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SENSEABLE CITY LAB

The Elusiveness of Data-driven Urbanism

"This 'big data' approach – having access to large-volume datasets to study a phenomena and its dynamics – has been touted as having the power to change the process by which urban space is designed, developed and evaluated."

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New technologies are allowing new ways to "sense" the city. For instance, systems already in place that were developed to support our technological standard of life may serve as a font of information on how our cities function. The premise of such sensing practices is that inhabitants unknowingly leave digital traces on various networks that are overlaid upon urban areas. Every time a credit card is used, a text message is sent, an Internet search query is submitted, a phone call is made or a purchase is processed, an entry with the time and location of the action is added to a dataset, administered and maintained by a service provider. This data may be connected to types of people, and the urban context then analyzed to reveal patterns of behavior and the flow of materials, capital, information and human resources within a city[1], granting a unique image of urban functioning in real-time.

This 'big data' approach – having access to large-volume datasets to study a phenomena and its dynamics – has been touted as having the power to change the process by which urban space is designed, developed and evaluated. This approach may be compared to that of urbanist Elisée Reclus, who traced the historical formation of cities as series of responses to the forces of nature, necessity and influence.[2] To him, the city needed to evolve and change, "answering to the requirements of the time." Today, we are able to dynamically sense, analyze and understand these forces more quickly, and with new datasets emerging, accumulate detailed knowledge over time to see patterns and trends. Yet, the use of data-driven processes in city making remains fragmented, despite the hype of the smart cities movement. The influences at play in the formation in cities are complex, with a multiplicity of forces to consider, and just as many aims and demands from its citizens.

This paper argue that the vision of a data-driven urbanism—the vision of using data as a generative ingredient for the creation of urban design and development—is not an idea unique to the present day, but an elusive dream of each generation of designer and practitioner as each seeks translate a newly found abundance of data, to inform and augment the process of city design and development. Further, this paper discuss the limitations are present in these methodologies of urban design.

DATA-DRIVEN URBANISM

This paper uses the term "data"—especially in the context of "big data"—more broadly. Today, the use of the term is often associated with sensors and devices that records information both indiscriminately and frequently, or a record with absolute numerical empiricism, often under the banner of "big data". The nature, or quantity of data, is only useful in the capacity to both record and analyze. Thus, "data" should be considered with a general appreciation for the context in which a project is realized, recognizing that ninetieth century urban designers, planners and theorists lacked the sensors and tools for absolute empiricism we take for granted today[3]. For instance, John Snow's "ghost map" of cholera outbreaks in Victorian London is often touted as an early "city science" or quantified project, although his methodology on its own would likely be considered "qualified" by today's standards.

Further, for the purposes of city design and development, "data" is only useful in that it records both time and place—the data, in its degrees of freedom, should be geo-temporal. As the disciplines of architecture, urban design and urban planning are concerned with physical space, data must also reflect the specificity of place and time. Herein lies a challenge for data-driven urbanism. Reclus argues that there is a latency period in urbanism—there exists a time delay from the point in which a change of society results in a physical change in the city. While increased efficiencies may be found within infrastructure of the city, the fundamental form of the physical is difficult to change and is increasingly so with larger sizes due to inertia. While easy to move individual people, adjust mechanized facades of buildings or change a streetlight dynamically (low inertia), buildings and cities are much more difficult respond in real-time (high inertia)—rooms rarely reconfigure themselves nor do neighborhoods change. As such, the translation of data, big or small, to design outcomes is questionable as the curation and selection of data requires the intuitive hand of the designer and thus breaking down the objectivity or dynamism of new datasets.

At tension is the scientific rigor made possible by these applications and the subjective translations to design made by the architect. These new technologies may bring new experiences for low inertia (and usually bottom-up) facets of life, the impacts on higher inertia, larger scale (and usually top-down) environmental design is unclear, particularly when evaluated in the truer sense of urban design—at the scale of the city (urban) and through the act of creation (design).

