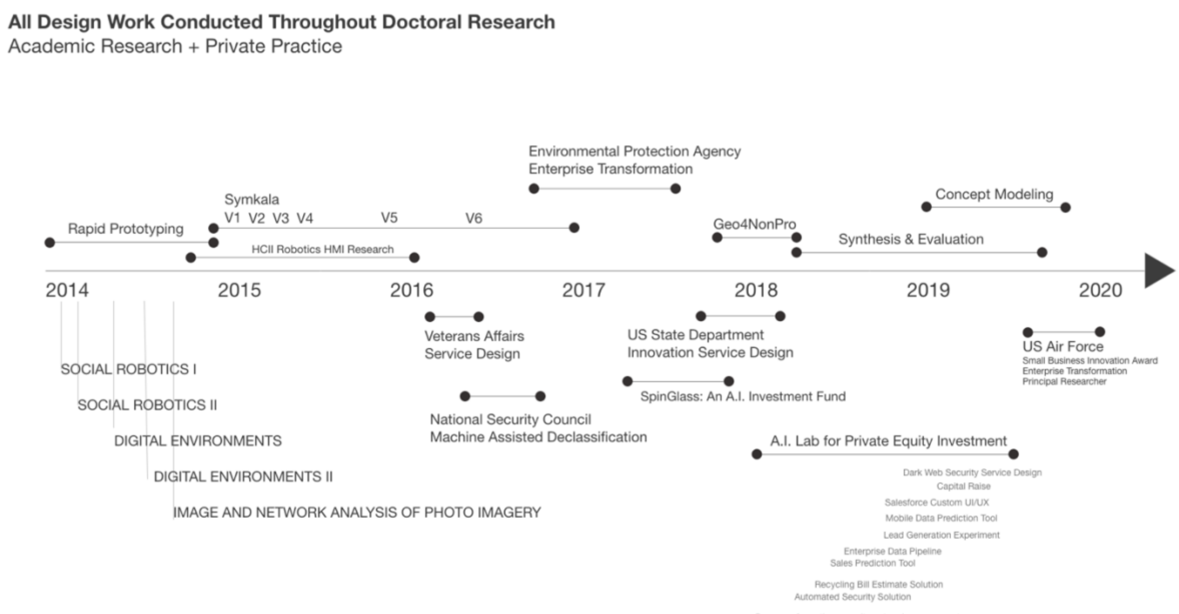


FIGURE 51 TIMELINE OF ALL CREATED WORKS FROM 2014 TO PRESENT

Having delivered a sizeable quantity of technical solutions to a wide diversity of organizations over the last six years, it has become apparent that all organizations continually wrestle with information integrity, and many, are forced to contend. with disinformation. I had worked on the design of Geo4NonPro concurrently to developing SpinGlass, and the constant problem by Geo4NonPro was the creation of erroneous tags to describe satellite imagery. I found this same problem continued elsewhere. One former client with attempted to build levels of validation, yet with no consideration for design, ended up with multiple repositories of useless information and many dollars spent on wasted hours.

I found that data scientists are rarely positioned to solve this problem. The best data scientists have strong abilities in software engineering and can build the cloud infrastructures and data transformation layers necessary to pull information, modify it, and push out a result. Best case scenario, that result is injected into an existing suite of business dependent software like Salesforce, and the company can leverage immediate returns. A good example is the assessment and ranking of customers or potential transactions, or partners. Yet to rank the quality and reliability of the problem as a data scientist is heavily dependent upon available meta-data. But if the meta-data cannot be trusted – and sometimes it cannot – then there is little clarity on what to do.

Throughout my journey of doctoral research and practice transformation, I continually return to the issue of disinformation. While I have built deeper expertise in venture creation and product delivery, I have certainly not solved disinformation. Yet I am more convinced that it demands attention by designers.

7.1.2 Teaching

Throughout the doctoral research, my time has been committed within five domains: Employment & Entrepreneurship, Literary Research, Teaching, and Conference Presentations. While the first domain has demanded constant engagement with various technical and disciplinary communities, teaching and conferencing presentations presented unique opportunities to explore my theories on design for systems change, for machine learning, and to counter disinformation. In this section I will touch about some of examples that have reciprocally informed my understanding of the discipline, my practice, and my contribution to the field.

Between 2014 and 2019, I taught undergraduate and graduate courses at Carnegie Mellon University, Chatham University in Pittsburgh Pennsylvania, and in the joint MBA program offered by John's Hopkins University and the Maryland Institute College of Art and Design in Baltimore, Maryland. Throughout 2016, I also presented a quarterly lecture to National Defense University on a "Human Factors Approach to Cyber Security."

At Carnegie Mellon University, I taught the first offering of *Systems*, and offered two additional courses entitled *Sensing Environments*, and *A.I. Product Service Systems*. Systems was a seminar course, weekly introducing students to a discipline, mode of inquiry, or techniques to begin thinking through structural relationships. My other course offerings yielded far more insight into my own work.

Design education offers the study the making of objects for any given problem, but by and large, tend to lack subject matter expertise. While not a popularly shared sentiment, I deeply believe that all design students should study design history, in addition to the history of science and technologies studies. I did not hold this belief previously but having deeply delved into the history of cybernetics and computation, I stumbled upon the realization that while modern design practices are heavily rooted in empathy, we simultaneously lack the ability to empathize – or draw boundaries – with our machines.

The distinction between human experience and computational logic is not a new discovery. It has been exhaustively covered by many of the founding researchers of artificial intelligence including Marvin Minsky, Terry Winograd, and Joseph Wiezenbaum. Wiezenbaum in particular, having pulled away from the allure of artificial intelligence following the rapid and popular reception of his pioneering software ELIZA, has argued for a deeper commitment for humans to understand the limits of their machines, and not to design for our machines, but to build our world in spite of them (Weizenbaum 1967). In a similar vein, Winograd and Flores carefully deconstructed the biological and phenomenological perception of the world against the capacity for a machine to give a response to mechanical signal (Winnograd and Flores 1986). It was through teaching, that I realized students were quick to propose solutions rooted in the logic of the machines, rather from their own internal desires. A common conversation would proceed as follows:

Me: "What is your idea?"

Student: "Well, I read about these sensors that are really good at picking up movement, but only in certain conditions, and an elevator seems like a good example of that condition, so I think I will make a technology to optimize the movement of elevators."

Me: "Optimize elevators? What does that mean? Like, you want to help manage big crowds of people waiting for elevators? Is that a major problem in your life?"

Student: "It could be. I don't know. I just know the sensor would work."

Such conversations were rarely so explicit, but they did take place. Or, on the other hand, a student had no familiarity with the workings of a technology and would say "then we use machine learning to identify *X*," as if machine learning with the solution to all problems. Students either failed to understand their tools or were subservient to their tools. Yet I wanted to know – what world are they creating for us to live in, with these tools or others?

To manage the problem, I invented a series of experimental exercises. In the first exercise I asked one student to describe a childhood toy, while another had to draw it (See Figure 53). Yet the description was limited to the kinds of logic used within software, such as edges, geometric relationships, some basic shapes. No one could use the word "soft" or "furry" to describe a teddy bear. The person drawing, simultaneously, has no context for the drawing. The person can only draw lines as articulated. Students were surprised by the outcome of the project. It was common for the person drawing – the computer – to never understand the input description (the program). The results sometimes aligned to the mental model of the describer, but just as often did not. The exercise was not a perfect proxy for building empathy of machine logic, but it was a step. Students began to realize that our sensors and software are highly constrained pulses of electricity.

In a second exercise, students were to design a system to transmit information between each other relying on physical sensations. Using heavy gauge steel wire, students were required that these systems were bigger than themselves, so as to be enveloped by the experience of creating and relaying messages. This was more challenging than I expected, but some small groups managed to achieve some breakthrough insights. Within Figure 52, a team of three students bound by wire are attempting to replicate expressive gestures across persons by relying on the tension of the wires. Their eyes were closed, and their bodies turned away from one another. This team realized they needed more than direct lines of contact, but atmospheric touchpoints, wires wrapped around their head and spring like shapes were scattered across the floor. Interpretation of another's gesture was often more dependent on the movement of these external wires than the direct connections. To relay information in a manner that could be more directly interpreted required an elaborate support structure beyond the direct kinetics of student bodies and tense wires.

Figure 52 Building empathy for the limits of machines

Adapting these insights into the domain of software design, reinforced the role of service design within machine learning products, and raised the idea that physical interactions are tied the value determination of information. To work within purely digital terms, as in the computer vision exercise, is to manage information at the lowest fidelity. Whereas the formulation of robust environments with multiple touchpoints distributed over time, permits the opportunity to qualify a given signal at multiple points in time and space before the next step of a sequence is performed.

Advancing these arguments upon my students, I was pleased to see some works emerge that displayed an internalization of these principles. One particular work inverted the idea of social media platforms like Facebook as screen-based experiences, into gestural experiences, informed by the content of screens but not determined by them. Attempting to cross the chasm between the viewing and clicking on images of important international events, the goal was to focus on building information systems as multi-modal systems of communication between distant groups, brought together by physical interaction, and less so by the further sharing or addition of minor text. I considered this work a grand example how future information systems can be woven into our lives as an extension of values rather than diluting them via technology driven "optimizations."

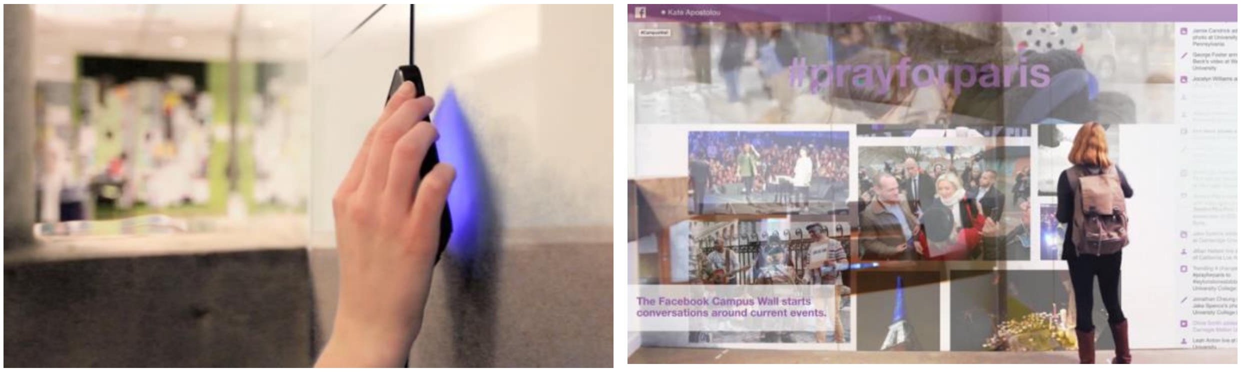


FIGURE 53 INFORMATION ENVIRONMENT DESIGN

7.1.3 Communicating

The demands of entrepreneurship have demanded a constant process of public interaction. This work began as a social process in Pittsburgh, crystalized through the creation of experimental software products, but was further reinforced by other forms of continued public engagement. (See Figure 46). This socialization has three primary roles: conferences, publication, and entrepreneurship.

With one foot in the world of academic research and the other in the domain of private venture, I have admittedly focused little on publication. The research journey directed me away from a vocation of scholarship and industry, but into desire to build organizations. My only publications were not peer review but selected by editorial review boards at Oxford University the United Nations General Assembly. I have nonetheless found satisfaction as a reviewer *for She-Ji: Journal of Economics, Innovation, and Design* from Tong Ji University and more recently for *Plos One*, to offer my budding expertise on design entrepreneurship for information systems, or the role of technologies within global development.

Outside of publishing, I intentionally have shared my work at conferences outside of design communities. I have spoken at conferences on Planning, GIS, and Digital Humanities, with only two in the realm of product and interaction design. I do this to provide an outlier point-of-view and utilize this opportunity as a means of discovery. By presenting at conferences for the digital humanities, geography, and urban planning, I am forced to discover and learn more about problems to inspire new applications by design. Concurrent to academic conferences, much of my time is absorbed in exploratory business meetings. In the last few years, I have had the rare opportunity to meet with CEOs, and board members of some of America's largest commercial companies in security, waste management, entertainment, and sports. Within these meetings I have the unique opportunity to offer the value of my research, learn their internal challenges, and theorize how insights from academic conferences may shape corporate realities.

Throughout these engagements a few patterns have emerged. By and large, many of the world's most powerful organizations are not sophisticated, but dependent on email and spreadsheets for human reporting and coordination efforts. If they do have a high technical capacity at hand, this capacity is siloed. For example, the gaming industry is highly resourced to identify and attract compulsive gamblers. It's approach to all other matter is specifically low-tech.

