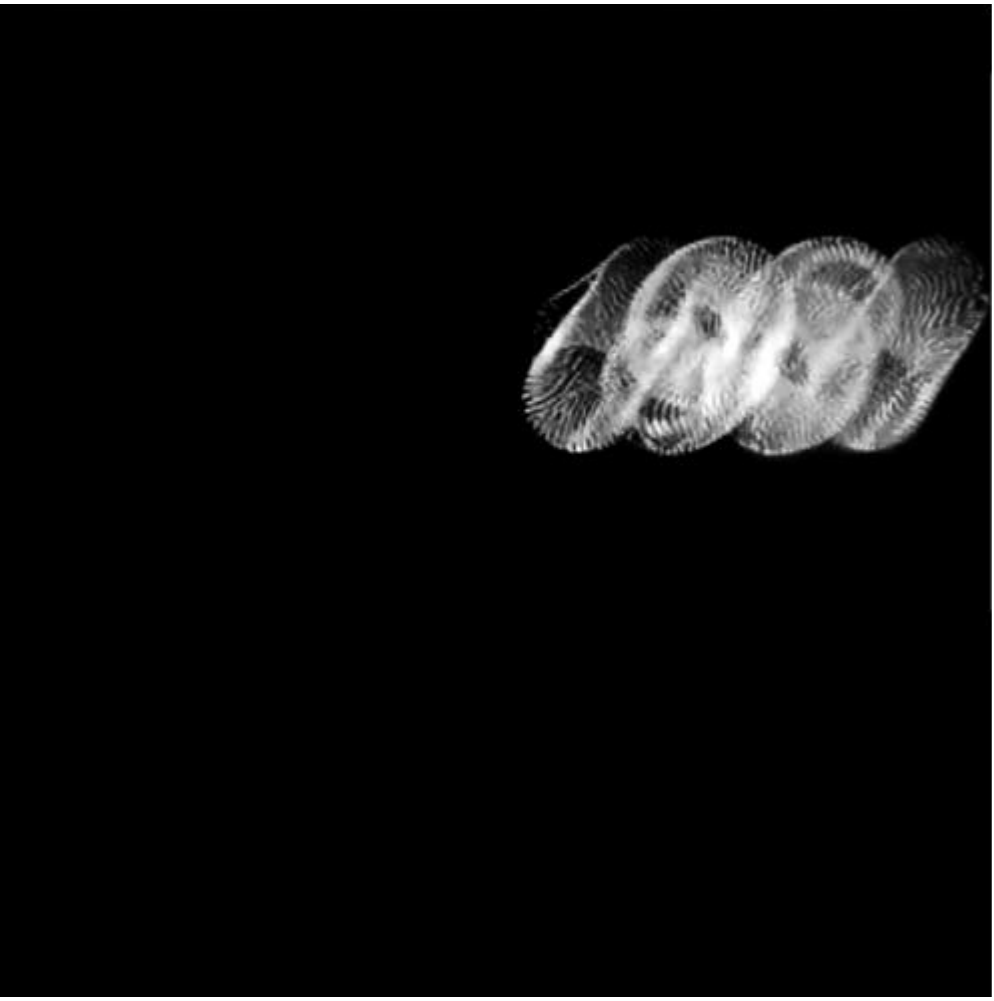
VISION *and* REASON *since* 1945

ORIT HALPERN



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INTRODUCTION__Dreams for Our Perceptual Present

There is a long history linking utopian ideals of technology and calculation with governance, of which Songdo and its sister "smart" cities are but the latest additions. For example, *New Atlantis*, written in 1624 by the English philosopher and statesman Francis Bacon, posited an ideal space governed by education, inductive reason, and empirical experimentation as a scientific practice. This utopia was invented to address the transformations in religion, knowledge, and power in the England of his day and to encourage his ideals of natural philosophy and governance.[1] In the late eighteenth century, the British social reformer and philosopher Jeremy Bentham presented an ideal architecture—the panopticon (fig. 1.1)—to demonstrate his ideal of a link between visuality, the rational and calculated management of space, and democratic government. Bentham posited a perfectly organized space where power could be wielded without force as part of a utopian reconceptualization of politics.[2]

Modern utopias have also often reflected the media, technology, and scientific methods of their time. The famous French architect Le Corbusier, for example, imagined cities of tomorrow in 1923 (fig. 1.1) that would be perfectly statistically managed, showcase the latest technologies, and eliminate disorganization and could be built and replicated through systemic, machine-like principles and the application of careful statistical social science. Le Corbusier invented a method of proportions that allowed his designs to be implemented at different scales—from individual homes to entire cities.[3] His plans went on to shape the future of cities like Brasília and Chandigarh and to define the future of public housing globally in the postwar years. According to the architectural historian Robert Fishman, Le Corbusier imagined that the industrialist and engineer had built the perfectly rationalized mode of production, and therefore architecture and planning had to provide a city that refracted and advanced modern technology and capital in the early to mid-twentieth century.[4]

If modernity had "a machine for living," to quote Le Corbusier's definition of his home design, by the 1970s architecture itself was being envisioned as

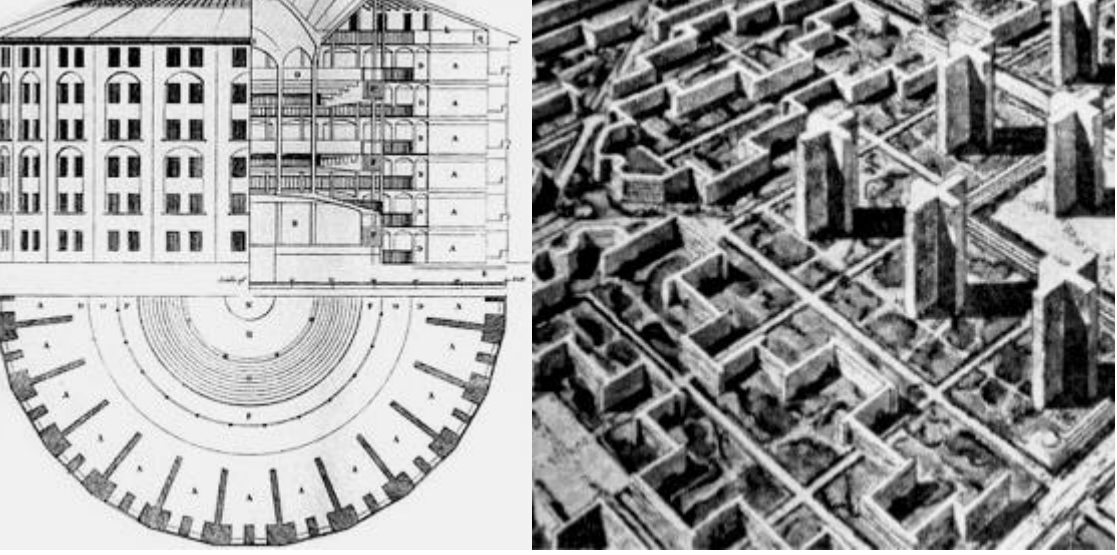


FIG. I.1__Jeremy Bentham's Panopticon penitentiary, drawn by Willey Reveley, 1791. Wikipedia, http://en.wikipedia.org/wiki/File:Panopticon.jpg; City of Tomorrow (1923). From Le Corbusier, *City of To-morrow*, 173; Songdo, satellite imagery, with →

a "machine," but a new one: a computational and artificially intelligent network composed of intimate feedback loops between designers, users, and computers. One of the key sites forwarding this vision of computational environments was the Massachusetts Institute of Technology (MIT) and the MIT Media Lab. In fact, MIT was initially supposed to be involved in the Songdo project, but there were problems in the collaboration that may have emanated from either capital constraints or ideological differences or both. The reason remains obscure, or at least my informants refused to elaborate. Many of the chief architects of the smart-city initiatives in South Korea claim MIT as inspiration and model, and much of our contemporary thinking about ubiquitous computing and smart cities in urban planning emanated from Nicholas Negroponte's Architecture Machine Group, which was started in 1967 at MIT with funding from major corporations and the Cybernetics Technology Division of the Advanced Research Projects Agency (ARPA, after 1972 DARPA), of the U.S. Department of Defense for the purposes of integrating computers into architecture and urban planning. Negroponte's ideas were popularized through the labs and a number of books introducing the idea of an "architecture machine" and later "soft architecture machines" in the early 1970s.[5]

Negroponte opened his text on "the architecture machine" with two premises. The first was that "computer-aided design cannot occur without machine intelligence" and that this intelligence must be "behavioral" and "must have a sophisticated set of sensors, effectors, and processors."[6] The fundamental re-

projected space to be reclaimed from the sea, and the outline of the projected topography of the official Incheon Free Economic Zone visible in white. Image: author, September 2, 2013.

organization of planning and architecture around computing did not, therefore, begin with any set of concepts usually linked to architecture. Instead, these manifestos opened with discussions of two elements: sensory capacity and intelligence. For Negroponte a true "architecture machine" would not be a modern machine serving human needs but an integrated system that was based on a new type of environmental intelligence related to the regular capacity to sense and respond to sensory inputs. His articles and books distilled a constellation of theories about intelligence and complexity to argue that design had to become process, a "conversation," in his words, between two intelligent species—human and machine—and not a linear cause-effect interaction.[7] "We are talking about a symbiosis that is a cohabitation of two intelligent species," he wrote.[8] He was not interested in computerizing design so much as rethinking the design process itself. This symbiosis was necessary to address both a human inability to deal with "large-scale problems"—beyond the protocols of architecture and planning, which were incapable of dealing with systemic problems, emergence, or changing contexts—and simultaneously architects' and planners' inability to handle large amounts of specific and local data.[9] Architecture as a machine was about design as a process that could mine data, find patterns, and produce new forms of emergent growth through feedback.

It is, therefore, not even to architecture that these original formulations of smart and sentient design and urban planning paid debt but rather to cyber-

netics, and to ideas of systems, behavioralism, and cognition that had emerged in the previous two decades out of work in the cognitive sciences and neural nets.[10] At the heart of Negroponte's manifestos for computer-aided design lay the work of cyberneticians, particularly the MIT mathematician Norbert Wiener, the neural net pioneer Warren McCulloch, and the British cybernetician Gordon Pask, along with influences from other pioneers in computer-aided design, such as Christopher Alexander.[11]

To begin, then, I want to start not with architecture but with cybernetics. In 1953, the MIT mathematician and cybernetician Norbert Wiener, in his memoir *Ex-Prodigy*, made a statement about diagrams that also imagined a new future into being, and that bears on our contemporary concerns with ubiquitous computing, data, and visualization. "I longed," he wrote, "to be a naturalist as other boys longed to be policemen and locomotive engineers. I was only dimly aware of the way in which the age of the naturalist and explorer was running out, leaving the mere tasks of gleaning to the next generation."[12] Developing this theme, he would later write, "even in zoology and botany, it was diagrams of complicated structures and the problems of growth and organization which excited my interest fully as much as tales of adventure and discovery."[13] In a series of popular books and technical manifestos, Wiener would go on to interrogate this "problem" that complexity poses. Written in a reflective moment after World War II, Wiener's comments sought to mark the passing of one age to another—the end of "exploration" and the emergence of another type of "organization."