INDIVIDUAL ACTS & QUANTIFICATION

The rise of data driven urbanism has offered a multitude of approaches in offering measurement and systems for augmentation. The marquees of this movement have been the new cities of Songdo in South Korea and Masdar in the United Arab Emirates. While the ambitions of these cities are noted, there is a concern that they lack the vigor of life found in cities that were created though acts of individual imagination. For Richard Sennett, these cities risk becoming twenty-first century urban disasters—recreations of the failed mid-century urban renewal projects. In his words, "yesterday's smart city, today's nightmare" where "the smart city's computers will calculate where offices and shops can be laid out most efficiently, where people should sleep, and how all the parts of urban life should be fitted together."[4]

"At last," he adds, "life in cities can be brought under control."

While a valid critique in the eyes of many, including this writer, the either/or debate of quantified (or presently, digital) urban design versus the traditional haphazard approach is one of false dichotomies, and although wrought with pitfalls noted through history, the use of data-informed design may be a means of informing a new direction forward. With the development of these new smart communities that sense and create data, there is a danger in that these information-rich cities "may do nothing to help people think for themselves or communicate well with one another" , creating a system where the technology further perpetuates prescription and undermines the organic sense of life created by open systems. In his words, "'user-friendly' in Masdar means choosing menu options rather than creating the menu."

Although the current generation of data-driven cities incorporates sensors and devices that quantify and enable many novel and new urban experiences and operational oversight, Sennett's larger criticism might be more generally focused on the process by which we make cities today rather than focused on the technology specifically. These closed systems are inherently more common in these typologies and any large-scale development, which is the de jeure process of city-making today, as "rigidity can be equated with the purity of form."[5]

The complexities of the city require that explanations be made in terms of rational system processes that both explain the status quo, and mold future development toward specific ends[6], and at the same time, unregulated development would bring with it serious evils (of crowding, disease, economic threats, etc.). The city, at the dawn of the twentieth century, posed spatial barriers to economic growth and thus, the movement to quantify and impact the city were necessities to develop the urban society. At the same time, the regularization and prescription of urban form allows for a global, topside understanding of the whole—vital for governance. While the accretive, baroque, growth of the city of the Old World may create distinct neighborhoods, a state that is seeking to implement a system of laws or regulation is unable to understand the activities or navigate the opaque structure of these self-organized places. While individual residents may have high spatial knowledge of this local district, the state is unable to get the same level of understanding.[7] As such, the state has in its interest to establish measured standards, most notably the Enlightenment-inspired grid, to offer itself order and logic to urban space. The however, is that this formal order does not seek to offer evidence of the system from the street, but rather from above and from outside.

LeCorbusier, more apparently than many precedents, uses numerical analysis to rationalize the need for both redevelopment but also his ideas. "Statistics are the Pegasus of the town planner. They are tedious, passionless but are a leaping off point for poetry," says LeCorbusier about this analysis.[8] For his Ville Contemporaine, he sought to use technical analysis and architectural synthesis to design a scheme for a city of three million people.

To support his plans, geometric and statistical analysis was presented as justification for his proposal (Figure 1), including calculations for maximizing open space, maximizing automotive speed and throughput, and a demographic study of the three million who would occupy the city[8]. Although the plan is much maligned with its severe Euclidean separation of programs and transportation infrastructure, and inhumanely scaled spaces, it used various measurement tactics to understand the potential improvements of the city numerically, giving insight

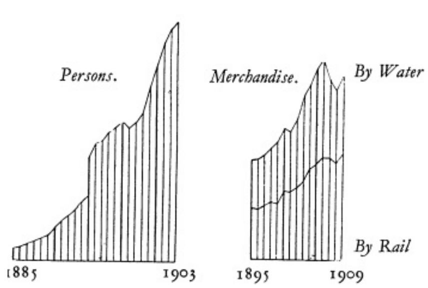

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Figure 1: Le Corbusier's Numerical Rational for the Ville Contemporaine.

into the potential outcomes of redevelopment. It was an early attempt at simulation. What is at question is whether the failures (and fears) of the plan were a result of the quantification, or of the designer (and his intuitive suppositions). It is uncertain whether the analysis informed the design or the design sought validation through analysis. As a counterpoint to the Ville Contemporaine, Milton Keynes, for instance, was among the fastest growing economies in Britain outside of London from 1997-2011, despite being a New Town that incorporated many modernist features seen in LeCorbusier's plan[9].