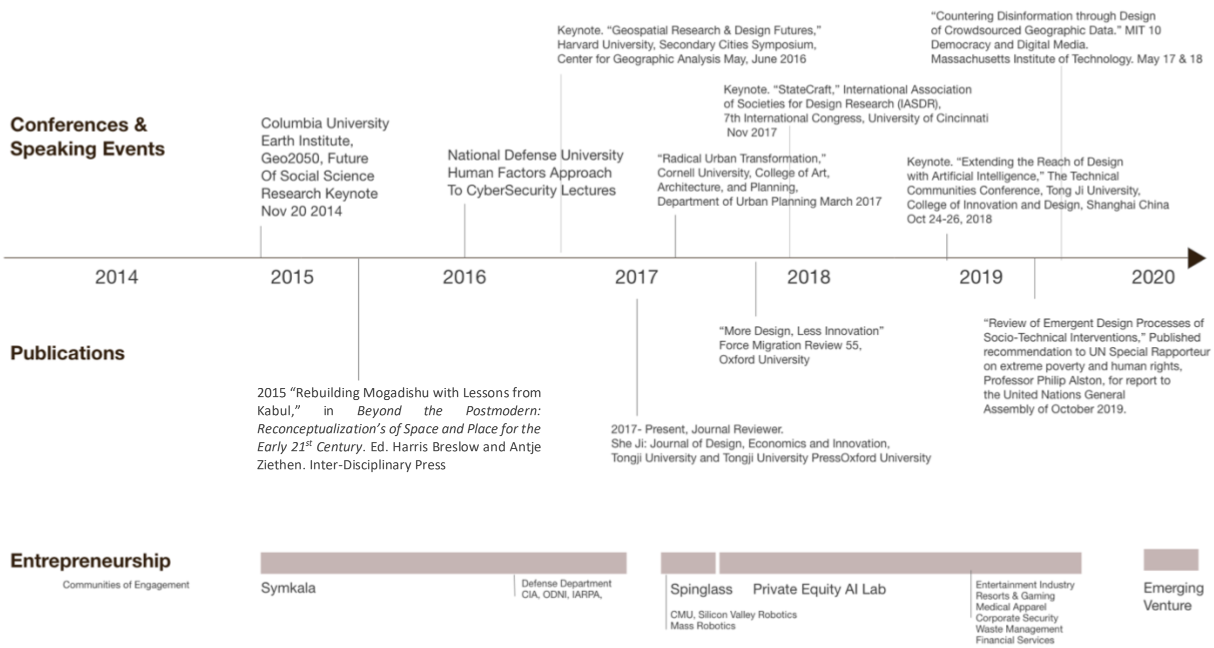


FIGURE 54 CHANNELS OF SOCIALIZATION AND FEEDBACK

By supplying the value of my practice to such companies, I have found consistent patterns. All such organizations share a dream of a Star Trek-like command center, where all the details of their business operations can be viewed on an interface in real time. They all want to discover "what works" and then cut out the rest. They all believe that the invisible hand of the market will take care of humanity under pressures of mass layoffs or structural transformations incurred by their efforts. Company leaders also has a formula for success, and only want tools to bring precision of execution, not to change the formula.

On the other hand, I have that the execution of my practice across domains is contingent upon my ability to identify and adapt the unique code of communication and prioritization. For example, while every project demands a period of design research, no business wants to pay for this period of *Discovery*. One must speak the language of the company and offer the deliverable not the practice. One must offer to provide a technical assessment report, or service blueprint, or some other artifact that can be purchased.

This journey of doctoral research has reinforced a personal commitment to entrepreneurship as a vehicle of transformation. Through the B2B2C model - business to business to customer - I have reached into individual lives of millions of people and slightly changed them. If successful, I can utilize design as a multiplier on a value, enabled and realized by material transactions. By building organizations to create products and services across, I can incur large, visible transformations at regional, national, or international scale.

This is difficult of course. To intentionally design an object of global impact, such as the modern mobile phone, is a mind-numbing challenge. To do this with information, as applications such as Facebook or Uber have achieved, is rarer still. To craft such products to counter disinformation is an additional layer of difficulty that I believe will demand increasing attention over time.

7.4 Section Summary

This section functions as reflection-on-practice, to describe how development of professional expertise in professional has shifted across disciplines, has been codified through reflection-in practice, and shared through teaching and speaking.

I began the process of doctoral research as a city planner specialized in working with communities in developing nations and conflict cities through ethnographic and participatory methods to yield objective, observable outcomes. I began this research with a goal to conduct research through business creation. Through the study of design literature, entrepreneurship as research, and a two-year appointment as a White House Presidential Fellow, my ethnographic practice shifted to benefit the creation of technical solutions for organizational change. Working through organizations, and by building my own, I discovered a gateway to conduct human-scale design with systems-level consequences. This process continued to rely upon ethnographic practices yet evolved to translate ethnographic observation into knowledge through the production of artifacts.

Within this journey my attention shifted to the threat of disinformation. In teaching, I worked with students to also translate ethnography into artifacts, always focusing on the materialization of thinking as a form of problem-solving. This priority for materialization is informed by theories of new venture creation and disinformation, as it is the means of creating new realities from abstract ideas. My students built upon this insight, channeling it into the creation of digital environments and modifications on existing commercial products, informing my own understanding of how disinformation and entrepreneurship may coexist.

I have intentionally shared this work with communities outside of design. I do this to continue the process of discovery, continually introducing my work as an outsider so that I may learn and benefit from new perspectives, new problems, and new opportunities for the world ahead.

Section 8: Analysis and Discussion

8.1 Section Abstract

The practice of design to manage ambiguity asserts a clear value for design to entrepreneurship. This research was integrated within the innovation ecosystems of Pittsburgh and Washington DC. Each ecosystem demonstrated a particular composition of assets as supply and demand functions. Because the ecosystems are emergent, the combination of assets do not necessarily generate a functioning and productive model. To manage this problem a designer may supply a strong focus on customer research and material production to establish a clear strategy, thus reducing reliance on the innovation ecosystem. Materializing processes and decisions as artifacts further benefits venture creation by slowing processes down and forcing careful consideration on strategy and implementation to generate greater returns.

The ability to counter disinformation in product design is determined by the limitations of the venture. Therefore, products that counter disinformation are produced by firms that have internalized information validity as a business goal, and then continually reorganize their structure and labor to achieve this goal.

To better channel systems-level insights to human-scale product design, designers must shift their methods outside of human-scale design and benefit from consideration of Rittel's precepts for social planning on goal formation, problem definition, and social equities. Channeling these priorities into products requires shifts in operations and venture strategy, with implications for machine learning products.

8.2 Question One: How to design a new venture within the modern innovation ecosystem?

8.2.1 The influence of innovation ecosystems on new venture design

The innovation ecosystem is the mix of institutions, resources, and ideas within a region from which novel business ideas and products are generated for greater economic benefit (Schumpeter, 1934; Bertola & J.C., 2003; Katz and Wagner 2006; P. Romer 1994). This concept has been appropriated and reproduced as the entrepreneurship ecosystem, the intentional effort to create conditions for innovation to drive economic growth, though it is a difficult model to prove (Katz and Wagner 2006, Nadgrodkiewicz 2013, Krugman 2013). The reviewed literature concerned with business has descriebed design research as concerned with interactions, materials and ecosystems (Junginger 2006, J. Forlizzi 2007, Muratovski 2017).

This research was integrated within the innovation ecosystems of Pittsburgh and Washington DC. Within Pittsburgh, this research consisted of engagement with ecosystem stakeholders such as the Swartz Center for Entrepreneurship, computer vision meetups, and CMU entrepreneurship showcases, the recruitment of collaborators for the development of initial prototypes, the generation of a business entity Symkala, the management of the company and creation of a GIS software, Symkala. Within Washington DC, engagement was limited to seeking out and meeting with possible clients. This decision was based on the lack of customer demand for my product within Pittsburgh and the high level of customer demand in Washington.

Each ecosystem demonstrated a particular composition of assets as supply and demand functions. To the point, Pittsburgh is far wealthier in the supply of expertise and accessible startup capital than Washington DC. Though Washington DC is driven by demand, with a range of entities seeking software solutions for complex information problems. Each entity maintained its own channels to intake and apply innovations. Within Pittsburgh a small number of institutions, such as Highmark and UPMC, held a demand role, while in Washington DC, a small number of technology incubators and venture firms attempted to generate supply.

Through ongoing research and mapping of stakeholders and implementation channels, I built an abstract understanding of how these two innovation ecosystems meet each other's needs and achieve my own goals. I built the company and the technology in Pittsburgh while attempting to sell the product in Washington. I held meetings with the leadership of several of these initiatives such as N-Step, overseen by the Directorate of National Intelligence (DNI), and the *Silicon Valley Program,* pioneered by Department of Homeland Security (DHS) in 2015. I also met with multiple program offices in DARPA, conducted a live demonstration to the CIA program IARPA, and also demoed working solutions to a secretive group of intelligence officers in Arlington VA. These intelligence communities were not free to discuss their users, their problems, or their needs. Likewise, they all had different levels of capacity to work with less mature teams or technologies.

What I did not expect was a structural incongruence in innovation systems. Though my company could supply the technology solutions desired in Washington, I could not meet the requirements for a transaction. The formation of my company as a small start-up and the artifacts generated to assert the company identify within the Pittsburgh innovation ecosystem did not align to the requirements for laborious documents, waterfall development programs, and the expectation that I would have an existing customer from within the government. My development of pitch decks, case studies, financial growth models, and online materials held limited value in the government offices. In particular, there was a consistent expectation that I have already found customers within private industry and have an established record of transactions to validate my product and price. More surprisingly, every stakeholder held a different set of requirements and maturity expectations. Because the ecosystems are emergent, the combination of assets do not necessarily generate a functioning and productive model.

Venture creation is heavily influenced by the misalignment between values, expectations and resources found within a singular ecosystem. Social and financial bias within innovation ecosystems is well researched domain, (Cumming and Dai 2010; Grube 2020). It has also been identified that the efforts by entrepreneurs to manage individual uncertainties may contribute the the production and growth of new uncertainties across the ecosystem (de Vasconcelos Goms, et al. 2018). Yet the bias that I have identified within the ecosystem concerns how funding, expertise, artifacts, and customer demand may or may not align for entrepreneur success. Though this insight may be found through lean methods on a case-by-case basis, it is systematically understood from the broader systems-level research and strategy created through a double diamond design process.

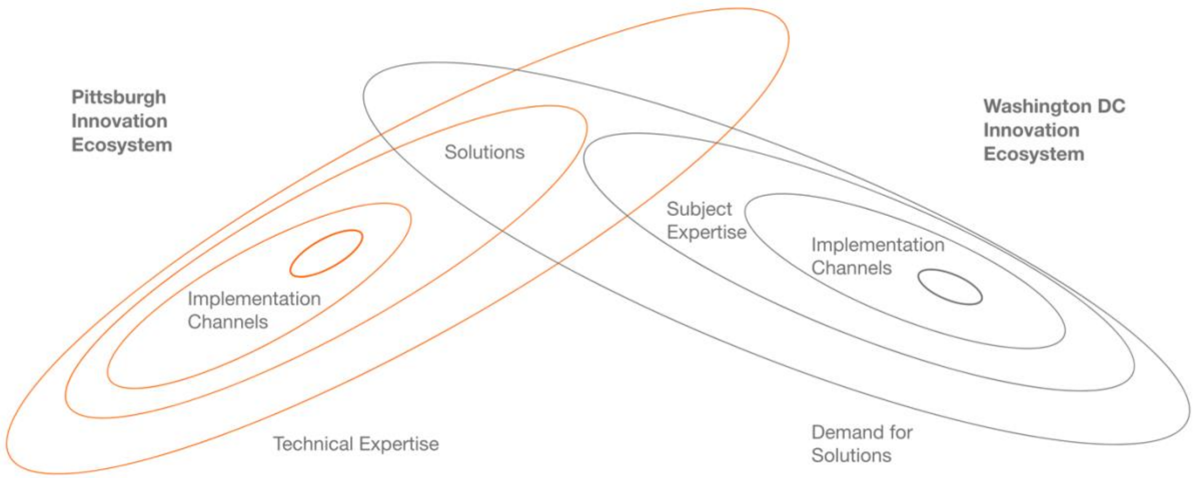


FIGURE 55 AN ILLUSTRATION OF THE STRUCTURAL MISALIGNMENT BETWEEN REGIONAL INNOVATION SYSTEMS

Pittsburgh offers limited seed funding, deep university research funding, deep technical expertise, limited reliance on communication materials, deep reliance on technology innovaiton, and has a narrow body of customers interested in piloting new, untested solutions. Such a model is ideal for lab-to-market ventures, and sales strategies based on the the corporate acquisition of intellectual property, such a composition benefits a finite number of entrepreneurs within Pittsburgh. For entpreneurs who do not have a novel technology incubated within the university, the resources at hand – incubators, shared worspaces, show case events – provide an opportunity to showcase products, but does not make available the investment capital or potential customer base for large-scale success. The additional resources, such as legal and financial council, are aligned to Silicon Valley business models, with limited input on how to best manage equity or seek non-dilutive funding.

Consequenty, the most strategic and effective entrepreneurs will adapt to the demands of the ecosystem, which might take place through lean, but may also be an exhaustive and laborious process of costant interations. Notably, I suspect this composition does benefit large corporate research and development operations within the city, wherein experts may conduct the exploratory work of entrepreneurship, yet without the frustrations and pitfalls of venture creation.

Washington DC offers a radically different composition of assets, asserting a different bias, and there for shapes different kinds of ventures. Washington DC has limited venture investement, but federal innovation grants and contracts provide non-dilutive capital and access to that funding is best secured when the entrepreneur secures an written statement of interests by a government office. Creation of such an agreement is a social process enabled by communications materials. Live demonstrations are appreciated by not essential. Access to funding does require understanding legal and registration requirements but these can be completed without assistance.

The city also contains deep expertise on problems but limited expertise on design, engineering, and process. Consequently, as a city with a large customer base and gateways to easy funding, it would appear easier to create a viable business – yet the lack of technical expertise, and the limited culture of entrepreneurship creates new challenges, as it is difficult to find and recruit talent. The artifacts required to access capital also force the entrepreneur to adopt antiquated methods, such as waterfall software development, or there is no understanding within an agency to value proposals offering newer techniques in design research or technology innovations.

The practice of design to manage ambiguity asserts a clear value for design to entrepreneurship. Yet the composition of the innovation ecosystem, in which a designer builds their venture, is likely to generate new limitations or obstacles for the designer. Working across ecosystems does not merit success if the funding, artifacts, talent, and customer base do not align into a coherent supply chain of value through products and services.