This was no small claim. When situated in the context of his other works about communications theory and computing, this seemingly minute comment about personal memory gestured to a fervent hope: that an epistemic transformation involving the relations between temporality, representation, and perception was in process. Wiener indicated a desire to see an older archival order, adjoined to modern interests in taxonomy and ontology, rendered obsolete by another mode of thought invested in prediction, self-referentiality, and communication. Wiener's words anticipate the emergence in the coming decades of a machine design that might indeed surpass the hand or eye of the architect; he imagined a new form of visualization and knowledge.

Wiener dreamed of a world where there is no "unknown" left to discover, only an accumulation of records that must be recombined, analyzed, and processed. Wiener argued that in observing too closely and documenting too "meticulously," one is unable to deduce patterns, to produce in his words a "flow of ideas." He wrote that "if he [a student] decides to take notes at all, he has already destroyed much of his ability to grasp the argument in flight,

and at the end of the course has nothing but a mass of illegible scribble. . . . It is far better to give up the idea of taking notes and to organize in his mind the material as it comes to him from the speaker."[14] *Ex-Prodigy*'s obsessive implication was this gap between thought and action, and not, as the autobiographical genre might lead us to expect, the need to document or account for past experiences. This subtle shift of emphasis away from concerns with documentary and personal experience opens a site to excavate the historical reformulation of relations between vision, cognition, and communication.[15]

Today, seated behind our personal computer monitors, constantly logged in to data networks through our personal devices, we stare at interfaces with multiple screens and no longer aspire to go out and explore the world. From the vast cityscapes of Songdo to our everyday use of numerous mobile devices, the environment is assumed to be an interface to elsewhere that will bring information to users. There is no "unknown" left to discover. We have come to assume that the world is always already fully recorded and archived; accessible at a moment's notice through the logics of computational searches. Wiener's words seemingly have been technologically realized, our relationship to historical time, documentation, and knowledge apparently reconfigured through the terms of communication and control. In the realms of neuroscience and the many attention deficit disorders we now cultivate as pathologies, this situation is ordained genetic. The speculation to build an architecture to harness this attention is at a frenzy. Humanity, it seems, always sought to communicate through screens, always wanted to garner ever more data from more locations, more immediately. It is the purpose of this work to denaturalize such assumptions.

Wiener's autobiography thus bridges late nineteenth- and early twentieth-century ideals of taxonomy, ontology, and archiving and post-mid-twentieth-century concepts of organization, method, and storage. He articulated a desire to see previous traditions in natural history and scientific representation replaced by a discourse of active diagrams, processes, and complexity. And Wiener did not dream alone. His memories found concrete expression in such diverse places as the new multimedia architectures of spectacular geopolitics and the minute neural nets of the mind.

In the postwar era, throughout the social sciences, neurosciences and cognitive sciences, computer sciences, arts and design, endless flow charts emerged producing images not of an outside world but of the patterns linking thought to action.[16] The social and human sciences turned to performance and visualization as a route to innovation.

Prominent designers, such as Gyorgy Kepes of MIT, for example, would ex-

claim that "the essential vision of reality presents us not with fugitive appearances but with felt patterns of order."[17] Arguing for a reality that is not "fugitive" and a beauty produced out of patterns rather than essence and forms, designers, engineers, and scientists propagated a discourse of a "new" vision emerging from informational abundance. This vision cannot be understood as solely concerning optics and eyes but rather, in Kepes's language, a "landscape of sense" produced through technologies like "radar and electronic computers"[18] that would organize perception, and practice, in many fields. This "felt order" would be the source of beauty, and would transform data from being set out in "terms of measured quantities" to being "set out in terms of recreated sensed forms . . . exhibiting properties of harmony, rhythm, and proportion.[19]

Kepes's compatriot and interlocutor, the designer and inventor Buckminster Fuller, the Cold War evangelist of a unity between art, design, and science through cybernetics in the 1960s and 1970s, vociferously propagated the concept of a renaissance "design scientist." In his effort to unify the varied fields of physical, social, biological, and design practices, he labeled the very process of inquiry a thing of "beauty" in and of itself. "It is one of our most exciting discoveries," he wrote, "that local discovery leads to a complex of further discoveries. Corollary to this we find that we no sooner get a problem solved than we are overwhelmed with a multiplicity of additional problems in a most beautiful payoff of heretofore unknown, previously unrecognized, and as-yet unsolved problems."[20] Complexity and problems, rather than solutions, became valuable. Implicitly, like Wiener, Fuller is calling for a valorization of process and method as material artifacts and objects, in the way that previously designers conceived of architecting a building or a chair. In his standard hypertextual fashion Fuller (known to give eight-hour lectures full of slides in a test of attention and repetition whose only goal was the inundation of data in a mimetic reperformance of this aesthetics of informational overload) argued that such practices fostered an "awareness of the processes leading to new degrees of comprehension." This search for awareness, he continued, "spontaneously motivates the writer to describe over and over again what—to the careless listener or reader—might seem to be tiresome repetition, but to the *successful explorer* is known to be essential mustering of *operational strategies* from which alone new thrusts of comprehension can be successfully accomplished."[21] Process, Fuller implies, *is* the site of exploration; generating in turn "strategies" that are also "beautiful." His argument for an optic of process and the beauty of method are the marks of a midcentury shift in the aesthetics and practices of information visualization. Fuller's pronouncements mark the rise

of a new aesthetic and practice of truth; a valorization of analysis and pattern seeking that I label "communicative objectivity."

If the stereotype of the nineteenth century is that of a naturalist or industrialist extracting value from natural resources (including alienating labor from human bodies), these citations from the preeminent designers and pedagogues of the mid-twentieth century gesture to an aspiration and desire for data as the site of value to emerge from the seeming informational abundance once assumed to be the province of nature. Data, Kepes and Fuller implied, appeals to our senses and can be seen, felt, and touched with seemingly no relationship to its content. Behind this materialization of data as an object to be marveled at, however, lay an aesthetic infrastructure of sensorial training and a new imaginary of vision as a channel and a capacity that was autonomous, networked, and circulative.

Such cybernetically inflected attitudes also emerged in the social and human sciences. "All that is offered here," a prominent textbook in political science from the early 1960s argued, "is a point of view. Men have long and often concerned themselves with the power of governments, much as some observers try to assess the muscle power of a horse or an athlete. Others have described the laws and institutions of states, much as anatomists describe the skeleton or organs of a body. . . . [Political science must] concern itself less with the bones or muscles of the body politic than with its nerves—its channels of communication and decision."[22] Written by one of the preeminent political scientists of the time, the Yale professor Karl Deutsch, the book implied that the study of government would be a study of perception, a training in "a point of view," to be guided by nervous diagrams. The entire book calls on visual metaphors and presents flow charts of decision-making trees that emulate those of computer programming, also emerging at the time (fig. 1.2). Like Wiener's drawings reconciling the slowness of the hand with the speed of thought, so in the study of organizations would the careful mapping of process synchronize the time of bureaucracy and the flow of information.

Rather than observe closely as an anatomist, Deutsch insisted on another type of vision. He wrote that "today we are learning in television [and other communications technologies] to translate any outline of a static or slow-changing thing, such as the edge of a mountain, or the edge of a human skull, or the lines of a human face, into a sequence of rapidly-changing little dots. . . . We learn, through scanning . . . how to put together these events, which move slowly but are strung out along a period of time, and to see them all at once."[23] Moving beyond a dialectic opposing close observation to theoretical abstractions, Deutsch's image world was simultaneously empirical and abstract. Be-

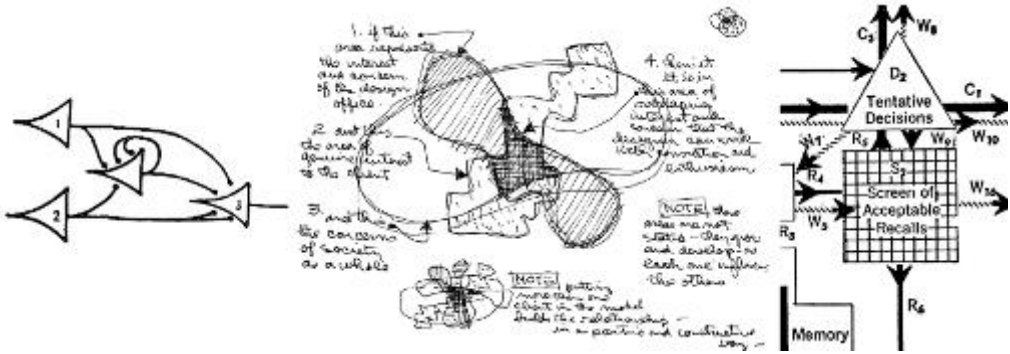


FIG. I.2__Neural net diagram by Warren McCulloch and Walter Pitts (1943), from McCulloch, *Embodiments of Mind*, 36; Design process flow chart, by Charles Eames, made for the exhibition "What Is Design," Musée des Arts Décoratifs, Paris (1969). The Work of Charles and Ray Eames, Manuscript Division, box 173, folder 9, Library of Congress. © 2013 Eames Office, LLC; Diagram of foreign policy decision-making process, by Karl Deutsch, from Deutsch, *Nerves of Government*, appendix.

tween the nearsightedness of the bureaucrat trapped in the trees for the forest and the abstracted metaphysics of the political theorists, the visual tactics of "scanning" and pattern seeking might create a bridge. These diagrams produced, in his words, a new "scale" of observation that turned discrete and nonsensical data points into coherent patterned flows.[24]

Deutsch's diagrams, which were ubiquitous during three decades of elite pedagogy in political science, linked local knowledge and global trends through a methodology of "scale" and "scanning" that mimed the television and communication technologies whose aesthetics they invoked. The purpose of these instructional images was to teach a cadre of elite future policy-makers, analysts, and legal thinkers how to see and scan for a new object of study—decision-making processes and managerial actions—to be able to reflexively use data to make the world visible and knowable.