Today's use of standards and regulation to drive the shape of space and the public realm all necessitate the act of measurement and quantification[10] in the creation of these regulations, or the evaluation of adherence to these norms. For instance, the use of height restrictions or floor area ratios is used to dictate program and configuration of buildings, and height requirements necessitate the use of quantification, albeit simplistically, as a means of regulating the shape of the public realm. Similarly, the use of setbacks to ensure the public's access to light and air share a similar lineage in prescription[11]. While the danger exists in the cloning and application of regulations without regard to place and local may create ubiquitous and unsympathetic places, an information-based strategy[10] is still a mechanism by which we can regulate space.

While historic practitioners have attempted to quantify many facets of urbanism, many artistic an aesthetic characteristics of urbanism are difficult to enumerate. Part of this difficulty is a lack of linguistic ability to describe how urban spaces feel. The compilation of urban artifacts—buildings, streets, districts—have the power to both be conditioned and to condition the inhabitant. In this regard, Rossi considers these forces to transform artifacts into works of art[12], yet an art that may be difficult to define and analyze. As a collection of individual works, the city does not necessarily "represent itself explicitly or scientifically" and that the social manifestations of the city are "born in unconscious life"[12], making it more abstract and difficult to define, let alone analyze.

Camillo Site directly challenged the notion that cities should be designed with artistic merits and ideals in mind, seeking what Aristotle said as "security and happiness for its inhabitants."[13] Directly said, those outcomes would not come from the "science of technicians" but from the "talent of the artist".[13] Criticizing his era, he commented the artistic approach to urbanism—aspects of composition which produced harmonious effects—where now yielding to the "loose and dull" outcomes of technical considerations and that successful Italian squares often made majestic moves that could not easily be measured against metrics of road efficiencies but created spaces whose magic was "easily nullified" if opened for the sake of roadway efficiency. There is space for the intuition of the designer through an aesthetic approach, and the rigor of a scientific one.

Haussmann's Paris could be seen as a middle case, reflecting matters of both spontaneous self-organization and top-down calculated planning. The problems given to Haussmann find parallels in the considerations of Le Corbusier. The pre-Haussmann Paris offered little public space and crowding, which exacerbated several cholera outbreaks. Similarly, traffic was congested on streets no wider than five meters in width, and often much smaller which were impossible to traverse on horseback or by carriage. Although inspired by the monumental plans of Sixtus V's Rome or Wren's unrealized London, Haussmann's charge was as a quantified approach to remedying real urban problems in the city and not just purely an aesthetic one.[15] To Jane Jacobs, the same challenges arise when considering the city through only the aesthetic lens, as the practical conduct of daily life does not lend the city to being "a work of art."[7]

As if in a rebuke of Daniel Burnham's efforts to transform cities, Jane Jacobs famously use the quip "make no large plans." [15] She argues that the diversity of users, buildings and programmatic uses are difficult matters to plan within the planning pseudoscience[16]—particularly in contrast to the city renewal projects happening around that seek to homogenize and rationalize. These processes are inadequate to address the complexity and diversity of urban life.

As if speaking to today's audience, she also comments on what emerged in her day as "organized complexity," the nascent beginnings of complexity sciences today. In both periods, the analysis of the city as a whole is quite difficult, and often rely on reduction and simplicity, much like Howard's Garden City[16]. Using the illustration of a park and how often it is used, the design might be a factor. The design depends on use, which depends on who is around, or when they are around. These factors, in turn, might be influenced by the surrounding buildings' ages, and block sizes. The interrelatedness and interdependence of factors makes an analysis of ratios difficult.