8.2.1 Future Research Opportunity

As an area for continued research opportunity, I question what kinds of artifacts best meet customer demands across different sectors for a given venture? To generate those artifacts, what design processes are best for the entrepreneur to identify critical factors in an ecosystem? By extension, if entrepreneurs could wield design method to nullify the inefficiencies of the entrepreneurship ecosystem, will this undermine prospective economic growth or enhance it?

8.2.2 The value of design research and processes for new venture creation

The research literature demonstrates that designers provide value to businesses through the creation of expertise on customers, the introduction of new ideas and methods, the use of structured methods to learn and build products, and the creation of new interactions and dialogue (Brown 2009; Bertola and J.C. 2003; Muratovski 2017, Junginger 2006, J. Forlizzi 2007). When design processes are combined with entrepreneurship, these contributions enable companies to manage ambiguity, to identify and understand customers, and to deliver positive product experiences (Dell'Era, Marchesi and Verganti 2010). Designers are not educated on micro-economics, organizational factors, leadership, legal matters, human resources, or other aspects of building a business. While entrepreneurship requires much improvisation, business education provides suitable insight on how to best build the business. There is a lack of research on how entrepreneurship through design can overcome these challenges (Nielsen and Christensen 2014). What value can design supply to entrepreneurship for new venture creation?

Furthermore, for entrepreneurs who lack formal business education, the modern approach is to rely upon lean methods. Lean demands rapid experimentation and constant feedback loops to inform business decisions, and outcomes are heavily informed by the composition of the greater innovation ecosystem customer (Ries 201; Batova, Clark and Card 2016; Mansoori and Lackeus 2019; Solaimani, van der Veen, et al. 2019). How then may design enable venture creation distinct form lean?

I applied the double diamond design process to the creation of Symkala. Divergent research required engaging the anchor institutions of the Pittsburgh innovation ecosystem, working across a wide spectrum of social relationships, and leveraging these relationships to create exploratory prototypes on what a company "could be." Given the nature of the Pittsburgh ecosystem, this generated a collection of technical experts to create novel technologies – the completion of the first diamond. These novel technologies, processed through personal reflection on previous life experiences, informed a mission and company concept – the completion of the second diamond. The designed venture concept, like the prototypes, reflected regional and personal expertise.

This path of material and production were effective to translate a chaos of resources into a venture. Though I was more systematic than lean in mapping and understanding institutions and resources, the outcome of the design process was a distillation of the innovation ecosystem. Notably this approach is effective to build the business, but I have learned that it is ineffective to determine the business.

Through error, I have learned that the invention of the business concept requires a different design process. Rather than mapping resources, I would have done better to research and map demands and needs across stakeholders. I would have done better to identify a working and accessible business that I can copy, and then use design to do it better. Through this research and continued practice, it has become clear that a successful business is an exploitation of a market inefficiency. It does not need to be sophisticated, novel, or profound. But it likely solves a problem that has historically always needed solved, problems like food production, waste disposal, room and board. To design a venture thus requires first stepping away from the innovation ecosystem. A designer must first become familiar with the basic needs of an economy and identify a gap or improvement to those needs. Once that gap is identified, the approach I utilized to engage and create products through innovation resources becomes a viable path.

To meet the more banal concerns of venture creation that are usually outside of design education, the value of design is to materialize traditionally non-material processes. For example, in all customer engagements I rely upon something I call "the heartbeat deck." It is a simple slide deck in which the first three slides are always identical. They state, "why are we here, what is our approach, what have we done?" Each slide looks exactly the same and gets repeated at every meeting in ritualistic fashion. The third slide contains actions on a timeline, which incrementally updates. Following those three slides we can introduce any new content to be discussed. The heartbeat deck establishes a script for communications, a scaffolding for meetings, and ensures that memories remain intact. It enables a ritual for dialogue and is always shared with the client at a reoccurring time. If the meeting is not sent, the deck is created and sent to them anyway, at the exact same time.

By materializing business decisions, the company becomes transparent, employees are not surprised, and leadership has the ability to control dialogue. Codesign is welcome, except when it is not, and the material artifact is a concise means to set the parameters.

Creating a venture through materialization also forces the entrepreneur to move more slowly. Slow is good. The culture the innovation ecosystem and lean methods prioritizes speed of execution. The popular phrase "work fast and break things," does indeed enable rapid growth. Yet it also creates new vulnerabilities that may grow over time. To formulate the initial venture from nothing does not require speed – it requires precision. Precision is difficult to achieve if the venture is only in your mind. The traditional business plan document is a viable strategy to manifest the business and think it through but making decisions through materialization should not stop at the business plan. The venture will continue to grow and evolve, creating opportunities for new kinds of artifacts and new processes of making.

Of course, there are some few elements that require learning non-designerly subjects. Creating and distributing legal documents for equity allocations, payroll management, or upholding tax regulations definitely requires study. Yet these problems are not unique – they can be outsourced, or external experts can be sought. In fact, they are not even problems, but rather boxes to be checked as the entrepreneur spends the majority of focus on designing the business by materializing it.

In this manner, the design entrepreneur can better manage the incongruencies of innovation ecosystems. The entrepreneur can identify the assets that are needed and seek them out rather than burning hundreds of hours attempting to scaffold a business from ad-hoc resources. Through making, the designer of a new venture can slowly and mindfully create a new reality.

8.2.3 Future Research Opportunity

To educate designers for entrepreneurship, it remains unclear how one can materialize the process of problem discovery. In my own practice today, working across potential problem owners and seeking out market inefficiencies, the process is manually intensive and with a simple reliance on email and project management software. Yet I suspect there is a better approach, akin to service design, in which the designer could better capture and assess the limitations of interwoven businesses. As a research question I ask, is there an approach to for designers to better surface market gaps?

8.3 How can design entrepreneurs better engage and manage disinformation in the world?

Disinformation is the creation and circulation of false information either by intention as disinformation, or by accident, misinformation, has immediate and far reaching impact upon the economy (Dohse 2013; Jain 2018; Vosoughi, Roy and Aral 2018). At this time there is no significant design research on how to manage disinformation, only essays proposing human-centered, collaborative, and service-centered methods (Manzini 2017, Tonkinwise 2017, Facebook 2017, UX Collective 2019). There is also no research concerning design, entrepreneurship, and disinformation.

To research how to better engage disinformation as a design entrepreneur, I built a company and two products. The company, Symkala, produced a novel geographic information system also named Symkala. This was selected because Geographic disinformation is an emerging threat and current GIS solutions are not prepared to manage it (Tucker, 2019). To invent a new approach to GIS, I relied upon research in materiality, machine learning as a material, and Rittel's dialogue mapping software, IBIS (Dourish 2015; Yang, Banovic and Zimmerman 2018; Yang, Scuito, et al. 2018; Rittel and Noble 1988). I also redesigned the software Geo4NonPro and advised the product stakeholders on development and deployment.

As an entrepreneur, the less insidious counterpart to disinformation – misinformation – is a constant. Misinformation is the circulation of false information but lacks the intent to harm. Although misinformation and corrupted data may circulate openly within entrepreneurial ecosystems to the detriment of entrepreneurs, the persistence of false data within information products is not a byproduct of this phenomenon. I do question, however, if the methods for venture creation and the culture of innovation ecosystem can be held accountable for the malleability of new technologies to spread disinformation.

Disinformation within information products is generated by malicious users who seek to manipulate the outcome of future events by transforming a commonly shared mental model about the conditions of those events. At no point in my participation or engagement with the innovation economies of Pittsburgh or Washington DC -or outside of my core research within New York City, San Francisco or Las Angeles - did a company founder or prospective customer state a desire to create false information. Rather, the efforts to sway elections, manipulate social stability, and undermine social institutions is generated by foreign states or non-state actors who leverage the embedded functionality of these applications for their own intent.[3]

Within Symkala, I sought manage the flow of information from its source to its consumption through a series of sequential steps with layers of machine augmentation. The result was the graph visualization of an argument, through the constant re-triangulation of evidence created across multiple persons or teams to formulate a case for action. If valid information was introduced that complemented the pattern, the argument was more valid. If only false information was introduced to create the pattern, the argument derived appeared valid but was false. If most of the data was true, and only some was false, the overall result would be true. This system is not too dissimilar from IBIS, though it benefits from the materiality and geographic attributes of information. Like IBIS could be used as a tool for design, Symkala was not going to solve the problem of disinformation. I suspect no singular technology will do so.

This is because disinformation is now effectively woven into all mediate social interactions. To counter disinformation, one must work across tiers of socio-technical experiences between individuals, small groups, and collectives as illustrated in Figure 56. Through building Symkala, I learned that disinformation can permeate banal geographic information systems because the malicious actor exploits the stagnancy of institutions, archaic forms of information system delivery, flaws in the design of data, and failures to build checks and balances into the organizational and social diffusion of the technology. Institutions that recognize the international security threat embedded within the global landscape of human machine interaction will transform their organization to present their vision and priorities through people and processes.

3 A non-state actor is a legal term to identify an individual or organization that has political influence on par with the state but lacks formal affiliation or recognition. Terrorist groups are regularly recognized as non-state actors.

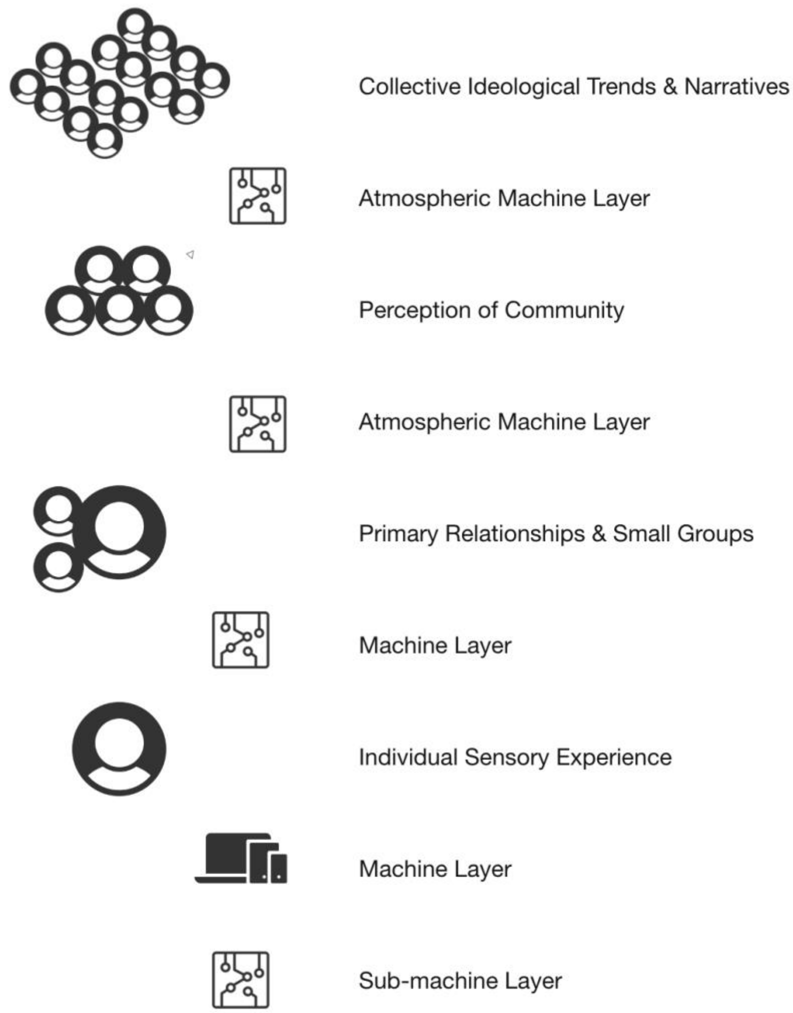


FIGURE 56 THE EMERGENT, INTERWOVEN FABRIC OF MACHINES AND HUMAN EXPERIENCE

Notably this insight aligns with Rittel's contention in 1971 that planners require deeper expertise in goal formation, problem definition and in equities. Rittel's description of the Goal and the Problem Definition are akin to my own findings within the innovation ecosystems concerning the power of the Vision and the Narrative. Yet distinct from Rittel, I advocate that concern for equities cannot be merely espoused and pursued, but must be lived, through the concrete determination of organizational roles and processes.

Another way to think about it, is that the design of a products is determined by the constraints of organization to achieve a goal. If the goal is merely to profit, then it doesn't matter if the data is phenomenologically sound, it only matters that the profit spikes. In figure 57, I have illustrated two circles, the left contains the individual human actor while the right represents the business organization. The business organization builds a technology for the user according to business goals. The user is not thinking about the business goals but absorbs the interaction experience into daily life. The digital experience is part of the day-to-day life and the individual responds through behaviors. Some behaviors may seem passive – such as scrolling – but these behaviors are a performance of individual priorities. As priorities are transferred back to the business the business must continually reorganize itself to provide new technology interactions for increased revenue. In this sense, I would argue that the "work" of any company is the constant and incremental reorganization of itself to meet worldly demands. As to how, or what, other activity takes place in the human interaction experience is ignored. If disinformation is among the priorities of the business, it will organize accordingly.