Data visualization became a democratic virtue and moral good; reason was now understood as algorithmic, rule-bound, definitive, and fast. The reconfiguration of the eye of the technocrat came with the reformulation of the mind of the decision-maker and of the organization itself. The rise of cognition as a model for human thinking and organizational behavior and the rise of visualization as a virtue came hand in hand. Ideas of territory, population, and design were rethought in tandem with transformed ideas about knowledge, representation, and measurement in the social and human sciences. This

book unites these two strains of history that are so closely merged in contemporary digital environments.

This book traces the trajectory laid out above to link design, architecture, and artistic practices with cybernetics and the human and social sciences. Excavating Wiener's initial concerns about the relationship between nineteenth-century science and archiving, and his own efforts in pioneering the science of communication and control that he labeled "cybernetics," I chart the relationship between contemporary obsessions with storage, visualization, and interactivity in digital systems to previous modernist concerns with archiving, representation, and memory. Postwar design and communication sciences, believing the world to be inundated with data, produced new tactics of management for which observers had to be trained and the mind reconceived. The result of this reformulation of vision and reason was the production of a range of new tactics, and imaginaries, for the management and orchestration of life.

In my description of contemporary ubiquitous computing environments and data-driven sciences, I have therefore specifically drawn attention to three elements that emerge prominently in cybernetic accounts: the way contemporary discourses on data revise epistemology, create temporalities, and produce aesthetics. The book genealogically traces these three aspects of our present that are so critical to this reformulation of observation and knowledge: first, the reconceptualization of the archive and the document in cybernetics and the human sciences; second, the reformulation of perception and the emergence of data visualization and the interface as central design concerns; and third, the redefinition of consciousness as cognition in the human, cognitive, and social sciences. These three loci—the reformulation of temporality and truth, the reformulation of attention and distraction into interactivity, and the reconfiguration of reason into rationality—structure the book. My argument is that the reconceptualization of evidence, vision, and cognition are the foundations for producing new techniques of calculation, measurement, and administration. I seek to account for this condition that finds itself most graphically demonstrated in such extreme prototypes as Songdo, but can be found more ubiquitously in our armory of electronic and graphical interfaces.

Histories of the Present

How, then, would one begin to comprehend this transformation in the treatment of the senses as commodities, technologies, and infrastructures? This book started over a decade ago, when the concepts of interactivity and his-

tories of observation were still novel ideas. Works like Lev Manovich's *Language of New Media*, Alexander Galloway's *Protocol*, and Katherine Hayles's *How We Became Post-Human* were read alongside an emergent concern in the history of science and art in histories of the body, rationality, taste, and emotion. The rise of a history of observation, perception, and objectivity, written by figures like Jonathan Crary, Wolfgang Schievelbusch, and Lorraine Daston and Peter Galison, interested me as fully as the discussions about the nature of new media.[25]

In the intervening time, complexes like Songdo have moved from being at the margins of literary critics' imaginations to being built and circulated spatial products. As a historian grappling with the media subjects, new questions began to emerge: What makes such a space feasible and even seemingly natural? Are our models of software and hardware based on certain architectures of computing the most useful to account for these emergent formations? Do discourses of embodiment, or even materiality, account for a world where major corporations are also invested in object-oriented thinking? The world is alive with datafiable objects that are also commodities and bodies for the engineers at Cisco. What types of temporal narratives, then, would be able to produce a history of the senses and of observation and knowledge that might challenge the stability of the present without recourse to an imagined ahistoricity of objects and matter?

As Eugene Thacker and Alexander Galloway have put it in their most recent book, *The Exploit*, "again and again, poetic, philosophical, and biological studies ask the same question: how does this 'intelligent,' global organization emerge from a myriad of local, 'dumb' interactions?"[26] Swarms, clouds, black boxes—the question is not unimportant, and in tracing the specific tactics and forms that reason took in the last half a century, I seek to situate such questions. I am not answering why one would pose such a question but rather asking under what conditions would it be thinkable, and even virtuous, to pose such questions about stupidity, either from the perspective of media theory or engineering?

In the late 1940s and early 1950s, for example, the same phenomena—swarms, clouds, masses—were treated far differently. There was no effort to be morally neutral when it came to media protocols. For political theorists such as the German-Jewish émigré and prominent political theorist Hannah Arendt, such phenomena posed mortal threats to the future of life. In *The Human Condition*, published in 1958, Arendt is concerned with a world in which "*speech has lost its power*" to a "language of mathematical symbols which . . . in no way can be translated back into speech." This loss of a critical place for human ac-

tivities to enter the realms of representation and subjectivity she aligns with "automation," particularly the automation of computational machines. These losses, of labor and of language, are for her fundamentally about losing connection and ability to act politically as individuals, not as masses. Her conception of freedom is fundamentally liberal, linked to the ability to represent and know the world and to act as a connected but independent agent. This is a vision absolutely antagonistic to the types of affective and networked theory often being supported in our present.[27] Her colleague, interlocutor, and fellow émigré the prominent Frankfurt School theorist Theodor Adorno, would write of the "culture industries" in a similar light. "The masses," Adorno wrote, "are not the measure but the ideology of the cultural industry." For Adorno, the culture industries turn concerns of class criticism or artistic imagination into a routinized format through the "dehumanizing" protocols of stardom. Ironically, these protocols appeal to aura and individuality while crafting unthinking masses. Thus, the effect of such media is "anti-enlightenment." In his words, "it impedes the development of autonomous, independent individuals who judge and decide consciously for themselves."[28] The culture industries are guilty of producing the masses while denying the right of the same populations to gain, for Adorno, freedom and agency. Similar discourses about hoards, swarms, and unthinking masses characterized Communism as well at the time. From the science fiction fantasies of body snatching and zombies to the characterization of brainwashing and the Chinese Army during the Korean War, the dominant view of Communism was as a force against agency, rendering individuals subservient to some common intelligence.[29]

I call attention to these debates, however, not to account for the reality of media but to ask about history. These commentators demonstrate that in 1948, ideas of feedback and information inundation were negatively associated with totalitarian regimes, and hardly considered virtuous. The social sciences had only begun to even contemplate the idea that communication was a social virtue, and many political theorists, cultural analysts, and popular psychologists would have found our contemporary valuation of collectivity, social networking, and analytics terrifying. These changes in the moral value and aesthetics assigned to different ideas are the markers of historical revisions in attitudes toward, and imaginaries of, the place of media technologies within societies and the constitution of knowledge and truth. I am particularly interested in the years between 1945 and the early 1970s because this is a period when one can still witness debates between modern and prewar conceptions of truth, certainty, and subjectivity and emerging ideas of communication and cybernetics.

I follow Deleuze, who asked in his cinema books not what is cinema but what is philosophy after cinema? My question is a derivative. I ask what is it to tell history under the conditions of digital media? The status of historicism is under duress, and the organization of temporality in this text is one of feedback and density, not orderly linear time. I examine how reason, cognition, and sentience were redefined in a manner that makes it logical and even valuable to pose such philosophical questions, and, on a more pragmatic note, to begin building territories, for example, based on ideals of distributed intelligence and a belief that space can be sentient, and smart, through (literally) so much "stupidity." These are pathways that produce an albeit limited, but at least speculative, history of concepts such as "interactivity," "beautiful data," and the interface.

To comprehend this transformation in the treatment of the senses as commodities, technologies, and infrastructures and the concomitant transformation in population and governance without recourse to technical determinism, I focus, therefore, not on realized technologies but on post–World War II ideas, pedagogies, and practices of observation in cybernetics, communication sciences, and their affiliated social and design sciences. Such an attitude follows the lead of figures such as the art historian Jonathan Crary[30] in his history of observation and media genealogists, such as Jonathan Sterne, who are not as interested in the realized technology of recording the senses as in the "possibilities" for producing media technologies.[31]

As Crary notes, "observer" means "'to conform one's action, to comply with,' as in observing rules, codes, regulations, and practices." He continues that observation is more than representational practice, rather "[the observer] is only an *effect* of an irreducibly heterogeneous system of discursive, social, technological, and institutional relations. There is no observing subject prior to this continually shifting field."[32] Crary wrote about the nineteenth century, but what is increasingly evident is that contemporary forms of observation and perception may not even be linked back to single bodies or unified subjects. Life here has to be considered as a set of mechanically calibrated movements and gestures operating at various embodied and even molecular levels. The sensory networks of train systems and smart cities are operating at multiple scales. But what likens these networks to practices of an "observer" is that they operate within certain conditions of possibility, "embedded in systems of conventions and limitations,"[33] and, I might add, affordances and capacities, that are historically situated. To produce this account, therefore, I insist on linking the transformation in attitudes to perception *with* the reformulation of ideas of reason and cognition, because this alignment between how we know

and how we sense is critical to understanding and contesting contemporary attitudes to intelligence, data banking, and interactivity.

Vision, Visualization, Visuality, *Visibilités*

One of the curious elements of invoking terms like "vision" and "observation" in our present is that it complicates the very idea of sense perception itself. Moreover, in that no computer actually sees the way a human being does, one needs to ask what it is that is being invoked with the language of vision? As should by now be obvious from the opening of the book, "vision" in this text operates as a holding term for multiple functions: as a physical sense, a set of practices and discourses, and a metaphor that translates between different mediums and different communication systems. Vision is thus a discourse that multiplies and divides from within.

To offer a cartography of this complicated terrain, I want to start with one of the more popular words applied to contemporary data display—"visualization." According to the OED, the term is not ancient but rather a modern convention, only appearing in 1883 to depict the formation of mental images of things "not actually present in sight."[34] Throughout the next few decades, this term expanded to encompass any "action or processes of making visible."[35] Visualization slowly mutated from the description of human psychological processes to the larger terrain of rendering practices by machines, scientific instrumentation, and numeric measures. Most important, visualization came to define bringing that which is not already present into sight. Visualizations, according to current definition, make new relationships appear and produce new objects and spaces for action and speculation.

While the language of vision perseveres, it is important not to assume a direct correlation between vision as a sense and visualization as an object and practice. Married initially to psychology, and now digital computation and algorithmic logic, the substrate and content of this practice has often had little to do with human sense perception or the optic system. Moreover, with the rise of emphasis on haptic interactions and interactivity, visualizations also often take multisensorial modes. Vision cannot be taken, therefore, as an isolated form of perception, but rather must be understood as inseparable from other senses.