In all these cases, what is implicit is the role of the intuitive hand of the designer in curating the process. As much as LeCorbusier valorized traffic quantifications as justification for his Parisian proposal, Sitte does the same with aesthetic models. In each case, the objectivity of data is curated subjectively, and valorizing some complexity over others. As such, regardless of method or manner of city building, the empiricism of data is at question and the process is largely unchanged.

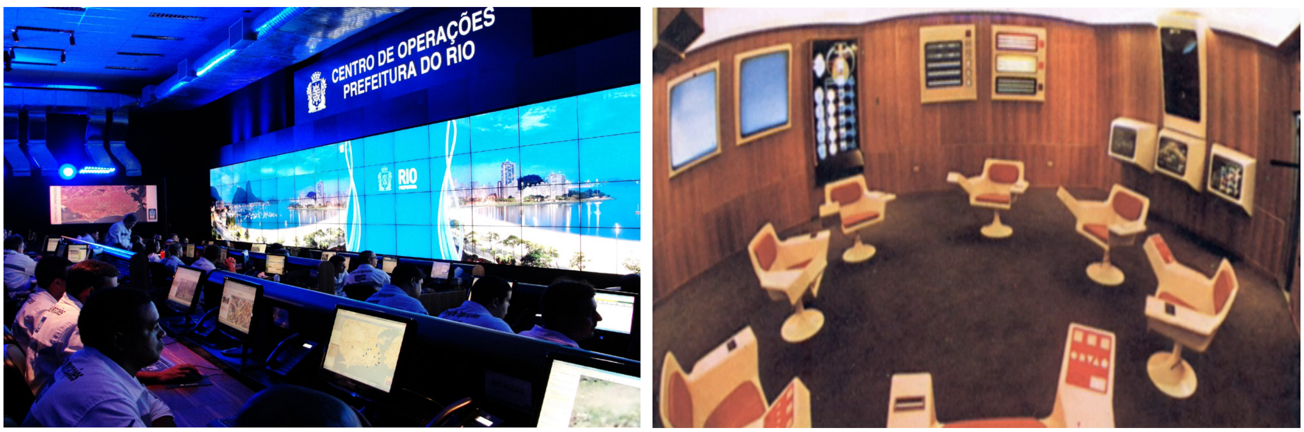
CONTEMPORARY DATA

In contemporary urbanism, the drive to quantify using data has similar goals as in the past: to centrally capture the patterns and behaviors of a place, and performing analysis on that data. In this, McLuhan[17] foresaw technology serving as civic thermostats "to pattern life in ways that will optimize human awareness." He said, "already, it's technologically feasible to employ the computer to program societies in beneficial ways." He stressed that "the programming of societies could actually be conducted quite constructively and humanistically." Greenfield comments that "the final intent of all this… is to make every unfolding process of the city visible to those charged with its management; to render the previously opaque or indeterminate not merely knowable but actionable; and ultimately, to permit the "optimization" of all the flows of matter, energy and information that constitute a great urban place."[18]

Many of these data-driven urbanism initiatives are those that can be considered top-down, where the mandate and relationship comes from government or developer. The decision making process is centralized, and as a result, have the opportunity and the resources to move boldly, with economy and efficiency. This is the business atmosphere that has attracted some of the largest parties involved in the "smart cities" movement—the technology companies. These bold, centralized decisions actions can find drastic impacts. The implementation of the Electronic Road Pricing in Singapore required an incredible investment in technology and policy change, expedited possibly by the semi-autocratic government. Although understandably unpopular among most road users, the program has achieved many of its goals in reducing congestion in the center city, increasing average road speeds by 20%, reduced the number of vehicles on the roadways while also observing increased car-pooling. A centralized policy environment also allows Singapore to test and implement more easily changes to the system that include variable pricing and traffic estimation and prediction. Perhaps the most iconic image of the top-down "smart city" is the Rio Operations Center (Figure 2a), from where IBM offered the ability to gain a topsight view of the works of the favela as a whole—security cameras, traffic analytics and more all viewable in a single sight. Reminiscent of the failed 1970s' Project Cybersyn real-time economic room (Figure 2b), computer models seek to explain what is happening while decision-makers viewing seek to explain why and what to do.[19]