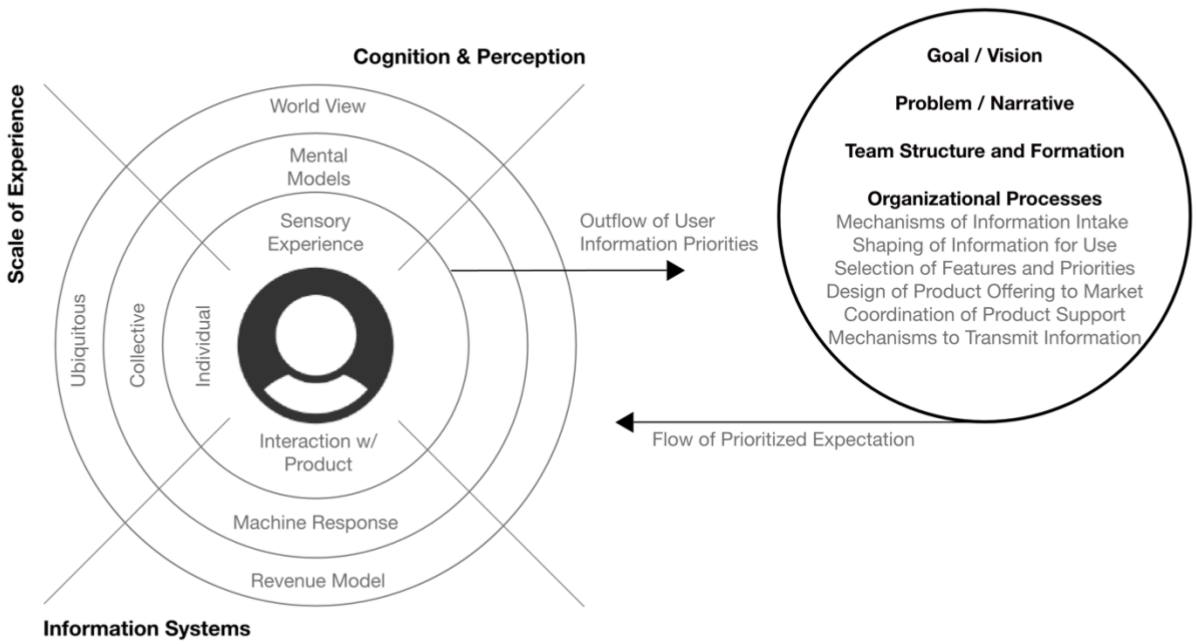


FIGURE 57 THE HUMAN TO BUSINESS INTERACTION LOOP, WHEREIN DISINFORMATION MAY. BE SOWN WITH MINIMAL IMPACT UPON BUSINESS PRIORITIES UNLESS THE BUSINESS CONTINUOUSLY REORGANIZES ITSELF TO CONTEND WITH SHIFTING PRIORITIES

This necessity for continual reorganization of a business to provide a higher order of value is evidenced by my work with Geo4NonPro. Though the stakeholder community was dissatisfied by the limited adoption of the product in the world, there was no desire to make the organization, its funding, or its data more transparent. I could offer some value through better interaction design, but the digital experience was restrained by a lack of trust. To increase adoption, it was necessary for the organization to change its structure, to communicate this change, and to reflect these changes in the design of its product. But as it did none of these things, the product remained underutilized.

Beyond the narrow confines of the disinformation problem, this research has generated a contribution to the field of GIS through applied research. Though Symkala did not achieve a market goal or solve the problem of disinformation within GIS data, the invention of new workflows, new user experiences, and a priority on the management of data ontologies is distinct within the domain of GIS. While the work reinforces the necessity for clear goals and defined problems on behalf of the user to achieve great utility, Symkala is unique as a GIS software in that it affords consideration of social equities, the provenance of the data, and introduces a novel approach to human-machine relations. Notably, the interface and workflow not only augments who judgement, but offsets the limitations of machine logic. In this capacity, it offers a model of design in which one builds empathy for the limitations of machines as a means to craft paths of human interaction.

Geo4NonPro also offered a broader contribution to communities of experts in the domain of nuclear security and nonproliferation, while also making a contribution to the culture of social mapping tool creation as described in the literature review with technologies such as Open Street Map or Ushahidi. Geo4NonPro is distinct from other crowdsourcing applications because the objective is to achieve clarity in existing information – not to build the information – and because the created data is intended to train algorithms for automated analysis. The challenges confronting Geo4NonPro raise that the challenges to success for such as technology is not technical, but contextual. Open Street Map, for example, has had great success and rampant growth over the years but the OSM community is greatly motivated on account that the OSM organization is incredibly transparent. The transparency is a critical motivating factor in participation, as the transparency also reinforces user confidence in the data.

8.4.1 Future Research Opportunity

For design entrepreneurs to better engage and manage information in the world, I question how design research can better capture systems-levels priorities of users, at user scale, and translate those priorities into business goals? It is common to see companies promoting virtuous behaviors as a form of corporate social responsibility, but these actions do not always directly benefit the business goals of the company. I have had clients who also began with such actions but incrementally reduced and ended them under the stress to stay open or to grow. Such responsibilities are rarely the top priority unless they directly correlate to revenue. How can designers offset this challenge from within? Or, how can designers enable companies to perform without having to deprioritize these initiatives over time?

-

8.5 Question 3: How can design entrepreneurs better apply systems-level insights to human-scale product design to mitigate threats such as disinformation?

To do this research, it was necessary to go outside the conventions of user centered design. To create a product within systems level impact required a vision for that product, a strategic choice on the type of product to be built to realize that vision, and then a consideration of how that product may live in multiple scenarios to affect many different lives. In this respect, I intentionally channeling Rittel's expectations of social planners into product design, through goal formation, problem definition, and prioritization of equities. I could then utilize human centered design techniques for the more granular decisions of interaction design, information architecture, and information management.

To apply Rittel's priorities also required a shift in design research methods. I began the work with several months of divergent systems study of the entrepreneur ecosystem through participation, dialogue, and desk review. I then tested my understanding of the ecosystem by attempting to build products within it and reintroduced those products into the ecosystem to gauge response.

Goal formation was thus a large, ambiguous, and collaborative process as much as it required disciplined study and research. It required a large sample size of research interactions, a constant search for new events or opportunities, and a relentless pursuit for approximately two years. Goal formation for product design to influence system-scale problems is an active and difficult process. It will require the design of the venture, the design of the product concept, the narrative, the team, the language used by the organization, and the design of rituals as structural reinforcement. More importantly, the design entrepreneur must continually reorganize these internal mechanics to align to the goal.

Problem definition is also a high-risk endeavor. Consistently, individuals were drawn the espoused vision but uncertain on the choice of implementation. My objective to reinvent GIS was considered a peculiar choice by most individuals and institutions I encountered. Questioning if this was a poor decision founded entirely on bias, I explored reconfigurations of the problem on multiple occasion. Perhaps it was not GIS, but merely a tool to manage algorithmic training data? Or perhaps it was a tool for knowledge management – a fancy filing system for large-scale institutions to run analytics on their archive of reports? Over and again I could get in front of persons who were interested, and yet they found the software overwhelming. To define the product is where more conventional design methods best apply – deep quantities of time with a user community.

Yet notably, solving a problem for a user community does not merit a successful entrepreneurial endeavor. That community must have money and a means to acquire the product. That community must have a risk tolerance appropriate to try your product. And the entrepreneur must design provide a safe path for the community to experience it, trust it, and purchase it. Two the entrepreneur must therefore design a product to achieve the goal, design a solution to a problem, and design a transaction.

In Symkala and Geo4Nonpro, the subject of equities was embedded in the data, access to the data, and understanding the lifecycle of the data beyond individual use. This is both a matter of policy, service design, organizational design and interaction design. Equities must be built into the DNA of the organization and structurally aligned to the goal while reflected in the products.

To channel these broad domains of research and exploratory prototyping into a business and products, it was fundamental to reflect and reinterpret my mental model of separate human and machine systems in Figure 58 as a fluid, entirely human, construct stretched over time. To reinterpret the relationship as a service design blueprint, the machine layer is treated as a stakeholder in frontstage and back-stage operations, to create, transform, and consume information throughout the ecosystem of stakeholders and processes.

FIGURE 58 HUMAN MACHINE INTERACTION AS SERVICE DESIGN BLUEPRINT

This blueprint was further experimented upon within teaching. Over the course of three semesters of teaching courses on product design for computer vision, and machine learning for services, that students regularly failed to consider how machine learning creates a series of looped experiences, and through those experiences the data and the user will adapt toward a common pattern. That common pattern has strengths and weaknesses. In the case of social media technologies, disinformation is a particular threat to the common pattern unless responsibility is taken to design user experience limitations within the sequence of feedback loops.

One might interpret my proposal as the creation of an algorithmic policy layer, an approach identified in the literature as already in practice but proving unsuccessful to counter disinformation. The distinction is that companies are attempting to construct and inject these policy layers far after disinformation has become a problem, whereas my recommendation is a proactive approach to manage the possible threat of disinformation when building a new venture.

I do not advocate that designers attempt to master plan the entire sequence of interactions to elicit and regulate for the most common pattern. Rather, I have found through these blueprints, one should at a minimum map two probable stages of the human-machine feedback loop to establish a direction of for human-machine information exchange over time. If working with a data scientist or if the abilities are at hand, one can create data simulations.

In this manner, I found I could distill the greater understanding of abstract systems into human-scale experiences, with some degree of confidence that the trajectory of information created through human-machine interaction over time may have some parameters created up front. Those parameters assert the values and intentions of my work in the product, to realize a vision and not just solve the problem.

8.5.1 Future Research Opportunity

For design entrepreneurs to better engage and manage information in the world, I question how design research can better capture systems-levels priorities of users, at user scale, and translate those priorities into business goals? It is common to see companies promoting virtuous behaviors as a form of corporate social responsibility, but these actions do not always directly benefit the business goals of the company. I have had clients who also began with such actions but incrementally reduced and ended them under the stress to stay open or to grow. Such responsibilities are rarely the top priority unless they directly correlate to revenue. How can designers offset this challenge from within? Or, how can designers enable companies to perform without having to deprioritize these initiatives over time?

8.6 Conclusion

Companies and products produced by innovation ecosystems have magnified the global threat of disinformation. Disinformation circulated through software is fragmenting societies, undermining democracies and causing global harm. How then can entrepreneurs apply design processes to create ventures and products to counter disinformation and afford more positive consequences?

While designers have been increasingly valued within businesses and for entrepreneurship on account of the ability to provide customer research expertise and structured processes for iterative learning, the contribution of design to venture creation has gone unresearched. Furthermore, there is no design literature on countering disinformation.

By conducting practice-based research, I have conducted divergent research in the Pittsburgh innovation ecosystem, built software prototypes, a company, and GIS products, to examine the contributions of design to entrepreneurship and tactics to manage disinformation. Through reflection-in-action and reflection-on-action, I have systematically considered the implications of this research and my own journey of practice transformation.

From this work, I have identified a clear and practical contribution design to venture creation from within innovation ecosystems. Innovation ecosystems are emergent and internal assets do not necessarily generate a final value and are biased toward particular ventures. Designers can offset these inefficiencies through customer research and material production to establish a clear strategy. Materializing artifacts offers continued benefits in venture creation to manage the challenges of narrative creation, internal communications, recruitment, and delivery practices by forcing deliberate and mindful decisions and communicating those decisions.

Through the design of a new venture, the designer is uniquely positioned to translate higher level social values into business goals. In this manner, the nascent firm can take responsibility for disinformation within product design. Firms that have internalized information validity as a business goal, will continually reorganize their structure and labor to achieve this goal through their product delivery.

To more broadly apply systems-level insights to human-scale product design, will require a shift in methods. In this research I utilized Rittel's precepts for social planning on goal formation, problem definition, and social equities as a roadmap for product design to positive effect. Channeling these priorities into products requires will require shifts in operations and venture strategy, though these shifts can be supported through material artifacts.

Bibliography

18F. 2019. *18F Methods Guide, Government Services Administration.* October 19. Accessed Nov 13, 2019. https://methods.18f.gov/discover/.

Acha, Virginia. 2017. "Open by Design: The role of design in open innovation." *Academy of Management Proceedings.*

Agbo, Mathias. 2018. "The Role of Designers in a Democracy." *New Design Ideas* 128-132.

Akers, John, Gagan Bansal , Gabriel Cadamuro, Christine Chen, Quanze Chen, Lucy Lin, Phoebe Mulcaire, et al. 2018. "Technology-Enabled Disinformation: Summary, Lessons, and Recommendations." *Technical Report University of Washington* 1-15.

Akkach, Samer. 2015. "Design and the Question of Eurcentricity." *Design Philosophy Papers* 1 (6): 321-326.

Alexander, Christopher. 1964. *Nothes on the Synthesis of Form.* Cambridge: Harvard University Press.

Allcott, Hunt, Matthew Gentzkow, and Chuan Yu. 2018. "Trends in the Diffusion of Misinformation on Social Media." October. Accessed April 19, 2019. https://web.stanford.edu/~gentzkow/research/fake-news-trends.pdf.

Amatullo., Mariana. 2015. *Design attitude and social innovation: empirical studies of the return on design.* Doctoral Disertation, Cleveland: Weatherhead School of Magement, Case Western Reserve University.

Andes, Scott, Mitch Horowitz, Ryan Helwig, and Bruce Katz. 2017. *Capturing the next economy: Pittsburgh's rise as a global innovation city.* The Anne T. and Robert M. Bass Initiative on Innovation and Placemaking.

Andes, Scott, Mitch Horowitze, Ryan Helwig, and Bruce Katz. 2017. *Capturing the next economy: Pittsburgh's rise as a global innovation city.* Washington DC: The Brookings Institution.

Andrews, J. H. 2009. *Maps in Those Days: Cartographic Methods Before 1850.* Printed in England by MPG Books, Bodmin, Cornwall.: Four Courts Press.

AP. 1993. *Pepsi Estimates Syringe Hoax Cost $35 million in lost sales, added expenses.* October 7. Accessed February 6, 2020. https://apnews.com/2f8d3dcf86e44bd594c33e7615b87f0b.