In the present, visualization is most often understood not only as a process but also an object, a subject and discipline, a vocation, a market, and an epistemology. For example, SAS, one of the major contemporary makers of data visualization software and enterprise solutions, on their website states

that visualization is the practice of making complex data (also not defined in this case) "dynamic," "universal," and "valuable." The website enjoins future clients to believe that visualization software allows previously "invisible" relationships in market or other data to become "visible" and operable.[36] The prime figure behind the "smart" city and now "smart planet" mandate, IBM, repeats this definition in discussing analytics and visualization: "organizations are overwhelmed with data. On a smarter planet, the most successful organizations can turn this data into valuable insights about customers, operations, even pricing . . . for business optimization by enabling rapid, informed and confident decisions and actions." Visualization, IBM then insists, is part of making data actionable through representation while also facilitating the ongoing analysis of data.[37] Repeating the assumption of an "overwhelming" data landscape, visualization is understood to offer a map for action. At the same time visualization and analytics, comprehending and analyzing, are viewed as an integrated process.

Visualization, both marketing manuals and studies of digital images suggest, is the language for the act of translation between a complex world and a human observer.[38] Visualizations are about making the inhuman, that which is beyond or outside sensory recognition, relatable to the human being. One might understand "visualization" in this context as the formulation of an interaction between different scales and agents—human, network, global, nonhuman.

Visualization is also about temporal scales. For example, IBM and SAS assume that data only becomes valuable, or a site of action, once it is crafted into the realm of appearances. However, the realm of the image and the space of data are not in the same time. As in the nineteenth-century definitions, when visualization was solely about mental images and thus not synchronous with the world, in our present a visualization is understood as being out of time and space, nonsynchronic with the event it is depicting, translating, comprehending, and guiding.

This nonsynchronicity preoccupies our imaginings of "real-time" interactivity and data visualization, driving a constant redefinition of the temporal lags between collecting, analyzing, displaying, and using interfaces. Underpinning the contemporary frenzy to visualize is an implicit supposition that cognition, and value, lags behind the workings of networks and markets. The work of visualization is thus temporal—to modulate and manage this time lapse.

As the preeminent language for negotiating our data-filled world, "visualization" invokes a specific technical and temporal condition and encourages

particular practices of measurement, design, and experimentation. Visualization, like the term "data," looms, therefore, as a never fully defined verb/noun that straddles the actual practices of depicting and modeling the world, the images that are used, and the forms of attention by which users are trained to use interfaces and engage with screens.

If the language of visualization organizes our present relationship to the interface, the term's relatively recent emergence at the end of the nineteenth century also poses historical questions. For historians of science and art, "visuality" is the language for asking about such historically specific formulations of sense. It is the language for inquiry into the historical, technical, social, physical, and environmental conditions that shape the experience of "seeing." The filmmaker Harun Farocki, for example, offers a clear-cut example of how the most physiological act of seeing is permeated with history. In a famous film, *Images of the World and the Inscription of War* (1988), Farocki offers a tableau. He asks how is it that American and British analysts looking at aerial surveillance photographs fail to see Auschwitz, and only identify Buna manufacturing plants in 1944, but two CIA analysts can later find the camp in the same images in 1978 after seeing melodramatic TV series about the Holocaust? This difference, as the film theorist Kaja Silverman has made explicit, is about how physiological capacities are conditioned and vary under historical conditions.[39] The same example could be repeated with attention, identity, or any number of other examples that demonstrate that while the actual sense of vision may traverse history, its organization and arrangement is historical, culturally, and technically specific. The emergence of panoramas, impressionist painting, abstraction in art, and so forth are all the trace markers of a history of visuality, where how we see comes into contact with the ideas, structures, and technologies of society.[40] Things that appear strange, ugly, or invisible in one era are not so at other times, and our forms of attention, distraction, beauty, disgust, and empathy are all physically and psychically real and simultaneously historically modulated.

When I speak of vision, then, it often encompasses the actual sensory-motor-cognitive apparatus of seeing, the eye, the brain, nerves, even if not always human. But vision, particularly within a Western tradition, also operates metaphorically as a term organizing how we know about and represent the world; a metaphor for knowledge, and for the command over a world beyond or outside or subjective experience.[41] To be seen by another, to see, to be objective, to survey, all these definitions apply in etymology and philosophy to the Latin root: *videre*.[42] *Videre* is also at the root of the word "evidence," and I maintain the language of vision precisely because its etymology provides a

space to begin asking how truth and knowledge are being reconstituted in different historical moments.

The history of evidence is also, for Deleuze, reading Foucault, one of vision. For Deleuze visuality is closely linked to *visibilités*, or what in English I will label "visibilities." Deleuze defines this term as "visualness,"[43] implying that vision cannot only be understood in a physiological sense but must also be understood as a quality or operation. For Deleuze visibilities are sites of production constituting an assemblage of relationships, enunciations, epistemologies, and properties that render agents into objects of intervention for power. Visibilities are historically stipulated apparatuses for producing evidence about bodies, subjects, and now, perhaps, new modalities of population.

The philosopher John Rajchman offers an example to illustrate this difficult idea. He reminds us of the two instances at the start of Foucault's *Discipline and Punish* and *Birth of the Clinic*: the careful description of the torture of the regicide and the close detailing of the bathing cure of a hysteric. "In both cases," Rajchman writes, "we have pictures not simply of what things looked like, but how things were made visible, how things were given to be seen, how things were 'shown' to knowledge or to power—two ways in which things became seeable. In the case of the prison, it is a question of two ways crime was made visible in the body, through 'spectacle' or through 'surveillance.' In the case of the clinic, it is a question of two ways of organizing 'the space in which bodies and eyes meet.'"[44] As this example demonstrates, visibilities are married to visuality as the historically situated conditioning infrastructure for how subjects come to be known to power. Visibilities are accumulations of a density of multiple strategies, discourses, and bodies in particular assemblages at specific moments. Therefore, visibilities are not merely "visual." Visibilities can be constituted through a range of tactics from the organization of space—both haptic and aural—to the use of statistics.

"Vision" is thus a term that multiplies—visualization, visuality, visibilities. These multiple permutations of the term "vision" demonstrate that vision cannot therefore be merely about the isolated sense of vision but must also be about what, following Walter Benjamin, I would label a technical condition—and what, following Foucault, makes the organization of the senses critical to understanding the tactics of governance and power at any historical moment. The "task of the history of aesthetic forms," the film theorist David Rodowick argues, "is to understand the specific set of formal possibilities—modes of envisioning and representing, of seeing and saying—historically available to different cultures in different times."[45] This study is ultimately dedicated to

comprehending just such historical transformations of sense and the specific conditioning of attention under particular technical conditions.

In focusing on the relationship between epistemology and sense, I follow the lead of historians of science, art, and media that focus on histories of observation, knowledge, and aesthetics. The history of science has long been concerned with how instrumentation, standards, and measurement techniques are co-produced with new ideas of perception, observation, cognition, and life. From pharmaceutical trials and statistical instruments, to the complex photographic and cinematic apparatus necessary to capture, assess, and study the world, our idea of ourselves, and of others, is never separate from our practices of observation, documentation, and truth.[46] As Jimena Canales notes in her history of a tenth of a second, a history taken from the perspective of measurement begins to collapse clear-cut distinctions between the modern and nonmodern and makes visible the contests and heterogeneities that produce knowledge. Discourses concerning truth, facts, and representation demonstrate continuities and fissures in history. More important, problems of measurement allow us to focus on epistemic uncertainty and desire; on sites where cultural and social interest is invested before and outside of technical realization.[47]

In linking histories of the senses to those of visibility and measure, I can also begin to account for transformations in governance. In fact, the very etymology of the word "cybernetics" already suggests a relationship to histories of governance. Cybernetics is, in Wiener's words, an "emergent term" derived from the Greek *kubernetes*, or "steersman," the same Greek word from which we eventually also derived the word "governor."[48] Cybernetics is thus a science of control or prediction of future events and actions. From the start, despite disavowals by many prominent practitioners, the ideas of communication and control were applied to theorizing and reenvisioning systems, both sociological and biological. A history of cybernetics must therefore also extend to account for a history of governmentality, and to how governmentality links to ideals of knowledge and sense.

In his final lectures, Foucault defined "governmentality" as "the genesis of a political knowledge [savoir] that was to place at the center of its concerns the notion of population and the mechanisms capable of ensuring its regulation."[49] For Foucault, the particular form of political reason that emerges throughout the second half of the twentieth century comes under the rubric of biopolitics and is intimately tied to data, calculation, and economy, particularly neoliberal economics. He defines biopolitical governance as related

to a "new type of calculation that consists in saying and telling government: I accept, wish, plan, and calculate that all this should be left alone."[50] In our present, this calculative rationality is certainly evident in the new smart cities, where ubiquitous computing is imagined as necessary to supplant, and displace, the role of democratic government. More critically, these technical systems serve a discourse of security and defense—of life, futurity, and value. It is a very thin line between the autonomous robotic systems of networked trains and smart sensor cameras monitoring traffic flow and consumer consumption to the more militarized drones or smart border fences that make up the landscapes of contemporary war and security.

But there is a longer history to security and politics that links itself to the cybernetic ideas of information and prediction. In the 1920s the economist Frank Knight isolated the term "uncertainty." Uncertainty, unlike risk, according to Knight, has no clearly defined endpoints or values.[51] Songdo is one potent example of this management of uncertainty. The city serves as a vacillating network awaiting purposes not yet assigned and preparing for disasters of environment and ecology that have not yet been assessed or definitively calculated and whose temporal horizons are eternally deferred. Interviewees I spoke with from government and Cisco repeated the same discourse—bandwidth is valuable even if its function, and monetization, has not yet been determined.[52] Contemporary technical networks reformulate governmentality through the production and manipulation of temporalities. Preemption through the management of uncertainty supports the increased penetration of computational interventions in the name of sustainability, and central to this capacity, as Wiener suggested from the start, is an ability to reenvision, visualize, and manage data in specific ways.

One of the central themes in this book is to trace just how the historical reorganization of vision and reason (or "intelligence") that began in the mid-twentieth century reformulated population and territory in ways that support (and sometimes contest) contemporary forms of biopolitical governance and economy.[53] While the manipulation and direct monetization and materialization of time as a commodity appears central to contemporary financial and technical systems, this book will demonstrate that these contemporary phenomena are intimately linked to transformations in knowledge, observation, and archiving that began already in the mid-twentieth century. In the work of individuals like Herbert Simon in business and finance, the designs of urban planners like Kevin Lynch at MIT, and the rising discourses of systems and networks, very quickly concerns about total war and risk were eclipsed into

those of economy, consumption, and ecology, making life, as the sociologists Patricia Clough and Craig Willse frame it, in its emergent mode the very target of technical automation.[54]

Organization

This book traces this cybernetic trajectory and the reformulation of vision I have just mapped in order to situate our contemporary forms of perception and cognition in relationship to historical factors. It is also a narrative deeply concerned with the relationship between these historical forms of attention and thought as related to governmentality—particularly biopolitical rationality.