This model has both the opportunity for real change, or real scorn. While successful initiatives can drastically improve overall infrastructure, it may also be exclusionary. Seen in a way, the governmentality of these ICT infrastructures are perhaps best approximated to by Deleuze's notion of 'societies of control' in that it provides a set of modulations that constantly direct how citizens act rather than allowing them to find their own agency.[20] These infrastructures can be seen as the remnant of twentieth century paternalism, regardless of the measured outcomes.[19]

In this regard, top-down infrastructural research is the providence of an emerging field of research called "city (urban) science" or "urban physics". Leveraging data, computational power and new mathematical models, scientists are attempting to find new uses or efficiencies in space. The application of these new mechanisms to measure space can allow planners to understand social dynam-



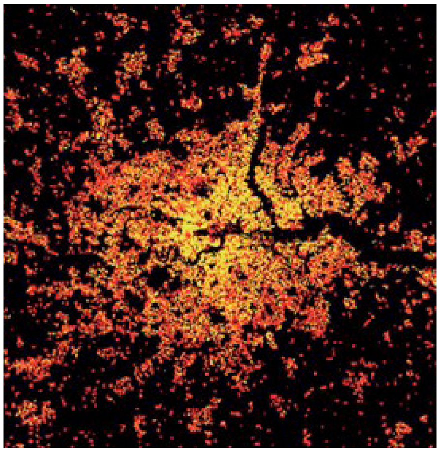
2a, 2b

ics with new precision. Hiller's work on space syntax seeks to understand spatial grammars and aspects of spatial configuration[21] (although as Ratti pointed out, there is still much to be learned in this domain[22]). By using computational tools to understand aspects of connectivity and topological aspects of the city, the research can inform space making to better support movements through space, with the hope of correlating confutation with social life.

For instance, the work of Michael Batty is analyzing the accretive structure of cities through fractal analysis and hierarchical networks to understand optimal growth patterns through image recognition[23] (Figure 3), and present research from the Senseable City Lab is considering planning models for cities that load-balance traffic times based on computational models from computer science using mobile phone data. Similarly, researchers are seeking to understand social dynamics of behavior, such as universal communication patterns in cities. [24] Thirty years ago, William H. Whyte used observation to understand the life of urban spaces: why places were crowded or jammed, how people make small adjustments in plazas, and where people decide to linger or sit.[25] A recent New

Figure 2a: IBM Rio Operations Control Room

Figure 2b: Cybersyn Economic Control Room

3 

York-based startup called Placemeter is taking the thinking Whyte had, and is applying it across the breath of the city to measure and quantify how people move and use public space. While their commercial applications have impact for retail spaces, their use and image processing of public CCTV cameras across New York is generating new metrics of what causes people to linger in certain spots, or how people navigate through public spaces, contributing to a larger understanding of public spaces in the city.

This social dynamics involved with the use of information within these systems is often of concern. Quite often, with the implementation of these technologies, the policy outcomes are not considered holistically or socially. Graham comments that "with utopianism and crude technological determinism often dominating popular and, in many cases, academic debates, it is not surprising that the potential roles of urban policy makers and planners in 'socially shaping' new technologies in cities at the local level are usually overlooked."[26] Further, at a practical level, "users are often faced by a mismatch between the standards or requirements of the infrastructure and the circumstances of their needs, desires and abilities"[30] Models, therefore, are not oracles and caution is always warranted when trying to understand the future of a community.