Archer, Bruce. 1995. "The Nature of Research." *Codesign* 6-13.

Argyris, Chris, and Donald Schorn. 1974. *Theory in Practice: Increasing Professional Effectiveness.* Jossey-Bass Publishers: San Francisco.

Arnheim, Rudolf. 1993. "Sketching and the Pscyhology of Design." *Design Issues* 9 (2): 15-19.

Arnstein, Sherry R. 1969. "A Ladder of Citizen Participation." *JAIP* 35 (4): 216-224.

Atkinson, Claire. 2019. *Fake news can cause 'irreversible damage' to companies – and sink their stock prices.* April 25. Accessed February 6, 2020. https://www.nbcnews.com/business/business-news/fake-news-can-cause-irreversible-damage-companies-sink-their-stock-n995436.

Bardzell, Jeffrey, Shaowen Bardzell, and Erik Stolterman. 2014. "Reading Critical Designs: Supporting Reasoned Interpretations of Critical Design." *Proceedings of CHI 2014* 1951-1960.

Barrett, Paul M., Tara Wadhwa, and Dorothee Baumann-Pauly. 2018. *Combating Russian Disinformation: The Case for Stepping up the Fight Online.* New York: NYU Stern Center for Business and Human Rights.

Batova, Tatiana, Dave Clark, and Daniel Card. 2016. "Challenges of lean customer discovery as invention." *IEEE ProComm 2016 - International Professional Communication Conference* . Austin: IEEE.

BBC. 2018. *BBC Media Centre.* Oct 12. Accessed Nov 14, 2019. https://www.bbc.co.uk/mediacentre/latestnews/2018/bbc-beyond-fake-news-research.

—. 2018. *What we've learnt about fake news in Africa.* November 12. Accessed November 14, 2019. https://www.bbc.com/news/world-africa-46138284.

Bennet, Jane. 2009. *Vibrant matter: A political ecology of things.* Duke University Press.

Bernardo, Francisco, Michael Zbyszynski, Rebecca Fiebrink, and Mick Grierson. 2017. "Interactive Machine Learning for End-User Innovation." *2017 AAAI Spring Symposium Series on Designing the User Experience of Machine Learning Systems.* AAAI Spring Symposium. 369-375.

Bertola, P., and Teixeira J.C. 2003. "Design as a knowledge agent: How design as a knowledge process is embedded in organizations to foster innovation." *Design Studies* 24 (4): 181-194.

Bhattacharya, Avisek. 2015. *Electoral Inclusion of Young Middle Class Internal Migrants in Urban India.* Graduate Thesis, Kanpur: IIT Kanpur.

Bijker, Wiebe E., et al. 2012. *The social construction of technological systems: New directions in the sociology and history of technology.* Cambrdige: MIT Press.

Bijker, Wiebe. 1995. *Of Bicycles, Bakelights and Bulbs.* Cambridge: MIT Press.

BJ, Kraus, Brandon MP, Robinson RJ, Connerney MA, Hasselmo ME, and Eichenbaum H. 2015. "During Running in Place, Grid Cells Integrate Elapsed Time and Distance Run." *Neuron* 578-589.

Bjögvinsson, Erling, Pelle Ehn, and Per-Anders Hillgren. 2012. "Design Things and Design Thinking: Contemporary Participatory Design Challenges ." *Design Issues* 28 (3): 101-116.

Bodine-Baron, Elizabeth, Todd C. Helmus, Radin Andrew, and Elina Treyger. 2019. "Countering Russian Social Media Influence." *RAND.* April. https://www.rand.org/pubs/research_reports/RR2740.html.

Boehnert, Joanna. 2014. "Design vs the Design Industry." *Design Philosophy Papers* 12 (2): 119-136.

Bonsiepe, Gui. 2007. "The Uneasy Relationship between Design and Design Research." In *Design Research Now*, by BIRD Board of International Research in Design, edited by Ralph Michael. Basel: Birkhauser.

Bostrom, Nick. 2018. "Interview with Nick Bostrom." In *Architects of Intelligence: The truth about AI from the people building it*, by Martin Ford, 97-116. Birmingham: Packt Publishing Ltd.

Bourdieu, Pierre. 1980. "The production of belief: contribution to an economy of symbolic goods." *Media Culture Society* 2: 261-293.

Bradshaw, Samantha, and Philip N. Howard. 2019. *Challenging Truth and Trust: A Global Inventory of Organized Social Media Manipulation.* Computational Propaganda Research Project, Oxford: University of Oxford Internet Institute.

Bradshaw, Samantha, Lisa-Maria Neudert, and Philip N. Howard. 2018. *Government responses to malicious use of social media.* Riga: NATO Stratcom COE.

Braunerhjelm, Pontus. 2010. "Entrepreneurship, Innovation, and Economic Growth: Past experiences, current knowledge and policy implications." *Working Paper, Swedish Entrepreneurship Forum Stockhold Sweden.*

Broughel, James, and Adam Thierer. 2019. *Technological Innovation and Economic Growth: A Brief Report on the Evidence.* Mercatus Research, Arlington: Mercatus Center, George Mason University.

Broumas, Antonios. 2013. "Governing Media through Technology: The Empowerment Perspective." In *Routledge Handbook of Media Law*, by M. (eds) Price, Verhulst S. and L. Morgan. New York: Routledge.

Brown, Tim. 2009. *Change By Design: How Design Thinking Transforms Organizations and Inspires Innovation.* New York: Harper Collins.

Brown, Tim. 2008. "Design Thinking." *Harvard Business Review* 1-1-.

Brown, Tim, and Jocelyn Wyatt. Winter 2010. "Design Thinking for Social Innovation." *Stanford Social Innovation Review* 31-35.

Brynjolfsson, Erik, and Andrew McAfee. 2018. *Machine, Platform, Crowd: Harnessing Our Digital Future.* Cambridge: MIT Press.

—. 2014. *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.* MIT Press.

Buchanan, Richard. 1992. "Wicked Problems in Design Thinking." *Design Issues* 8 (2): 5-21.

Buchanon, Richard. 1985. "Declaration by Design: Rhetoric, Argument, and Demonstration in Design Practice." *Design Issues* 4-22.

Buchanon, Richard. 2008. "Introduction: Design and Organizational Change." *Design Issues* 24 (1): 2-9.

Buchanon, Richard. 2019. "Systems Thinking and Design Thinking: The Search for Principles in the World We Are Making." *She Ji: Journal of Design, Economics, and Innovation* 5 (2): 85-109.

Buchanon, Richard. 1992. "Wicked Problems in Design Thinking." *Design Issues* 8 (2): 5-21.

Bussolon, Stefano, Barabara Russi, and Fabio Del Missier. 2006. "Online card sorting as good as the paper version." *ECCE '06: Proceedings of the 13th Eurpoean conference on Cognitive ergonomics: trust and control in complex socio-technical systemsSeptember* 113-114.

C, Dell'Era, Marchesi A, and Verganti R. 2010. "Mastering Technologies in Design-Driven Innovation." *Research-Technology Management* 12-23.

Calypso AI. 2019. *What is AI Security?* June 19. Accessed March 26, 2020. https://calypsoai.com/insights/calypso-newswire/what-is-ai-security/.

Canan, Mustafa, and Rik Warren. 2018. "Cognitive Schemas and Disinformation Effects on Decision Making in lay Populations." In *ICCWS 2018 13th International Conference on Cyber Warfare and Security*, by Louise Leenan. ACPIL.

Candogan, Ozan, and Kimon Drakopoulos. 2017. "ptimal Signaling of Content Accuracy: Engagement vs. Misinformation ." *Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3051275* 1-83. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3051275.

Cantarello, Silvia, Anna Nosella, Giorgio Petroni, and Karen Venturini. 2011. "External technology sourcing: evidence from design-driven innovation." *Management Decision* 49 (6): 962-983.

Carnegie Mellon University. 2020. *Swartz Center for Entrepreneurship.* Accessed March 2020. https://www.cmu.edu/swartz-center-for-entrepreneurship/index.html.

Caro, Robert. 1974. *The Power Broker: Robert Moses and the Fall of New York.* New York: Knopf.

Cecez-Kecmanovic, Dubravka, Robert D. Galliers, Ola Henfridsson, Sue Newell, and Richard Vidgen. 2014. "THE SOCIOMATERIALITY OF INFORMATION SYSTEMS: CURRENT STATUS, FUTURE DIRECTIONS ." *MIS Quarterly: Special Issue - Sociomateriality of IS and Organizing* 38 (3): 809-830.

Chadwick, George. 1971. *A Systems View of Planning: Towards a theory of the urban and regional planning process.* Oxford: Pergamon Press.

Chaparro, Barabara, Veronica D. Hinkle, and Shannon K. Riley. 2008. "The usability of computerized card sorting: a comparison of three applications by researchers and end users." *Journal of Usability Studies* 4 (1): 31-48.

CHEQ: University of Baltimore. 2019. *The Economic Cost of Bad Actors on the Internet.* Fake News, University of Baltimore.

Chia, Robert C.H., and Robin Hold. 2009. *Strategy Without Design: The Silent Efficacy of Indirect Action.* Cambridge: Cambridge University Press.

Chrisman, N. 2006. *Charting the unknown: how computer mapping at Harvard became GIS.* Redlands: ESRI.

Churchman, C. W., J P Protzen, and M M Webber. 2006. "In Memoriam: Horst W.J. Rittel." *Design Issues 22 (4)* 18-20.

Colins, Harry. 2010. *Tacit and Explicit Knowledge.* University of Chicago.

Colombo, Massimo G., Cristina Rossi-Lamastra, and Beatrice Matassini. 25. "The organiztional design of high-tech entrepreneurial ventures." *Foundations and Trends in Entrepreneurship.* Hanover MA: Publishers Inc.

Conant, Joyce M. 2015. *Army researcher invents new ways for intelligence analysts to visualize, interact with information.* June 30. Accessed December 12, 2019. https://www.army.mil/article/151432/.

Copeland, Rob, and Katherine Bindley. 2019. "Millions of Business Listings on Google Maps Are Fake – and Google Profits." *Wall Street Journal*, June 20.

Cramer, Henriette, and Jennifer Thom. 2017. "Not-so-autonomous, Very Human Decisions in Machine Learning: Questions when Designing for ML." *The AAAI 2017 Spring Symposium on Designing the User Experience of Machine Learning Systems.* AAAI Spring Symposium. 412-414.

Cross, N. 2006. *Designerly Ways of Knowing.* London: Springer.

Cross, Nigel. 2006. *Designerly Ways of Knowing.* Vol. 3. Verlog: Springer.

Cross, Nigel. 2001. "Designerly ways of knowing: Design discipiline versus design science." *Design Issues* 17 (3): 49-55.

Crouch, Christopher, and Jane Pearce. 2013. *Doing research in design.* Bloomsbury.

Cuartielles, David. 2004. "The Darwinian evolution of contemporary thought species." In *Design [X] Research: Essays on interaciton design as knowledge construction*, by Ed. Pelle Ehn and Jonas Löwgren, 21-36. MALMÖ UNIVERSITY SCHOOL OF ARTS AND COMMUNICATION .

Cumming, Douglas, and Na Dai. 2010. "Local bias in venture capital investments." *Journal of empirical finance* 17 (3): 362-380.

Dalsgaard, Peter. 2012. "Participatory Design in Large-Scale Public Projects: Challenges and Opportunities." *Design Issues* 28 (3): 34-47.

Daniel, Jody. 2017. *Impact of Emerging Technologies on WMD Verification.* Sensitive But Unclassified, Washington DCE: US Department of State, Bureau of Arms Control, Verification, and Compliance: Office of Verification, Planning, and Outreach.

Davenport, Thomas. 2013. "Data is Worthless if You Don't Communicate It." *Harvard Business Review*, June 18.

de Vasconcelos Goms, Leonardo Augusto, Mario Sergio Salerno, Robert Phall, and David R. Robert. 2018. "How entrepreneurs manage collective uncertainties in innovation systems." *Technological forecasing and social change* 164-185.

Dell'Era, C, A Marchesi, and R Verganti. 2010. "Mastering Technologies in Design-Driven Innovation." *Research-Technology Management* 12-23.

Derakhshan, Hossein, and Clair Wardle. 2017. "Information Disorder: Definitions." *Understanding and Addressing the Disinformation System.* Philidelphia: Annenberg School of Communication, University of Pennsylvania. 5-12.

Diebel, Katherine, and Richard, Anderson, Ruth Anderson. 2005. "Using edit distance to analyze card sorts." *Expert Systems* 129-138.

DiSalvo, Carl. 2012. *Adversarial Design.* Cambridge: MIT Press.

Doblin, Jay. 1987. "A Short, Grandoise Theory of Design." *STA Design Journal.*

Dohse, Kaitlin. 2013. "FABRICATING FEEDBACK: BLURRING THE LINE BETWEEN BRAND MANAGEMENT AND BOGUS REVIEWS." *Journal of Law, Technology and Policy* 2013 (2): 363 - 392.

Dormer, Paul. 1994. *Art of the Maker.* Thames and Hudson.

Dorst, Kees. 2011. "The core of 'design thinking' and its application." *Design Studies* 32: 521-532.

Dorst, Kees, and Nigel Cross. 2001. "Creativity in the design process: co-evolution of problem-solution." *Design Issues* 22: 425-437.

Dourish, Paul. 2014. "No SQL: The shifting materialities of database technology." *Computational Culture: A journal of software studies* 4.

Dourish, Paul. 2015. "Rematerializing the Platform: Emulation and the Digital Material." *Unpublished.*

Dourish, Paul. 2007. "Responsibilities and Implications: Further thoughts on ethnography and design." *Proceedings of the 2007 conference on Designing for User Experiences.*

—. 2001. *Where the action is: foundation of emboddied interaction.* MIT.