The chapters group themselves in clouds around particular themes I have identified—storage and archiving, the interface and the training of the observer, the transformation in attitudes to cognition and knowledge, and the assemblage of these components into a new structure for the attentive reorganization of territory and population. Structuring these territories is my effort as a historian to trace particular practices and concepts as they move and mutate between different locations. This is, of course, a partial endeavor; the breadth and impact of the communication sciences is too great to be fully accounted for. Rather, I have selected figures and practitioners who focused on topics of visuality, storage, cognition, and design.

The first chapter serves as an interface to the book and maps the work of Norbert Wiener and his colleagues, particularly in neuroscience and cognitive science at MIT, in relationship to nineteenth-century concepts of recording, memory, sense, and time. The chapter centers on a theme critical to both theories of governmentality and history—the archive. The chapter traces how cybernetic ideas of storage, time, and process reformulated older nineteenth-century concepts of documentation, knowledge, and perception. I make a case for a contested history of time in digital media and probe the emergent potentials of a tension between the archive and the interface that underpins contemporary desires for interaction, data storage, and data visualization.

Returning to Wiener's discourse of diagrams, I investigate a nascent series of debates about time, storage, and memory that can also be read as the traces of what Lorraine Daston and Peter Galison, on another register, label "epistemic anxiety or instability"; those moments where the value and virtue of what constitutes evidence is contested.[55] These discussions demonstrated new sites of inquiry and interest for the scientists involved. In cybernetics these debates increasingly were no longer framed in terms of reality or metaphysical truth,

or even about objectivity as defined earlier in the century. The object of this book is to analyze and trace this transformation of ideas of mechanical objectivity, or even expert authority and trained judgment, into another form of methodological truth, that is, a truth about the strength and density of networks and the capacity to circulate information and action.[56]

If the archive organizes the first chapter, it is a history of the interface that organizes the second. This chapter traces how cybernetic concepts transformed aesthetic practice, urban planning, and engineering, business, and design education. Moving through a range of spaces from classrooms to urban redevelopment projects, I make a case for the reformulation of perception into interactivity. I trace the rise of a new epistemological ideal—"communicative objectivity"—emerging from the integration of design, cybernetics, and pedagogy in engineering and the arts.

The chapter maps the work of two designers and an urban planner—the aforementioned designer and artist Gyorgy Kepes, the urban planner Kevin Lynch, and the designer Charles Eames. These three figures were central to American modernism, postwar design, engineering education, and urban planning, and all of them engaged with cybernetics and the communication and cognitive sciences. Their work is landmark in creating infrastructures for postwar American life (and perhaps empire)—both attentive and physical.

In their respective projects, we can trace the reimagining of the observer as isolated but ecologically networked. This observer was linked to a new aesthetics of visualization and management. Interactivity as a personal mode of attention became associated with environment as a discourse for managing systems in fields ranging from marketing to urban planning. The chapter culminates with an examination of one site where practices in design, marketing, and management recombined, in the 1964–1965 New York World's Fair, with the innovative launch of the IBM installation "The Information Machine," which advertised the new information economy. The installation propagated an aesthetic of information inundation as a virtue at the same time that New York was undergoing massive transformations in transportation, suburbanization, economy, and race relations. I trace how environment and psychology[57] came to take the place of previous sociological discussions of systems and society, while new strategies of attention emerged as both the solutions and engines for a growing physical infrastructure of racial segregation and an emerging postindustrial economy.

These new forms of political, perhaps biopolitical governance, were not merely reductive and disciplinary. I also trace some of the new forms of producing and imagining urban space and human interrelationality that emerged

(for example community gardening) by viewing landscapes as ecologies of psychic and informational interaction. These new strategies for social intervention emerged even as ongoing historical problems of race, class, and gender could now be repressed and reformulated through consumption and interactivity.

The third chapter explores the doppelgänger of perception in cybernetics—cognition. If designers and planners used cybernetic paradigms to rethink vision and environment, human and social scientists used the same ideas to transform techniques of measurement, assessment, and calculation. Read together, these two chapters demonstrate how aesthetics and perception were linked in new assemblages to revise how, to quote IBM, we "think," and how, to repeat the concepts of the engineers at Cisco, space becomes "smart" through new models of sense, measure, and calculation.

The chapter mirrors the first by diachronically mapping how nineteenth- and early twentieth-century ideas of consciousness in psychoanalysis and reason and computability in mathematics and logic were transformed into cognition and rationality. Starting with the conception of neural nets of the psychiatrist and cybernetician Warren McCulloch and the logician Walter Pitts, I examine how these new ideas about mind and communication entered fields ranging from government to economics to computing. I trace the networks of interchange between cybernetic ideas of mind and the work of political scientists, such as the aforementioned Harvard and Yale professor Karl Deutsch, the organizational management, finance, and artificial intelligence pioneer Herbert Simon, and a number of other human and social scientists. In turning to the reformulation of cognition, I also expand the discussion of vision to the territory of new methods for making data and populations visible as objects for study, surveillance, and management.

These nervous networks, while labeled rational, were also, in McCulloch's psychiatrically informed language, "psychotic." In the cybernetically informed human and social sciences, computational rationality was no longer Enlightenment reason. What could be algorithmically defined and computed must by logical definition be antagonistic to intuition, genius, or liberal agency. In a curious turn, however, policy-makers and social scientists, having turned to a nonreasonable rationality and logic to redefine the behavior of subjects and systems, repressed their discovery by valorizing data visualization as a technique to command and control what was increasingly understood to be a world of unknowns, chance, and unreasonable behavior. The chapter explores this mutual interaction between the reformulation of reason in terms of cognition and rationality and the rise of new models of visualizing data and society.

Visualization, here, is a set of techniques by which to manage, calculate, and act on a world of incomplete information.

While much has been written about psychosis and schizophrenia as symptoms of contemporary information economies and endemic to the nature of capital, my analysis is not an explicit theory of psychosis or capital.[58] Rather, I take the language that cognitive scientists, neuroscientists, and social scientists invoked quite literally. This chapter examines what work the discourses of psychosis did in the computational and social sciences to allow new types of knowledge to emerge, and to produce new methods for experiment, calculation, and measurement. The remaining question is why it has been forgotten that rationality was defined in terms of psychosis, not reason, throughout the 1950s? A massive number of media theorists continue to insist on the enduring legacy of enlightened and liberal reason in the present; these assumptions demand interrogation.[59] We must ask: what is at stake in our contemporary amnesia? While contemporary culture looks ever more frequently to neuroscience, behaviorism, and data mining to predict human behavior, economists, policy-makers and even the public also continue to insist on older nineteenth- and earlier twentieth-century definitions of consciousness and choice. Politics happens in this interstice between the memory of liberal reason and the embrace of psychotic logics. This interaction between historical forms of reason and contemporary beliefs in cognition and rationality drives the desire to produce computational approaches to intelligence, economy, and governance. The political question is, however, what defines computation and rationality? These questions, black-boxed in our present, were hotly debated in the 1950s and early 1960s in a range of social and human sciences.

The fourth chapter completes the book in a feedback loop by linking the transformations in cognition and perception with governance and rationality to ask how politics and aesthetics are linked through the valorization of beautiful data. Examining cybernetic work on vision and cognition done by McCulloch, the MIT neuroscientist Jerome Lettvin, and the psychologist George Miller in connection to the design practices of the prominent designers George Nelson and Charles and Ray Eames and the pioneer computer animator John Whitney, Sr., I make a case for the radical reformulation of the very tactics by which bodies, territories, and networks are governed through measurement and attention. The chapter centers on changing attitudes to perception and cognition in the late 1950s as applied to U.S. Information Agency (USIA) propaganda and to the staging of Cold War politics. The chapter ruminates on the past to speculate on the inevitability and organization of contemporary forms of war and terror.

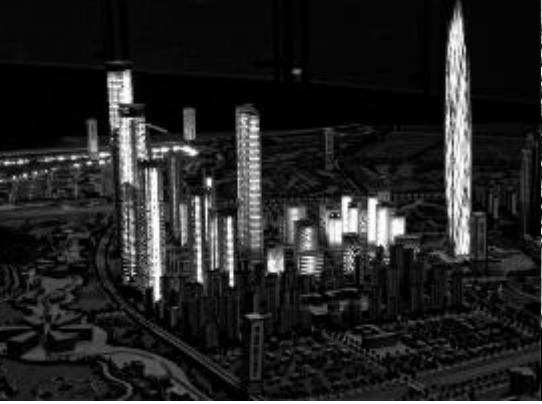
The book ends in interrogating the ethical and political implications of making data beautiful and affective. In the epilogue, we find ourselves simultaneously inside the gardens of IBM's corporate headquarters in suburban New York and standing on hilltops in Jerusalem at the Israel Museum's sculpture garden, contemplating the work of another prominent midcentury artist, Isamu Noguchi, and considering the implications of a new information aesthetics that links the inside of corporations to the reformulation of territories. Like the small rabbits and the performative control rooms of Songdo (fig. P.3), these different landscapes pressure the present and create different possibilities for the future.

Taking seriously the aesthetics and methods of cybernetics, each chapter is an effort to find patterns between fields. Each chapter holds together a series of objects related by way of discourse and method in the interest of unearthing their commonalities while insisting on the irreducible differences and simultaneous heterogeneities between them.

Why Tell History Anyway?

Technology always presents historians with confusing spectacles of obsolescence and novelty. To my eyes, trained in urban planning and public health, Songdo appears part science fiction, part twentieth-century utopianism. The nostalgic forms of past urban developments—a seeming grotesque parody of modernist grids and skyscrapers—is merged with the speculative landscape of server buildings and amorphous blocks of high-tech and biotech corporate installations. Cisco's managers reminded me that they were well acquainted with Le Corbusier. Songdo, they argued, adopted the best of modern architecture without its utopian and failed elements.[60]

In fact, for all its shiny newness, Songdo proclaims its historical, perhaps even already obsolete, nature as a matter of economic logic. The city plan is full of direct reenactments of archival forms. There is a "central park" based on the one in New York with a petting zoo of large bunnies for children (fig. I.3). The park is lined with communal kiosks containing books for sharing (the old paper ones, not the electronic readers). Particularly uncanny are the large control rooms dressed in bizarre trappings of Cold War science fiction awaiting the infusion of data from every system in the city—water, electricity, medical, traffic, environmental. The reality is that the humans who watch these screens are often passive observers (fig. I.3). For the most part, these systems run themselves. This intelligence is not always (in fact usually not) humanly controlled. And often it is stupid. Many little sensors operating in local net-



works making minute decisions about traffic lights, water flow, and subway exchanges are what constitute this city's "smartness."[61] One might even ask why, under such conditions, build so many interfaces and visualize at all?