Dourish, Paul, and M Mazmanian. 2011. "Media as Material: Information Representations as Material Foundations for Organizational Practice." *Working Paper for the Third International Symposium on Process Organization Studies.*

Dove, Graham, Kim Halskov, Jodi Forlizzi, and John Zimmerman. 2017. "Design Innovation: Challenges for Working with Machine Learning as a Design Material." *Proceedings of the SIGHCI Conference on Human Factors in Computing Systems.* (CHI'17).

—. 2017. "UX Design Innovation: Challenges for Working with Machine Learning as a Design Material." *Proceedings of ACM SIGCHI Conference on Human Factors in Computing Systems.* ACM SIGCHI Conference on Human Factors in Computing Systems.

Dubberly, Hugh. 2008. *How do you design.* San Francisco: Dubberly Design Office.

Dunne, A., and F. Raby. 2013. *Speculative Everything.* Cambridge: MIT Press.

Earl, Rebecca. 1997. "Information and Disinformation in Late Colonial New Granada." *The Americas* 54 (2): 167-184.

Eichengreen, Barry. 2008. *The European Economy since 1945: Coordinated Capitalism and Beyond.* Princeton University Press.

European Parliment. 2019. *Polarisation and the use of technology in political campaigns and communication.* Study: Panel for the Future of Science and Technology, Brussels: European Parlimentary Research Service.

Ewenstein, Boris, and Jennifer K. Whyte. 2007. "Visual representations as 'artefacts of knowing'." *Building Research & Information* 35 (1): 81-89.

Facebook. 2017. *Working to Stop Misinformation.* April 7. Accessed 7 February, 2020. https://uxdesign.cc/design-of-responsible-ai-ethics-and-design-from-human-to-humanity-centred-design-imbuing-values-43ba7478e745.

Faludi, Andreas. 1996. "Rationality, Critical Rationalism, and Planning Doctrine." In *Explorations in Planning Theory*, by Seymour J. Mandelbaum, Luigi Mazza and Robert W. Burchell. New Brunswick: Center for Urban Policy Research.

Ferreira, Roberto. 2008. "The CIA and Jacobo Arbenz: History of a disinformation campaign." *Journal of Their World Studies* 59-81.

Fetzer, James, H. 2004. "Disinformation: The use of false information." *Minds and Machines* 14 (2): 231-240.

Field, Anjalie, Doron Kliger, Shuly Wintner, Jennifer Pan, Dan Jurafsky, and Yulia. Tsvetkov. 2018. "Faming and Agenda-setting in Russian News: a computational analysis of intricate political strategies." *arXiv:1808.09386v2 [cs.CL] 29 Oct 2018.*

Filippetti, Andrea. 2011. "Innovation modes and design as a source of innovation: a firm-level analysis." *European Journal of Innovation Management* 14 (1): 5-26.

Florida, Richard. 2014. "The Creative Class and Economic Development." *Economic Development Quarterly* 196-205.

—. 2017. *The New Urban Crisis: How Our Cities Are Increasing Inequality, Deepening Segregation, and Failing the Middle Class-and What We Can Do About It.* Basic Books.

Floridi, Luciano. 1996. "Brave.Net.World: the internet as a disinformation superhighway?" *The Electronic Library* 14 (6): 509-514.

Forestor. 2019. "The Total Economic Impact of Invision: Cost Savings and Business Benefits Enabled by The Invision Platform for Digital Product Design." A Forrestor Total Economic Impact Study.

Forlizzi, Jodi. 2007. *Product Ecologies: Understanding the context of use surrounding products.* Doctoral Disertation, Pittsburgh: Carnegie Mellon University School of Computer Science.

Forlizzi, Jodi. 2008. "The Product Ecology: Understanding Social Product Use and Supporting Design Culture." *International Journal of Design* 2 (1): 11-20.

Forlizzi, Jodi. 2013. "The Product Service Ecology: Using a systems approach in design." *Systemic Design* 1-27.

Forlizzi, Jodi, and John Zimmerman. 2013. *Promoting Service Design as a Core Practice in Interaction Design.* HCI Institute and the School of Design, Carnegie Mellon University.

Forlizzi, Jody. 2018. "Moving beyond user-centered design." *Interactions* 22. Accessed 2020. https://interactions.acm.org/archive/view/september-october-2018/moving-beyond-user-centered-design.

Foster, Tom. 2019. "How Russian Trolls Are Using American Businesses as Their Weapons." *Inc.* May. Accessed May 2019. https://www.inc.com/magazine/201905/tom-foster/russian-trolls-facebook-social-media-attacks-brands-hoax-fake-disinformation.html.

Francastel, Pierre. 2000. *Art & Technology in the Nineteenth and Twentieth Centuries.* New York: Zone Books.

Freire, Paulo. 1968. *Pedagogy of the Oppressed.* Translated by Myra Bergman Ramos. Herder and Herder.

Friere, Karen; Borba, Gustavo; Diebold, Luisa. 2011. "Participatory Design as an Approach to Social Innovation." *Design Philosophy Papers* 9 (3): 235-250.

Fry, Tony. 1995. "A Geography of Power: Design History and Marginality." In *The Idea of Design: A Design Issues Reader*, by Victor Margolin and Richard Buchanon, 118-126. Cambridge: MIT Press.

Gallant, Linda. 2011. "Communicative Informatics: An active and creative audience framework of social media." *Triple C: Cognition, Communication, co-operation* 9 (2): 231-246.

Gans, Josh, David Hsu, and Scott Stern. 2002. "When does start-up innovation spur the gale of creative destruction." *The Rand Journal of Economics* 33 (4): 571-586.

Gans, Joshua, and Scott Stern. 2003. "The product market and the market for "ideas": commericialization strategies for technology entrepreneurs." *Research Policy* 32 (2): 333-350.

Garbuio, Massimo, Andy Dong, Nidthida Lin, Ted Tschang, and Dan Lovallo. 2018. *Demystifying the genius of entrepreneurship: How design cognition can help create the next generation of entrepreneurs.* Singapore: Singapore Management University Lee Kong Chian School Of Business.

Geels, Frank W. 2004. "From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory." *Research Policy* 33: 879-920.

Gillies, Marco, Frederic Bevilacqua, Alexis Heloir, Fabrizio Nunnari, Wendy Mackay, Saleema Amershi, Bongshin Lee, et al. 2016. "Human-Centered Machine Learning." *Chi 2016 Workshop Summary.* San Jose: CHI. 3558-3565.

Glen, Roy, Christy Suciu, and Christopher Baughn. 2014. "The need for design thinking in business schools." *Academy of management learning & education* 13 (4): 653-667.

Goldschmidt, Gabriela. 1994. "On visual design thinking: the vis kids of architecture." *Design Studies* 15 (2): 158-174.

Goodspeed, Robert. 2016. "Digital knowledge technologies in planning practice: from black boxes to media for collaborative inquiry." *Planning Theory & Practice* 17 (4): 577-600.

Goodspeed, Robert. 2016. "The Death and Life of Collaborative Planning Theory." *Urban Planning* 1 (4): 1-5.

Goodspeed, Robert, Peter Pelzer, and Christopher Pettit. 2017. "Planning our future cities: The role computer technologies can play." *Planning Knowledge and Research* 139.

Gorman, Carma. 2003. *The Industrial Design Reader.* New York: Allworth Press.

Gottfried, Jeffrey, and Elizabeth Grieco. 2018. *Younger Americans are better than older Americans at telling factual news statements from opinions.* Washington DC: Pew Research.

Green, Ben. 2019. *The Smart Enough City: Putting Technology in Its Place to Reclaim Our Urban Future.* MIT Press.

Grube, Maren. 2020. *Let's build an innovation ecosystem that includes women, too.* March 6. Accessed March 2020. https://policyoptions.irpp.org/magazines/march-2020/lets-build-an-innovation-ecosystem-that-includes-women-too/.

Guess, Andrew, Jonathan Nagler, and Joshua Tucker. 2019. "Less than you think: Prevalence and predictaors of fake new dissemination on Facebook." *Science Advances* 5: 1-8.

Gunes, Serkan. 2012. "Design entrepreneurship in product design education." *Procedia - Social and Behaviorial sciences* 51: 64-68.

Hagedoorn, John. 1996. "Innovation and Entrepreneurship: Schumpeter Revisited." *Industrial and Corporate Change* 5 (3): 883-896.

Hall, Tony. 2019. *Disinformation campaigns are distorting global news.* February 11 11. Accessed November 2019. https://www.ft.com/content/0df496e2-2a0b-11e9-9222-7024d72222bc.

Halpern, Orit. 2015. *Beautiful Data: A History of Vision and Reason since 1945 (.* Duke University Press Books.

Hanham, Melissa. 2016. *Announcing Geo4NonPro!* May 30. Accessed January 23, 2020. https://www.armscontrolwonk.com/archive/1201434/announcing-geo4nonpro/.

Harder, Marie K., Gemma Burford, and Elona Hoover. 2013. "What Is Participation? Design Leads the Way to a Cross-Disciplinary Framework." *Design Issues* 29 (4): 41-57.

Harper, M.E., Jentsch, F.G., Berry, D. et al. 2003. "TPL—KATS-card sort: A tool for assessing structural knowledge." *Behavior Research Methods, Instruments, & Computers* 35: 577-584.

Harper, Troy. 2018. *How social media disinformation is complicating emergency response* . July 6. Accessed Nov 2019. https://federalnewsnetwork.com/commentary/2018/07/how-social-media-disinformation-is-complicating-emergency-response/.

Harwell, Drew. 2018. "The Washington Post." *White House shares doctored video to support punishment of journalist Jim Acosta.* Nov 8. Accessed Nov 14, 2019.

https://www.washingtonpost.com/technology/2018/11/08/white-house-shares-doctored-video-support-punishment-journalist-jim-acosta/.

Heskett, John. 2017. *Design and the Creation of Value.* Edited by Clive Dilnot and Susan Boztepe. London: Bloomsbury.

—. 2017. *Design and the Creation of Value.* Edited by Clive Dilnot and Susan Boztepe. London: Bloomsbury.

Heskett, John. 2015. "Design from the Standpoint of Economics/Economics from the Standpoint of Design." *Design Issues* 31 (3): 88-104.

Heyleighen, Francis, Iavor Kostov, and Mixel Kiemen. 2013. "Mobilization Systems: technologies for motivating and coordinating human action." In *Routledge Handbook on Knowledge Economy, Education and Digital Futures*, by T. Besley and D. Araya Edited by M.A. Peters. Routledge.

Hindman, Matthew. 2018. *Disinformation, 'Fake News' and Influence Campaigs on Twitter.* Knight Foundation.

Immerwahr, Daniel. 2015. *Thinking Small: The United States and the Lure of Community Development.* Cambridge: Harvard University Press.

Ingram, Jack, Elizabeth Shove, and Matthew Watson. 2007. "Products and Practices: Selected concepts from Science and Technology Studes and from Social Theories of Consumption and Practice." *Design Issues* 23 (2): 3-16.

Institute for the future. 2018. *The Biology of Disinformation: Memes, media viruses, and cultural inoculation.* Digital Intelligence Futures Lab, Palo Alto: Institute for the Future.

International Trade Center. 2019. *Tech hubs in Africa: How can they support startups across the continent?* Geneva: ITC.

Jain, Lyric. 2018. *Is fake news bad for the economy?* Feb 15. Accessed Nov 2019. https://www.finance-monthly.com/2018/02/is-fake-news-bad-for-the-economy/.

Jeelsma, Jaap. 2003. "Innovating for Sustainability: Involving Users, Politics and Technology." *Innovation* 16 (2).

Jeon, Heesang. 2015. *Knowledge and Contemporary Capitalism in Light of Marx's Value Theory.* PhD Thesis, London: Department of Economics, School of Oriental and African Studies, University College of London.

Jerven, Morten. 2013. *Poor Numnbers: How we are misled by African Statistics and What to Do about it.* Cornell University Press.

Jones, John Chis. 1970. *Design Methods: Sees of Human Futures.* London: Wiley-Intersicience.

Jones, John Chris. 1959. "A Systematic Design Method." *Design* (124): 49-52.

—. 1970. *Design Methods: Seeds of Human Futures.* New York: Wiley-Interscience.

Junginger, Sabine. 2006. *Change in the making: Organization change through human-centered product design.* Doctoral Dissertation, Pittsburgh: Carnegie Mellon University.

Junginger, Sabine. 2008. "Product Development as a Vehicle for Organizational Change." *Design Issues* 24 (1): 26-35.

Katz, Bruce, and Julie Wagner. 2006. *Rise of the Innovation Districts.* Washington DC: The Brookings Institute.

Kavanagh, Jennifer, and Michael D. Rich. 2018. *Truth Decay: An initial exploration of the diminishing role of facts and analysis in american public life.* Washington DC: RAND.

Keshavarz, Mahmoud, and Ramia Maze. 2013. "Design and Dissensus: Framing and Staging Participation in Design Research." *Design Philosophy Papers* 11 (1): 7-29.

Kluitmans, Linda. 2013. *The impact of Information Quality on strategic decision-making.* Masters Thesis, Master of Science in Operations Management and Logistics, Eindhoven: Eindhoven University.

Koch, Janin. 2017. "Design Impliations for Designing with Collaborative Ai." *AAAI 2017 Spring Symposium on Designing the User Experience of Machine Learning Systems.* AAAI Spring Symposium. 415-418.

Kolko, John. 2010. "Abductive Thinking and Sensemaking: The Drivers of Design Synthesis." *Design Issues* 26 (1): 15-28.

Krippendorf, Klaus. 2007. "Design Research, an Oxymoron?" In *Design Research Now*, by BIRD Board of International Research in Design. Berlin: Birkhäuser.

Krippendorf, Klaus. 1989. "On the Essential Contexts of Artifacts or On the Proposition that 'Design Is Making Sense (of Things)." *Design Issues* 9-38.

—. 2006. *The Semantic Turn: A New Foundation for Design.* Boca Raton: CRC Press.

Krugman, Paul. 2013. "The New Growth Fizzle." *The New York Times*, August 18.

Kuijer, Lenneke. n.d. *Implications of Social Practice Theory for Sustainable Design.* Technische Universiteit Delft, 2014.

Kunz, Werner, and Horst W. J. Rittel. 1970. "Issues as elements of information systems." *Working Paper: Berkley Institute of Urban and Regional Development.*

Latour, Bruno. 1996. *Aramis, or the Love of Technology.* Cambridge: Harvard University Press.

Lawson, Brian. 2008. *How Designers Think.* London: Architectural Press.

Lazer, David, Matthew Baum, Nir Grinberg, Lisa Friedland, Kenneth Joseph, Will Hobbs, and Carolina Mattson. 2017. *Combatting Fake News: An Agenda for Research and Action.* Conference Final Report, Boston: Northeastern University & Harvard University.

Lee, Bryan, and Kyle Pilutti. 2017. *The Verification Clearinghouse: Debunking Websites and the Potential for Public Nonproliferation Monitoring.* CNS Occasional Paper #29, Monteray: Middlebury Institute of International Studies at Monteray.

Leonardi, Paul M., and Stephen R. Barley. 2008. "Materiality and change: Challenges to building better theory about technology and organizing." *Information and Organization* 18: 159-176.

Lewis, Becca. 2018. *Why influence matters in the spread of misinformation.* November 20. Accessed March 2019. https://knightfoundation.org/articles/why-influence-matters-in-the-spread-of-misinformation.

Lievens, Eva. 2019. *A human rights perspective on our algorithmic transparency.* Ghent: Human Rights Centre Ghent University.

Light, Jennifer S. 2015. *rom Warfare to Welfare: Defense Intellectuals and Urban Problems in Cold War America.* Chicago: University of Chicago Press.

Lindberg, Tilmann, Christoph Meinal, and Ralf Wagner. 2011. "Design Thinking: A fruitful concept for IT Development." In *Design Thinking: Understand - Improve - Apply*, by Ed. by Christoph Meinel and Larry Liefer, 3-18. Heidelberg: Hasso Plattner Institute.

Luo, Jianxi. 2015. "Design Science: The united innovation process: integrating science, design, and entrepreneurship as sub-processes." *Design Science* (Cambridge University Press) 1 (2): 1-29.

Macauley, Molly K. 2005. *The Value of Information: A Background Paper on Measuring the Contribution of Space-Derived Earth Science Data to National Resource Management.* Discussion Paper, Washington DC: Resources for the Future.

Maeda, John. 2017. *Design in Tech Report.* Accessed February 2017. www.designintechreport.wordpress.com.

Mansoori, Yashar, and Martin Lackeus. 2019. "Comparing effectuation to discovery-driven planning, prescriptive entreprenurship, business planning, lean startup, and design thinking." *Small Business Economics.*

Manzini, Ezio. 2017. *Collaborative, design-based democracy.* Accessed April 22, 2019. http://www.democracy-design.org/statement/ezio-manzini/.

—. 2015. *Design, When Everybody Designs: An Introduction to Design for Social Innovation.* Cambridge: Massachusetts Institute of Technology.

Manzini, Ezio. 2014. "Making things happen: social innovation and design." *Design Issues* 30 (1): 57-66.

Manzini, Ezio. 2014. "Making Things Happen: Social Innovation and Design." *Design Issues* 30 (1): 67.

Manzini, Ezio. 2009. "Viewpoint: New Design Knowledge." *Design Studies* 30 (1): 4-12.

Margolin, Victor, and Ezio Manzini. 2017. *Democracy and Design Platform.* March 5. Accessed April 22, 2019. http://www.democracy-design.org/open-letter-stand-up-democracy/.

Marwick, Alice, and Rebecca Lewis. 2017. *Media Manipulation and Disinformation Online.* Data & Society Research Institute.

Marx, Matt, and David Hsu. 2015. "Strategic switchbacks: Dynamic commercialization strategies for technology entrepreneurs." *Research Policy* 1815-1826.

Mascitelli, Ronald. 2003. "From Experience: Harnessing Tacit Knowledge to Achieve Breakthough Innovaiton." *The Journal of Product Innovation Management* 179-193.

Matsangou, Elizabeth. 2019. *Romer's endogenous growth theory could provide a solution for global problems.* January 15. Accessed February 8, 2020. https://www.worldfinance.com/markets/romers-endogenous-growth-theory-could-provide-a-solution-for-global-problems.

McGeehan, Timothy P. 2018. "21st Century Political Warfare: Countering Russian Disinformation." *Parameters* 48 (1): 49-57.

McKinsey & Company. October 2018. *The business value of design.* McKinsey & Company.

Menn, Joseph. 2018. *China-based campaign breached satellite, defense companies: Symantec.* June 19. Accessed January 21, 2020. https://www.reuters.com/article/us-china-usa-cyber/china-based-campaign-breached-satellite-defense-companies-symantec-idUSKBN1JF2X0.

Minsky, Marvin. 2007. *The emotion machine: Commonsense thinking, artificial intelligence, and the future of the human mind.* Simon and Schuster.

MIT. 2019. *Technolog Licensing Office.* Accessed November 2019. https://tlo.mit.edu/learn-about-intellectual-property/mit-ip-policies.

Moles, Abraham A. 1995. "Design and Immateriality: What of It in a Post Industrial Society." In *The Idea of Design: A Design Issues Reader*, by Victor Margolin and Richard Buchanon. Cambridge: MIT Press.

Morgan, Susan. 2018. "Fake news, disinformation, manipulation and online tactics to undermine democracy." *Journal of Cyber Policy* 3 (1): 39-43.

Mumford, Lewis. 1934. *Technics and Civilization.* New York City: Harcourt Brace and Company.

Muratovski, Gjoko. 2017. "Tour of duty: A conversation with Mitchell Sipus – Presidential Innovation Fellow at the White House." *Journal of Design, Business & Society* 3 (1): 7-19.

Murphy, Dan. 2019. *The oil-reliant United Arab Emirates is betting big on tech start-ups and A.I.* May 2. Accessed December 16, 2019. https://www.cnbc.com/2019/05/02/oil-reliant-uae-bets-big-on-tech-start-ups-and-ai.html.

Myerson, Jeremy. 2017. "Scaling Down: Why designers need to reverse their thinking." *She Ji: Journal of Design, Economics, and Innovation* 288-299.

Nadgrodkiewicz, Anna. 2013. *Building Entrepreneurship Ecosystems.* Accessed February 21, 2018. http://www.cipe.org/publications/detail/building-entrepreneurship-ecosystems-0.

National Endowment of the Arts. 2017. *Future of Design Survey.* Accessed February 7, 2018. www.futureofdesign.com.

Newcomb, Doug. 2017. "Why the auto industry c-suite should be nervous about Ford's new design thinking CEO." *Forbes*, May 23.

Nielsen, Suna Lowe, and Poul Rind Christensen. 2014. "The wicked problem of design management: persepectives from the field of entrepreneurship." *The design jounrla: An international journal for all aspects of design* 17 (4): 560-582.

Nielson, Jakob. 1995. *Card Sorting to Discover the Users' Model of the Information Space.* Nielsen Norman Group.

Nielson, Suna, Rind Christensen, Astrid Lassen, and Mette Mikkelson. 2017. "Hunting the opportuity: The promising nexus of design and entrepreneurship." *The Design Journal: An international Journal for All Aspects of Design* 618-638.

Nordhaus, William D. 1998. *Do real-output and real-wage measures capture reality? The history of lighting suggests not.* Cowles Foundation Paper NO. 957, New Haven: Cowles Foundaton for Research in Economics at Yale University.

Norman, Donald A, and Pieter Jan Stappers. 2015. "DesignX: Complex Sociotechnical Systems." *She Ji: Journal of Design, Economics, and Innovation* 83-106.

Norman, Donald A., and Roberto Verganti. 2014. "Incremental and Radical Innovation: Design Research vs. Technology and Meaning Change." *Design Issues* 30 (1).

Nousala, Susu, David Ing, and Peter Jones. 2018. "Systemic design agendas in education and design research." *She Ji* 1-14.

OECD. 2014. *Trends in Income Inequality and its impact on economic growth.* Research Report, Paris: Organisation for Economic Co-operation and Development.

Ohl, Ricky. 2008. *Computer Supported Argument Visualization: Modelling Wicked Problems.* PhD Thesis, Brisbane: Griffith Business School, Griffith University of Brisbane.

Paladino, Brandon. 2018. *Democracy Disconnected: Social Media's Caustic Influence on Southeast Asia's Fragile Republics.* Governance, Washington DC: Brookings.

Pallot, Marc, Brigette Trousse, Bernard Senach, and Dominique Scapin. Aug 2010. *Living Lab Research Landscape: From User Centered Design and User Experiences towards User Cocreation.* Paris: EsoceNet, Universcience.

Pangero, Paul. October 2016. "Designing Conversations for Socially-Conscious Design." *RSD5 Systemic Design Convference.* Toronto.

Papanek, Victor. 1988. "The Future Isn't What It Used To Be." *Design Issues* (MIT Press) 4-17.

Papenek, Victor. 2003. "Design for the Real World." In *The Industrial Design Reader*, by Ed. Carma Gorman, 188-190. New York: Allworth.

Pastor, Elizabeth. 2013. "The OTHER Design Thinking." *Issuu.* Accessed March 2020. https://issuu.com/humantific/docs/theotherdesignthinking.

Paul, Celeste Lyn. 2014. "Analyzing Card-Sorting Data Using Graph Visualization." *Journal of usability studies* 9 (3): 87-104.

Peterson, Jon A. 1979. "The impact of sanitary reform upon American Urban Planning, 1840-1890." *Journal Of Social History* 13 (1): 83-103.

Polanyi, Michael. 1966. *The Tacit Dimension.* Chicago: University of Chicago Press.

Posetti, Julie, and Alice Matthews. 2018. *A short guide to the history of 'fake news' and disinformation.* International Center for Journalists.

Potter, A., M. McClure, and K. Sellers. 2010. "Mass collaboration problem solving: A new approach to wicked problems." *IEEE: Collaborative Technologies and Systems (CTS), 2010 International Symposium on* 398 - 407.

Prier, Jarred. 2017. "Commanding the Trend: Social Media as Information Warfare." *Strategic Studies Quarterly* 11 (4): 50-85.

Quist, Jaco. 2007. *Backcasting for a sustainaBle future the impact after 10 years*. Delft: EBURON ACADEMIC PUBLISHERS.

Röderm, Tilmann J. 2012. "Informal Justice Systems: Challenges and Perspectives." *Innovations in Rule of Law* (Max Planck Institute for Comparative Public Law and International Law) 58-79.

Ravassard, Pascal, Ashley Kees, Bernard Willers, David Ho, Daniel Aharoni, Jesse Cushman, Zahra M. Aghajan, and Mayank R. Mehta. 2013. "Multisensory Control of Hippocampal Spatiotemporal Selectivity." *Science* 1342-1346.

Ray, Argha, and Joey F. George. 2019. "Online Disinformation and the Psychological Bases of Prejudice and Political Conservatism." *Proceedings of the 52nd Hawaii International Conference on System Sciences*. 2742 - 2752.

Rice, Andrew. 2016. "Is Jim Kim Yong Saving the World Bank – Or saving it from itself?" *Foreign Policy*, 4 27.

Rid, Thomas. 2016. *Rise of the Machines: A cybernetic history.* New York: W. W. Norton Company.

Ries, Eric. 2016. *Eric Ries, author "The Lean Startup," on the scientific, experimental method of building startups.* Accessed March 18, 2020. https://www.youtube.com/watch?v=gPlho1vOH6I.

—. 2011. *The lean startup: How today's entrepreneurs use continuous innovation to create radically successful businesses.* New York: Crown Business.

Rigby, Darell K., Jeff Sutherland, and Hirotaka Takeuchi. 2016. "The Secret History of Agile Innovation." *Harvard Business Review.* April 20. Accessed October 2019. https://hbr.org/2016/04/the-secret-history-of-agile-innovation.

Rith, C, and H Dubberly. 2007. "Why Horst W.J. Rittel Matters." *Design Issues 23 (1)* 72-74.

Rittel, H. W., and M. M. Weber. 1973. "Dilemmass in a General Theory of Planning." *Policy Science* 155-169.

Rittel, Horst W.J., and Douglas E Noble. 1988. "Issue based information systems for design." *Working Paper: Berkeley Institute of Urban and Regional Development* (Originally presented to the ACADIA '88 Conference, Association for Computer Aided Design in Architecture, University of Michigan, October 1988.).

Roberts, Nancy. 1998. "Radical Change by Entrepreneurial design." *Acquisition Review Quarterly* 107-128.

Robinson, Anthony C. 2019. "Elements of Viral Cartography." *Cartography and Geographic Information Science* 46 (4): 293-210.

Rogers, Adam. 2014. "Life After Warfare: How a Digital Map Could Help Revive Mogadishu." *WIRED Magazine*, July.

Romer, Paul A. 2019. "A Tax That Could Fix Big Tech." *The New York Times*, 5 6.

Romer, Paul. 1994. "The origins of endogenous growth." *The Journal of Economic Perspectives.* 8 (1): 3-22.