This relationship between the archive and the interface, and between historical forms of attention and ideals of intelligence, is one of the central themes of the book, and key to substantiating contemporary fantasies of visualization, logistics, and control.[62] It is precisely the older memory of surveillance and knowledge that drives an unremitting desire to increase the penetration of sensors, recording instrumentation, and analytic techniques in these territories of ubiquitous computing.

Digital infrastructures, therefore, like the colonial archives depicted by the anthropologist Ann Stoler, are produced through "grids of intelligibility . . . fashioned from uncertain knowledge." These are spaces full of "disquiet and anxieties."[63] Songdo appears stunningly legible as a commodity. Its grids appear to clearly replicate the ideal cities of the earlier twentieth century envisioned by collectives like the Congrès Internationaux d'Architecture Moderne and regularly put into play in the urban redevelopment projects of the United States and Europe in the 1960s.

This is a deceptive legibility.[64] Form does not follow function in Songdo. The perfectly reasoned surface area ratios underpinning the modern towers are failing to produce value. The development has only lost money for the real estate developers. Engineers openly confess to never speaking to developers or urban planners, and admit that the city could take any form desired (circles, spires, anything really the surface does not reflect the infrastructure). At the same time, the developers are being forced to admit that their standard strategies are self-destructive. Banking on real estate while selling bandwidth, it's unclear what is actually more valuable or what is actually being purchased in such developments.

Ironically, the function and action of the territory may actually be one

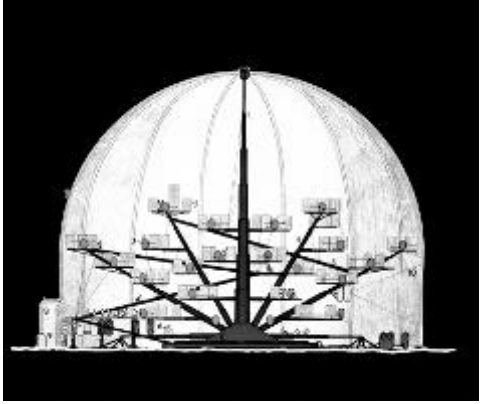


FIG. 1.3__**Prototype?** model for New Songdo City. Image: author, 2012. **Ideal?** Ville Radieuse–Le Corbusier (1924) from the article "AD Classics: Ville Radieuse/ Le Corbusier at http://www.archdaily .com/411878/ad-classics-ville-radieuse-le -corbusier/; **Real?** "Blow-out Village," Peter Cook. Archigram Archive © Archigram 1966.

that was envisioned in the fantastical projections of such countercultural and avant-garde urban designers as those of the group Archigram in the 1960s. The irony, of course, is that it is not the vision of the Congrès Internationaux d'Architecture Moderne (CIAM), so regularly linked in architectural history to rationalization, abstraction, colonialism, and the decontextualization of space and time, that is ascendant in this situation. Rather, it is the vision of the breakaway architectural movements, these avant-garde artists, that is realized in the function of this space.[65] Songdo is less playful than the fantasized cities of the London-based avant-garde group Archigram: walking cities that would roam the earth transporting their workers, or the "Blow-Out Village" (fig. 1.3), described by its designers as an entire temporary city that can be inflated from a hovercraft and can rove the earth. However, in many ways, Songdo is just that: an elastic and plastic territory, infinitely mobile, networked to the information economy. But this independent 1960s group, with their embrace of technology, consumerism, and futurism, imagined a humorous but attractive mode of being. Capital has many guises, and reason, or rationalization, as we most regularly imagine it, is rarely the one being deployed in the second half of the twentieth century.[66]

There is an excess in these developments, somewhat like the imagined camouflage of the insects of the surrealist Roger Caillois, whose mimetic capacities are so potent, their ability to look like the environment so perfect, that others of their own species cannibalize them.[67] In this case the resemblance of the new development to modernist fantasies and the most banal grids of real estate developers is almost perfect—except the function of monetizing space fails. The form, antiquated and enormous, has taken the reason of the market too perfectly. The developer has maximized the surface area ratio of saleable development, but at the cost of actually surviving.

If it is one of the most commonly held faiths in media studies that the separation between form and content that serves as the infrastructure for

mathematical theories of communication, and by extension digital media, is an engine for disembodiment and reductivism,[68] Songdo provokes a curious alternative understanding. The splits between the forms and contents at many levels—from the constraints in materials, capital, and engineering to the embrace of certain historical ideal types for urban planning—create spaces for action and imagination. On one hand there is something terrible about the connection between the infrastructure and the interface; on the other hand this split also allows different forms of materialization to potentially occur. If planners and designers had different concepts of urban form, and perhaps different genealogies of design, the city could look different, for example.

I might ask what imaginaries of planning and urban development have so affected the developers that they have failed, even at the cost of their own profit, to envision a different form of space and engagement with the environment? Are there other memories of information and space that might have been deployed here? Or has the quantification and monetization of space and sense reached so formal a point, the coupling between use and engineering so close, that alternative outcomes are impossible? The present is, of course, not known. History opens us to contemplating these spaces as assemblages of data layers and potentials, densities and probabilities that are never linear, causal, or inevitable.

Temporality is at stake. Songdo tells a story about the forces of history and powers of traces. This space is about the control of time and about breaking this control. In this space, older histories of architecture, economy, and modern vocabularies of planning have been both reified and destabilized. These folds in time incarnated in the landscape pressure the direct links between the past and future—and perhaps more pressing, which pasts are the grounds on which we speculate in the present? Is this the final fulfillment of avant-garde fantasy or corporate imaginaries? Were the earlier efforts at envisioning the global or sentient city capable of different visions than the contemporary instantiations? The links between counterculture and neoliberalism have now been well documented,[69] but the inevitability of this development also needs to be contested. Were there moments when technology and potentiality were more loosely coupled, when form was further from future? Would a knowledge of different efforts to imagine urban space in terms of computation, communication, and technology impact the visions of designers in the present? I certainly hope so. These are some of the questions that Songdo with its multiple temporalities—of capital, urban planning, technology, and politics—poses. I intend to demonstrate that there are many histories of our contemporary media-saturated environments, even within these most legible

and obvious forms, even within spaces and objects we think we know. I excavate these genealogies and reveal these absurd, conflicting, and nondeterministic options for envisioning the future of how we sense and live in data-filled environments.

I have called attention to our present because it demonstrates so potently how our imaginings of the past get activated in envisioning the types of futures we would like to build. These sites of seeming extreme speed are also sites of accumulation and density. Their own futures are not known. While it is definitely possible that these infrastructures in our present are now making obsolete the many principles of design and communication that I will lay out in this book, it is also true that we do not know, and only the past can even begin to allow us to reflexively contemplate the present at a rate, and a scale, different from that being encouraged by the developers.[70]

In contemplating the historical treatment of vision and reason, the dominant methodology of this book is, therefore, to mime the practices of design and cybernetics to intervene and engage with these seemingly scale-free forms of calculation that underpin contemporary digital infrastructures. In our contemporary environments we tend to assume seamless mobility in moving from local to global, through interfaces like Google Earth and flexible mobile territories like Songdo. This mobility is, in fact, a critical element of our modes of perception in the present, a topological movement that offers the experience of an integrated global media system—a particular constellation of communication theories, data, design, and navigation.[71] However, while scale is often discussed, the logic of scale is very particular and historically situated. Scale in geography and planning often comes through two main approaches. On one hand, as the architect and theorist El Hadi Jazairy argues, scale is an "ontological fact" that "organizes matter in a Russian doll structure from infinitely small to infinitely large." On the other hand scale is also a method, a form of measurement that serves to manage data and reach conclusions within a defined space and time. Both of these models presume that scale is an ontological reality, and a stable entity to be used across locations. Events happen within the frame, and commensurabilities occur between different scales. Counter to these two approaches, Jazairy suggests a definition of scale "as the unfolding of events that produces a certain scale," which is to say an unfolding that creates conditions of possibilities. Scale is plastic because it is not stable, it is a matter of ongoing relations between technologies, objects, agents, subjects, and territories.[72] Scale becomes about relationships between surfaces, topological strata that are not automatically commensurate.

Another way to understand scale is from the perspective of cybernetics and

the communication sciences and game theories that are the objects and subjects of this book. In cybernetics the fundamental epistemological quandary is how to relate the micro actions and macro systems. For the cybernetician Norbert Wiener, for example, the dominant epistemology was one of statistical mechanics, and the epistemological problem involved the incommensurability of translating between the actions of micro level phenomena and the behavior of systems. "Feedback" and "control" are the terms assigned to the practices negotiating these differences between "*actual* performance rather than its *expected* performance." The two are not deterministically linked; "in short, we are directed in time, and our relation to the future is different from our relation to the past. All our questions are conditioned by this asymmetry, and all our answers to these questions are equally conditioned by it." Wiener culminates his introduction by arguing that we now live in "Bergsonian time."[73] If in the nineteenth century concerns about time's discreteness and determinism continued to preoccupy scientists and philosophers, for cyberneticians this no longer held.[74] This incongruity between states and between times now sees itself encoded into the very infrastructural logics of cities like Songdo, economies based on data mining, and in financial and other speculative instruments that literally profit from and mechanize this asymmetry.

My intent here is to consider history as a matter of densities and probabilities rather than deterministic relations. This history operates like the logics of our contemporary data spaces between storage, memory, and interface. The book vacillates between demonstrating synchronic ideas of aesthetics and cognition at the time and diachronically exploring how mid-twentieth-century ideas of vision, knowledge, and recording were haunted and troubled in untimely ways by older nineteenth-century concepts borrowed from psychoanalysis, philosophy, mathematics, and physics. If there is a certain repetitive feature to this exercise, a performative stuttering that forces arguments to be returned to only to become new cyborg entities, then it deserves comment. The very nature of the phenomena of systems that use their past to predict the future in eternal loops mitigates against a linear or causal history. I have stayed true to my objects of study, and the book is organized thematically, not on a time line. It is also genealogical: the final chapter is an accumulation of those before it; an accumulation of densities. This feedback and looping is mimetic, and serves as a method to excavate the reformulation and reorganization of the senses through new infrastructures of knowledge and aesthetics that emerged through the merger of communication sciences, cognitive and psychological sciences, cybernetics, and design in the postwar period.