Rose, Arnold M. 1951. "Rumor in the Stock Market." *The Public Opinion Quarterly* 15 (3): 461-486.

Ross, Jamie. 2019. "Facebook Nixes Over 300 Fake News Pages Linked to Russia's Sputnik News Agency." *Daily Beast.* Jan 19. Accessed Nov 2019. https://www.thedailybeast.com/facebook-nixes-over-300-fake-news-pages-linked-to-russias-sputnik-news-agency.

Rule, Troy A. 2016. "Drone Zoning." *North Carolina Law Review* 95 (1): 133-200.

Salinas, Lata, Adam Thorpe, Alison Prendiville, and Sarah Rhodes. 2018. "Civic engagement as participation in designing for services." *ServDes2018.* Milan: Politecnico di Milano. 1-13.

Sarasvathy, Saras D. 2003. "Entrepreneurship as a science of the artificial." *Journal of Economic Pshychology* 24: 203-220.

Sarasvathy, Saras. 2009. *Effectuation: Elements of Entrepreneurial Expertise* . Edward Elgar Publishing.

Schön, Donald A. 1987. *Educating the Reflective Practitioner.* San Francisco: Jossey-Bass.

Schön, Donald A., and Martin Rein. 1995. *Frame reflection: Toward the resolution of intractable policy controversies.* Basic Books.

Schön, Donald, and Martin Rein. 1994. *Frame Reflection: Toward the resolution of intractable policy controversies.* New York: Basicbooks.

Schön, Donald A, and Glen Wiggins. 1992. "Kinds of seeing and their functions in designing." *Design Studies* 13 (2): 135-156.

Schön, Donald A. 1984. *The Reflective Practitioner: How professionals think in action.* Basic Books.

Schumpeter, Joseph A. 1934. *The Theory of Economic Development.* Cambridge MA: Harvard University Press.

Schumpeter, Joseph. 1942. *Capitalism, Socialism, and Democracy: Third Edition.* Vol. Second Edition 2008. New York: Harper Perennial Modern Classics.

Scott, Felicity D. 2010. *Architecture or Techno-Utopia: Politics After Modernism.* Cambridge: MIT Press, Second Edition.

Seitamaa-Hakkarainen, Pirita, and Kai Hakkarainen. 2000. "Visualization and Sketching in the Design Process." *The Design Journal* 3: 3-14.

Shepherd, Dean, Vangelis Souitaris, and Marc Gruber. 2020. "Creating New Ventures: A Review and Research Agenda." *Journal of Management* 1-32.

Shove, Elizabeth. 2007. *The Design of Everyday Life.* Oxford: Berg.

Simon, Herbert A. 1968. *The Sciences of the Artificial, 3rd Edition.* Cambridge: MIT Press.

—. 1968. *The Sciences of the Artificial, 3rd Edition.* Cambridge: MIT Press.

Simon, Herbert. 1969. *The Sciences of the Artificial: Third Edition.* Cambridge: MIT Press.

Smith, Adam. 1776, Reprinted 2007. *An Inquiry into the Nature and Causes of the Wealth of Nations.* Amsterdam: MetaLibri.

Solaimani, Sam, and Ardalan, van der Rhee, Bo Talab. 2019. "An integrative view on Lean innovation management." *Journal of Business Research* 105 (1): 109-120.

Solaimani, Sam, Jack van der Veen, Durward Sobek, Ergodan Gulyaz, and Venu Venugpol. 2019. "On the application of lean principles and practices of innovation managment." *The TQM Journal* 1754-2731.

Spinosa, C, F Flores, and H.L. Dreyfus. 2001. *Disclosing New Worlds: Entrepreneurship, Democratic Action, and the Cultivation of Solidarity.* Cambridge: MIT Press.

StartNow Pittsburgh. 2019. *Resources.* Accessed February 5, 2020. https://startnowpgh.com/resources/.

Steiger, David, and Natalie Steiger. 2008. "Instance-based cognitive mapping: a process for discovering a knowledge worker's tacit mental model." *Knowledge Management Research & Practice* 6 (4): 312-321.

Stolarick, Kevin, and Lou Musante. 2014. "Inclusion, Innovation, and Integrative Design: Pittsburgh Creatives Clusters, What could Pittsburgh look like in 2020?"

Sutika Sipus, Mallory. 2015. *Insurgent Alliances in Afghanistan.* Peace Brief, Washington DC: US Institute of Peace.

Sweidan, Osama D. 2016. "Political Instability and Economic Growth: Evidence from Jordan." *Review of Middle East Economics and Finance* 12 (3): 279-300.

Taylor, Adam. 2016. *Before 'fake news,' there was Sovient 'disinformation'.* November 26. Accessed March 2019. https://www.washingtonpost.com/news/worldviews/wp/2016/11/26/before-fake-news-there-was-soviet-disinformation/?utm_term=.2c1840b7de34.

Taylor, Frederick W. 1911. *Principles of scientific management.* New York: Harper & Brothers.

Taylor, Nigel. 1998. *Urban Planning Theory Since 1945.* London: SAGE.

Tenove, Chris, and Spencer, Moscrop, David McKay. 2018. *Digital Threats to Democractic Elections: How foreign actors use digital techniques to undermine democracy.* Santa Barbara: Centre for the Study of Democratic Institutions.

The Economist. 2018. "Most criticisms of the Doing Business rankings miss the point." *The Economist*, Nov 3.

Thompson, Nicholas, and Issie Lapowsky. 2018. "How Russian Trolls Used Meme Warfare to Divide America." *WIRED*. Dec 17. Accessed Nov 2019. https://www.wired.com/story/russia-ira-propaganda-senate-report/.

Tonkinwise, Cameron. 2014. "How We Intend to Future: Review of Anthony Dunne and Fiona Raby, Speculative Everything: Design, Fiction, and Social Dreaming." *Design Philosophy Papers* 12 (2): 169-187.

—. 2017. "This Time, it is really happening: Democracy must be defended by undemocratic design specifications." *Academia.edu.* December. Accessed April 23, 2019. https://www.academia.edu/35779909/Democracy_must_be_Defended_by_Undemocratic_Designs.

Tonkinwise, Cameron. 2012. "Weeding the City of Unsustainable Cooling, or, Many Designs rather than Massive Design." In *Design Ecologies: Essays on the Nature of Design*, edited by Lisa Blotstein Lisa Tilder. Chronicle Books.

Townsend, Anthony. 2014. *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia.* W. W. Norton & Company.

Trist, Erik, and K. Bamworth. 1951. "Some social and psychological consequences of the longwall method of coal getting." *Human Relations* 4: 3-38.

Tucker, Joshua, Guess Andrew , Barbera Pablo, Vaccari Cristian, Siegal Alexandra, Sanovich Sergey, Stukal Denis, and Nyhan Brendan. 2018. *Social Media, Political Polarization, and Political Disinformation: A Review of the Scientific Literature.* Research Paper, Menlo Park: William + Flora Hewlett Foundation.

Tucker, Patrick. 2019. *The Newest AI-Enabled Weapon: 'Deep-Faking' Photos of the Earth.* March 31. Accessed March 26, 2020. https://www.defenseone.com/technology/2019/03/next-phase-ai-deep-faking-whole-world-and-china-ahead/155944/.

—. 2019. *The NSA Is Studying Satellite Hacking* . September 20. Accessed March 26, 2020. https://www.defenseone.com/technology/2019/09/nsa-studying-satellite-hacking/160009/.

U.S. Congress, Office of Technology Assessment. 1995. *Innovation and Commercialization of Emerging Technologies.* U.S. Congress Office of Technology Assessment.

UK Design Council. 2007. *The value of design factfinder report.* Design Council.

—. 2020. *What is the framework for innovation? Design Council's evolved Double Diamond.* Accessed February 5, 2020. https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond.

UN General Assembly. 1948. *Universal Declaration of Human Rights.* Paris.

University of Pittsburgh. 2020. *Pitt Innovation & Ecosystem Links.* Accessed March 20. https://www.innovation.pitt.edu/resources/pitt-innovation-ecosystem/.

University, Carnegie Mellon. 2019. *CMU Center for Technology Transfer and Enterprise Creation.* Accessed November 2019. https://www.cmu.edu/cttec/.

US Senate. 2018. "United States Senate Committeon Foriegn Relatins." *https://www.foreign.senate.gov.* January 10. Accessed March 2019. https://www.foreign.senate.gov/imo/media/doc/FinalRR.pdf.

UX Collective. 2019. *Design of Responsible AI: imbuing values into autonomous systems.* Accessed February 7, 2010. https://uxdesign.cc/design-of-responsible-ai-ethics-and-design-from-human-to-humanity-centred-design-imbuing-values-43ba7478e745.

Van Bruggen, Jan M., and Paul A. Kirschner. 2003. "Designing External Representation to Support Solving Wicked Problems." In *Arguing to Learn: Confronting Cognitions in Collaborative Learning Environments*, edited by J. Andriessen, M. Baker and D. Suthers, 177-203. Kluwer Academic.

van der Linden, Sander, Jon Roozenbeek, Ruurd Oostwoud, Josh Compton, and Stephan Lewandowsky. 2019. *The Science of Prebunking: Inoculating the Public Against Fake News.* October 7. Accessed February 7, 2020. http://data.parliament.uk/writtenevidence/committeeevidence.svc/evidencedocument/digital-culture-media-and-sport-committee/fake-news/written/79482.html.

Veblen, Theorstein. 1904. *The Theory of Business Enterprise.* Charles Scribner & Sons.

Verbeek, Peter-Paul. 2005. *What things do: Philisophical Reflections on Technology, Agency, and Design.* Pennsylvania State University Press.

Verbeek, Peter-Paul, and Petran Kockelkoren. 1998. "The things that matter." *Design Issues* 14 (3): 28-42.

Vermeeren, Arnold, Virpi Roto, and Kaisa Vaananen. 2016. "Deseign-inclusive UX research: design as a part of doing user experience research." *Behaviour & Information Technology* 35 (1): 21-37.

Vosoughi, Soroush, Deb Roy, and Sinan Aral. 2018. "The spread of true and false news online." *ScienceMag* 1146-1151.

Vosoughi, Soroush, Deb Roy, and Sinan Aral. 2018. "The spread of true and false news online." *Science* 359 (6380): 1146-1151.

Waserman, Arnold. 2013. *Thinking About 50 Years of Design Thinking.* Accessed March 2020. https://vimeo.com/60342260.

Weiner, Norbert. 1964. *God & Golem Inc.* Cambridge: MIT Press.

Weizenbaum, Joseph. 1967. "Contextual Understanding by Computers." *Computational Linguistics* 10 (8): 474-480.

Weller, Amanda J. 2019. "Design Thinking for a user-centered approach to artificial intelligence." *She Ji: Journal of Design, Economics, and Innovation* 5 (4): 394-396.

Werner, Kunz, and Horst Rittel. 1970. "Issues as Elements of Information Systems, Working Paper 131." Studiengruppe für Systemforschung, Heidelberg.

West, Darrell M. 2017. *How to combat fake news and disinformation.* Research Report, Center for Technology Innovation, Brookings Institution, Washington DC: Brookings Instuttion.

Accessed March 2019. https://www.brookings.edu/research/how-to-combat-fake-news-and-disinformation/.

West, Sarah Myers. 2018. "Censored, suspended, shadowbanned: User interpretatiosn of content moderation on social media platforms." *New media & Society* 20 (11): 4366-4383.

White, Damian. 2015. "Worker Centered Design!" *Transition Design Symposium, March 2-5.* Pittsburgh: Carnegie Mellon University, School of Design.

Widener, Michael N. 2016. "Local regulating of Drone Activity in Lower Airspace." *Chapt. 19, Zoning and Planning Law Handbook, 2017 ed.; 22 Boston U. J. Sci. & Tech. L. 239 (2016); Arizona Summit Law School Paper Series No. 2016-A-02.*

Winnograd, Terry, and Fernando Flores. 1986. *Understanding Computers and Cognition: A new foundation for design.* Norwood, NJ: Ablex.

Yang, Kai-Cheng, Onur Varol, Clayton A. Davis, Emilio Ferrara, Alessandro Flammini, and Filippo Menczer. 2019. "Arming the public with artificial intelligence to counter social bots." *arXiv:1901.00912v2 [cs.CY] 6 Feb 2019* 1-27.

Yang, Kai-Cheng, Onur Varol, Clayton Davis, Emilio Ferrara, Alessandro Flammini, and Filippo Menczer. 2019. *Arming the public with artificial intelligence to counter social bots.* arXiv: 1901.00912v2 [cs.CY] 6 Feb 2019.

Yang, Qian, Alex Scuito, John Zimmerman, Jodi Forlizzi, and Aaron Steifield. 2018. "Investigating how experienced UX Designers Work with Machine Learning." *DIS 2018.* Hong Kong: DIS. 585-596.

Yang, Qian, Nikola Banovic, and John Zimmerman. 2018. "Mapping Machine Learning Advances from HCI Research to Reveal Starting Places for Design Innovation." *CHI 2018 Conference Proceedings.* Montreal: CHI. 1-11.

Yaraghi, Niam, and Ravi Shamika. 2017. "The Current and Future State of the Sharing Economy." *Brookings India IMPACT Series* 1-38.

Ziesel, John. 1981. *Inquiry by Design: Environment, Behavior, Neuroscience in Architeture, Interiors, Landscape, and Planning.* Belmont: Wadsworth Inc.

—. 1984. *Inquriy by Design: Tools for Environment-Behavior Research.* Cambriege: Cambridge University Press.

Zhang, Stephen X., and Elco Van Burg. 2019. "Advancing entrepreneurship as a design science: developing additional design principles for effectuation." *Small Business Economics.*