There is much at stake in the organization of such histories and how we

FIG. I.4__"Central Park," New Songdo Smart City, Incheon Free Trade Zone, South Korea. Image: author, July 4, 2012.

wish to construct the answers to these questions I pose about the forms of vision and knowledge that now underpin our contemporary belief in data, visualization, and bandwidth as the very architectures for life. As the media theorist Jussi Parikka argues,

> what do we actually talk about when we address animals, insects, and media technologies? Do we think of them as predefined, discrete forms of reality. . . . Could [we not] approach things as intensive molecular flows, in which, for example, the notion of "media" was only the end result of connections, articulations of flows, affects, speeds, densities, discourses, and practices (namely, assemblages)? Could we see media as a contracting of sensations into a certain field of consistency—whether called an environment or a media ecology?[75]

If we were to consider media less stable, ontologically definable, or possessing particular necessary and defined attributes, would this contribute to rethinking our imaginations of technology? I focus on this "contracting of sensations into fields of consistency" that are the archival substrate of such technologies as entire sentient cities. This "contraction" is also an assembling of densities and forms; these are sites of accumulation in the way Bruno Latour speaks of producing "immutable" mobiles and accumulating agents into facts in actor networks, or the way Foucault speaks of visibility—those spaces where representation, practice, technology accumulate—to show things in the world,

whether subjects or objects to power.[76] In unpacking these assemblages the present can become an unknown territory of accumulated densities rather than a natural and inevitable future.

This book is, therefore, a speculative endeavor, in all the ways "speculate" is defined—as both a matter of reflection and mediation, a matter of conjecture, and a matter of risk with possible gains and losses.[77] And, as in the case of the many speculators and corporations trying to bank in on these developments only to be frustrated in their financial ambitions, it is useful to be reminded that the present is often haunted by the past and the future is often cloudy and never predictable . . . is visualizable but not necessarily visible.

ings are built by GALE International, affiliated with the engineering and architecture firm Kohn Pedersen Fox Associates, located in New York City. Kohn Pedersen Fox did the master urban plan. The master plan for the buildings, however, was rarely worked on in consultation with the technology infrastructure groups. One of the outstanding features of this "digital" city is how its built form has little relationship to its technical infrastructure. Form and function are seemingly disassociated. From interviews with Tony Kim, July 6, 2012, and Gui Nam Choi, July 6, 2012.

9 Lindsay, "The New New Urbanism," 90.

10 Definitions of terms like "information" and "data" are kept rather black-boxed in this endeavor or reduced to behavioral concepts like bit rate.

11 Interviews with IFEZ officials, July 4, 2012, and interviews with Tony Kim, Senior Vertical Manager at Public Sector Internet Business Solutions Group Cisco Systems, July 6, 2012. Both officials detailed and demonstrated marketing videos showing the rollout of telemedicine applications.

12 This situation offers sustenance to Deleuze's claim that "individuals" have become "dividuals," and masses have become samples, data, markets, or "banks." Deleuze, "Postscript on the Societies of Control."

13 As theorist Patricia Clough puts it, there is presently an "affective turn" that "marks these historical changes . . . indicative of the changing global processes of accumulating capital and employing labor power through the deployment of technoscience to reach beyond the limitations of the human in experimentation with the structure and organization of the human body, or what is called 'life itself.'" Clough and Halley, *Affective Turn*, 3.

14 There are numerous debates about biopolitics and digital media. Many theorists follow a more Agambenian approach that views contemporary capital and politics as leading to an inexorable transformation of life into capital. I take a less disciplinary and perhaps more optimistic approach and follow the lead of feminist philosophers like Rosie Bradotti, Donna Haraway, and Elizabeth Grosz in insisting on the productive elements of these assemblages. Haraway, "Cyborg Manifesto," Braidotti, *Nomadic Subjects*, Grosz, *Nick of Time*.

15 Ben Rooney, "Big Data Demands New Skills." Wall Street Journal, February 10, 2012, http://blogs.wsj.com/tech-europe/2012/02/10/big-data-demands-new-skills/?mod=google_news_blog.

16 Seagran and Hammerbacher, *Beautiful Data*, Segel and Heer, *Beautiful Data*, Edward Tufte, *Beautiful Evidence*.

17 Benjamin, *Illuminations*, 238.

18 Easterling, *Enduring Innocence*, 1–13.

INTRODUCTION. **Dreams for Our Perceptual Present**

1 Bacon, *New Atlantis and the City of the Sun*.

2 Bentham, "Panopticon."

3 Le Corbusier, *City of To-morrow and Its Planning*, 173.

4 Fishman, *Urban Utopias in the Twentieth Century*, 186–87.
5 Anable, "Architecture Machine Group's *Aspen Movie Map*," 500.
6 Negroponte, *Architecture Machine*, 1.
7 Counter to other building management design programs at the time, such as those developed by Skidmore, Owings, and Merrill, an architectural firm responsible for many of the largest and most impressive post-war corporate buildings around the world, Negroponte and his colleagues dreamed of an ecology, formed out of constant feedback loops of machine human interactions, one that evolved and changed, grew "intelligent." Negroponte, *Architecture Machine*, 7.
8 Negroponte, *Architecture Machine*, 7.
9 Negroponte, *Architecture Machine*, 3.
10 While there has long been a discussion of architecture as media, or reflecting media, it should be critically noted that the Architecture Machine Group was later absorbed into today's Media Lab, eliminating the language of architecture entirely. Negroponte has been remembered as regularly posting on blackboards that TV, computers, and publishing had to merge "now." The dominant philosophy was the integration of media and a cybernetic philosophy that design must not be merely computer aided but actually a matter of interactivity coconstituted through the integration between humans and machine systems. The lab grew from a collaboration between the Architecture Machine Group, the Center for Advanced Visual Study (founded by Hungarian artist and designer Gyorgy Kepes), and two other groups working on visual language and video and digital cinema. Interview with Michael Naimark, one of the members of the Aspen Movie Map team, August 12, 2013. See also other works by Negroponte, including *Soft Architecture Machines*.
11 Negroponte, *Soft Architecture Machines*; Negroponte, *Architecture Machine*.
12 Norbert Wiener, *Ex-Prodigy*, 63.
13 Wiener, *Ex-Prodigy*, 63.
14 Wiener, *Ex-Prodigy*, 130.
15 I open with this memoir because we are arguably still negotiating the legacy of this transformation. The choice of Norbert Wiener is, of course, not arbitrary. The foremost preachers of the new gospel of networked and smart cities, such as the former and current directors of the Media Lab, William Mitchell and Nicholas Negroponte, respectively, all came from MIT (the Media Lab was originally involved in the Songdo project but withdrew due to supposedly conceptual, but probably monetary, concerns) and all laid claim to cybernetic influence. Mitchell labeled these "cyborg" producing cities. See Mitchell, *Me++*, Negroponte, *Soft Architecture Machines* and *Architecture Machine*.
16 Such statements rethinking the role of representation, memory, and perception were repeated in many fields at the time, ranging from anthropology to biology, to sociology, to computing, to architecture. For more information on the influence and use of information theory and communication science on a variety of fields see: Keller, *Refiguring Life*, 89–99. For an opposing argument on the role of information theory in the history of molecular biology see Kay, *Who Wrote the*

Book of Life? Keller views cybernetic and information theories as providing the possibility to view life in its complexity, while Kay posits an account that argues that these notions of codes are ultimately reductive.

On postwar attempts to build a unified theory of science see: Bowker, "How to Be Universal." And on the cultural impact of cybernetics see: Edwards, *The Closed World Computers*. For the impact of communications theory, cybernetics, and digital media architecture, design, and the arts see: Pamela M. Lee, *Chronophobia*.

17 Kepes, *New Landscape in Art and Science*, 24.

18 Kepes, *New Landscape in Art and Science*, 20.

19 Kepes, *New Landscape in Art and Science*, 22–24.

20 Fuller, *Synergetics*.

21 Fuller, *Synergetics*.

22 Deutsch, *Nerves of Government*, ix.

23 Deutsch, "Review: A New Landscape Revisited by Gyorgy Kepes Manuscript," April 1960, Karl Deutsch Papers, HUGFP, 141.50, manuscripts and research materials ca. 1940–1990, box 1, Harvard University Archives.

24 Deutsch, "Review: A New Landscape Revisited by Gyorgy Kepes Manuscript," April 1960, Karl Deutsch Papers, HUGFP, 141.50, manuscripts and research materials ca. 1940–1990, box 1, Harvard University Archives.

25 Hayles, *How We Became Posthuman*; Manovich, *Language of New Media*; Galloway, *Protocol*; Galison and Daston, *Objectivity*; Crary, *Techniques of the Observer*; Schievelbusch, *Railway Journey*.

26 Galloway and Thacker, *Exploit*, 67.

27 Arendt, *Human Condition*, 4–6. It is worth noting, of course, that there were other attitudes to the productivity of mass mediation at the time, including Walter Benjamin.

28 Adorno, "Culture Industry Reconsidered," 32, 37.

29 Melley, "Brainwashed," Marks, *Search for the "Manchurian Candidate."* The famous document NSC-68, establishing containment as an American policy, framed Soviet Communism as a "slave state" lacking diversity or freedom, forwarding the idea of a mass homogenous group. The document, written for President Truman, included in its authors Secretary of State Dean Acheson, and was an extension of George Kennan's strategy of containment, but with a narrowly military focus. The document makes statements such as: "the implacable purpose of the slave state to eliminate the challenge of freedom has placed the two great powers at opposite poles. It is this fact which gives the present polarization of power the quality of crisis. . . . [On the other hand] the free society values the individual as an end in himself. . . . From this idea of freedom with responsibility derives the marvelous diversity, the deep tolerance, the lawfulness of the free society." NSC Study Group et al., *NSC 68*. The document clearly defines Communism as opposed to liberal subjectivity, and makes this connection by envisioning Communist political movements and political actors as faceless hordes or swarming masses who lack reason.

30 Crary, *Techniques of the Observer*, 3.

31 Sterne, *Audible Past*, 1–2.
32 Crary, *Techniques of the Observer*, 6.
33 Crary, *Techniques of the Observer*, 6.
34 *Oxford English Dictionary* (Oxford: Clarendon Press, 2013).
35 *Oxford English Dictionary*.
36 SAS software, accessed May 6, 2013, www.sas.com/data-visualization/overview.html?gclid=CKHRtpP6hbcCFYef4AodbEcAow.
37 This summary is taken from the "Smart Planet" website and the "Graphics and Visualization" website of IBM, accessed January 2, 2013, www.ibm.com/smarterplanet/us/en/overview/ideas/index.html?re=spfesearcher.watson.ibm.com/researcher/view_pic.php?id=143.
38 A number of theorists and scholars have informed this understanding of "visualization," even if not directly speaking about data visualization practices. See: Mitchell, *Reconfigured Eye*, Manovich, *Language of New Media*, Beller, *Cinematic Mode of Production*.
39 Silverman, *Threshold of the Visible World*, 131.
40 Oetterman, *Panorama*, Braun, *Picturing Time*, Dickerman, *Inventing Abstraction*.
41 There is an extensive literature on the complex histories and ontologies of "vision" in Western thought. Some critical works that have critically engaged histories of vision, ideas of oculocentrism, and of the relationship between vision, knowledge, power, and difference, and concepts of abstraction and representation to which I am indebted: Krauss, *Originality of the Avant-Garde and Other Modernist Myths*; Rose, *Sexuality in the Field of Vision*; Jay, *Downcast Eyes*; Bryson, *Vision and Painting*.
42 These definitions are taken from the website of Farlex, Inc., accessed March 6, 2013, www.thefreedictionary.com/vision.
43 This discussion is indebted to Rajchman, "Foucault's Art of Seeing."
44 Rajchman, "Foucault's Art of Seeing," 91.
45 Rodowick, *Gilles Deleuze's Time Machine*, 5.
46 For a sampling of work on standards and measures as related to the production of new forms of perception, observation, and governance see: Sekula, "Body and the Archive"; Gould, *Mismeasure of Man*; Gould, *Mismeasure of Man*; Braun, *Picturing Time*; Dagognet, *Etienne-Jules Marey*; Cartwright, *Screening the Body*; Bowker, *Sorting Things Out*; Star and Bowker, "How to Infrastructure"; Lampland and Star, *Standards and Their Stories*; May, "Sensing"; Mumford, *Technics and Civilization*; Carson, *Measure of Merit*; Dumit, *Drugs for Life: How Pharmaceutical Companies Define Our Health*.
47 Canales, *Tenth of a Second*, 215–19.
48 Wiener, *Human Use of Human Beings*, 15.
49 Rabinow, *Ethics*, 67.
50 Foucault, *Birth of Biopolitics*, 20.
51 Knight, *Risk, Uncertainty, Profit*.
52 For a comprehensive treatment of the theme of "uncertainty" and the logic of smart cities please see: Halpern et al., "Test-Bed Urbanism."
53 For an elaborate discussion on territory in Foucault's late lectures see: Foucault,

Birth of Biopolitics; Foucault, *Security, Territory, Population*; Elden, "Governmentality, Calculation, Territory."

54 Clough and Willse, *Beyond Biopolitics: Essays on the Governance of Life and Death*, 1.

55 Galison and Daston, *Objectivity*, 49, 50.

56 I call on Deleuze and Guattari's concept of "assemblage" here. In *A Thousand Plateaus* Deleuze and Guattari speak of the nature of assemblages as sites of concentration, or density, where bodies, discourses, agents, technologies all accumulate, each with their own histories. Assemblage denotes a site of historical accumulation. Assemblages are topographical and temporal entities, that accumulate in Deleuze and Guattari's language "content" and "expression," which is another way to say that an assemblage is a marriage of historical content with forms, "on one hand it is a *machinic assemblage* of bodies, of actions and passions, an intermingling of bodies reacting to one another; on the other hand it is a *collective assemblage of enunciation*, of acts and statements, of incorporeal transformations attributed to bodies." Deleuze and Guattari, *Thousand Plateaus: Capitalism and Schizophrenia*, 88.

57 See for example Jackie Orr's work on panic and the rise of "psycho-power"; Orr, *Panic Diaries*. On shifts in planning and governance to ideas of ecologies and networks see: Graham and Marvin, *Splintering Urbanism*; on the emergence of risk and environment see: Beck, *Risk Society*.

58 Chun, *Control and Freedom*; Deleuze, *Anti-Oedipus*; Liu, *Freudian Robot*; Massumi, *User's Guide to Capitalism and Schizophrenia*.

59 Hayles, *How We Became Posthuman*; Golumbia, *Cultural Logic of Computation*; Amadae, *Rationalizing Capitalist Democracy*. For an opposing account see: Mirowski, *Machine Dreams*; Daston, "Rule of Rules."

60 From interviews with Tony Kim, senior vertical manager, Public Sector Internet Business Solutions Group, Cisco Systems, July 6, 2012, and Gui Nam Choi, client solutions executive, Cisco, July 6, 2012.

61 The planners and engineers of Songdo, and other smart cities in South Korea, regularly mention Tokyo and Japanese engineering as models. In Japan, the subway systems, for example, are run on decentralized data clouds. The network is not centralized; rather, each station speaks to the next, like a hive or the Internet's packet-switching architecture. Decisions about directing trains are made locally, and the network fluctuates according to localized demands that are regulated through a decentralized system of stations. As the anthropologist Michael Fisch notes in his study of the Tokyo infrastructure, these systems no longer rely on centralized cognition or command centers but diffuse the functions of regulating feedback into the network. In his words, the new form of autonomous traffic control "is its operation beyond capacity, whereby the entire focus of railroad operators is not on maintaining precision per se but rather on maintaining the precision of the margin of indeterminacy. The margin of indeterminacy is the space and time of the human and machine interface. Put differently, it is the dimension in which bodies and machines, with their incommensurable qualities (technicities), intersect with the time and space of institutionalized regularities

to produce a metastable techno-social environment of everyday urban life. In other words, it is a dimension of perpetual precarity that is held together by collective investment in the security of repetition and routine." The Seoul subway system that extends to Songdo operates on a similar technical architecture, possessing a decentralized and autonomous traffic control system for which human beings are only necessary in cases of extreme disruption, but in which daily disorders—of traffic, accident, and so on—are managed through the autonomous network. The idea, therefore, of increasing control finds its corollary in the networking and dispersal of power and sense, and what is remarkable about these systems is their approach to the indeterminacy and unknowability of the systems' actions to human observers. Fisch, "Tokyo's Commuter Suicides and the Society of Emergence," 329, 331–38.

62 Wendy Hui Kyong Chun has a complex discussion of memory and transparency that bears on this conversation and that I will return to in chapter 1. See: Chun, *Programmed Visions*.

63 Stoler, *Along the Archival Grain*, 1.

64 As Keller Easterling has noted, these architectures are charmingly "enduring(ly) innocent," masquerading in innocence and experimentation while smoothing space for the renegotiation of politics by way of aesthetics. Easterling, *Enduring Innocence*, 2–3.

65 When Le Corbusier produced his models for this utopian machine city, retrofitted for mobility and providing machine-buildings that would perfectly regulate human life, he was imagining redesigning the French colonial city of Algiers. While the colonial administration denied his plan, he never realized that his work both aided and abetted, even if through a different vision of the independent artist, a regime that was violently racist. For a discussion of Le Corbusier's utopian vision in relationship to colonialism see: Fishman, *Urban Utopias in the Twentieth Century*, 244–52, Corbusier, *City of To-morrow and Its Planning*. Felicity Scott in *Architecture and Techno-utopia* makes a similar argument about the potential in modernism, and the failure of some of the more radical efforts—like ant-farm—to actually produce alternative visions of space and territory. Scott, *Architecture and Techno-utopia*.

66 Steiner, *Beyond Archigram*.

67 Caillois, "Mimicry and Legendary Psychasthenia."

68 Some major discussions about the ideologies of communication and the body, history, and situation: Hayles, *How We Became Posthuman*; Golumbia, *Cultural Logic of Computation*; Keller, *Refiguring Life*.

69 See, for example: Fred Turner, *From Counterculture to Cyberculture*.

70 I take my lead here from Elizabeth Grosz's work on the Nietzschean "untimely" as a force for emergence. Grosz, *Nick of Time*.

71 Lury et al., "Introduction." The sociologists Celia Lury, Tiziana Terranova, and Luciana Parisi have recently written about "topology" as a central concern for discussions of the social, as it is a form of thinking linked to the relations between surfaces without depth, and where "movement" in their terms is not an aftereffect but constitutive of social processes.

72 Jazairy, "Toward a Plastic Conception of Scale," 1. Other urban theorists, like Ash Amin, are also attempting to think about urban space in terms of probability distributions and conditions of possibility. Amin and Cohendet, *Architectures of Knowledge*.
73 Wiener, *Human Use of Human Beings*, 24, 33.
74 Wiener, *Cybernetics*, 44.
75 Parikka, *Insect Media*, xx, xxi.
76 Bruno Latour is interested in accumulation and densities as producing effects and agents. While the term "immutable" is contestable, the idea that forms are made by accumulating agents, documents, and inscriptions is a suitable analogy to the way I will be dealing with density and scale in this text. Latour, "Visualization and Cognition," 6. Foucault, *Discipline and Punish*; Rajchman, "Foucault's Art of Seeing."
77 Definition of "speculate" from the *Oxford English Dictionary*.

CHAPTER 1. **Archiving**

1 The virtual is used throughout this chapter to denote that which does not yet exist but is being brought into being. It serves as both an operation and a field for conditions of possibility. I am not using the term, however, in the sense of a simulation or a simulacra. The virtual cannot exist as a materialized form in the present.
2 Wiener, *Human Use of Human Beings*, 7, 11.
3 Wiener, *Human Use of Human Beings*, 15.
4 Arguably, after the war, this "complex" is never dismantled. The reorganization of research, economy, and military formalized during the war is fortified as part of the Cold War by the GI Bill with its emphasis on higher education, and by the Cold War infusion of scientific research funds through the Department of Defense and later the National Science Foundation as a central strategy for safeguarding national security. In fact, science funding never returns to prewar levels in the period between the mid-1940s and the late 1960s, and far exceeds even World War II funding levels during the Cold War. For example, after the launching of *Sputnik* in 1957, defense funding of scientific research was higher than peak wartime levels, and fifty to sixty times prewar levels. Leslie, *Cold War and American Science*, 1–10. See also: Akera, *Calculating a Natural World*, 181–222; Hughes, *Rescuing Prometheus*.
5 Lettvin, cited from Simon Garfunkel, *Building 20: A Survey part of Jerome B. Wiesner: A Random Walk through the 20th Century Website at MIT*, accessed October 16, 2012, http://ic.media.mit.edu/projects/JBW/ARTICLES/SIMSONG.HTM.
6 Brand, *How Buildings Learn*.
7 Weaver also oversaw research in operations research, demonstrating the close integration between the fields. Originally this work was considered part of operations research.
8 Wiener, *Cybernetics*, introduction. Wiener also repeats this idea in many of his