Of course, with the growing number of datasets, and novel approaches to using data, new perspectives on creating and evaluating urban spaces will continue to be created. To quote from Hillier, the relationship between the act of quantifying and the artistic, intuitive moves might be summed as follows: "Architecture is law governed but it is not determinate. What is governed by the laws is not the form of individual buildings but the field of possibility within which the choice of form is made."[21]

THE RULES OF THE GAME?

The challenge facing this type of integration, as Firmino notes, citing Batty, is the uncertainly about the fundamental relation between data and cities[28], as the pace of technological development "is increasing at a faster rate than our ability to adapt analytics and policy structures to these new circumstances. Other professionals and forces, notably the technologists, now share "real city-making power" of once attributed to planners, and with this dynamic, there exists an knowledge asymmetry between those who traditionally shape the community, and data operators. This dynamic begs a type of relationship can be established between planners and these technologies, and perhaps more fundamentally questions what are new planning mechanisms and attitudes capable of dealing with these data-influenced infrastructures. This tension handicaps attempts to construct a more democratic system or to change the relationship in governance and the governed, and similarly the process of urban design and planning.

For cities seeking the second direction of "smart", an opposite approach to top-down might be advantageous—start with the public. Bottom-up initiatives often seek to leverages the citizenry as part of the actor-network as a means of action.[29] Bottom-up taps into the sociability of the city, leveraging the diverse range of talents and interests of its citizens and in turn creating tools that further the sociability of the community. Democratizing access to urban information—as it is happening more often with new open data initiatives all across the world—allows citizens to participate in optimizing how the space of the city is used. While more democratic in nature, full adoption is never guaranteed. By allowing the participation and creativity of the populace, cities can make savvier investments in cheaper technology that may work better to stoke civic

Figure 3: Fractal analysis of London's sprawling urban mophology.

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involvement than the more complicated, expensive products being sold by information-technology developers. Accepting the diversity of interests and talents of its citizens, specified outcomes are never guaranteed, nor do they necessarily have the agency to transform the physical artifice of the city beyond localized interventions.

The risk of bottom-up is that assumes 1) adoption reflects universal acceptance and 2) equal access, risk and benefit by the public. Being created democratically does not, in this case, necessarily reflect democratic accessibility and in fact, can be exclusionary to certain demographics.[30] At the same time, it is very difficult to excite civic hackers to do dull, dirty and dangerous work (such as implementing an electronic road pricing infrastructure!). With mostly proofs of concept, there are few *Ubers* and *Zipcars* with a large scale of impact. Results certainly may vary.[19]

For many communities, the ultimate metric for any initiative is gained efficiency (read: cost). For top-down and hybrid systems, civic leaders are seeking some level of increased productivity with existing resources: new services and experiences (at little to no cost), better utilization of existing infrastructures (to save costs), or improvements in perception (at little to no cost). The power of bottom-up, or the hybrid system, is that one can leverage the power of the individual with similar emphasis on efficiency through the collective action of the citizenry. Ensuring open access to this data happily frees it to serve the needs of the "the autocatalytic city"[31], where adaptive processes are founded on accurate, real-time local intelligence, city-dwellers are empowered to respond appropriately to highly dynamic conditions and emergent urban order is produced from the bottom up.[18]

In these cases, space can be transformed both though the long-term, individual interactions of daily life, or through new technologies. In 2010, Jamaica Plain resident Benjamin Resner spent $350 to build and install a real-time tracking display — the first unofficial MBTA countdown clock—at his neighborhood JP Licks ice cream shop, offering other customers the chance to enjoy their ice cream in peace while waiting for the bus (Figure 4a). In the months afterward, JP Licks reported an increase in sales (Powers 2014), all the while transforming the space of the "bus stop" into something more commercially supportive, and likely comfortable. The urban relationship, therefore, changes from a bus stop-street relationship, to a blurred distinction between street and private commercial space. A similar approach was considered in the design for the Senseable City Lab's eyestop proposal for Florence, where displays would also inform a person whether there was time to enjoy a cup of coffee, or whether the waiter should run back to the stop (Figure 4b).

The challenge of these arguably "small data" or more interventionist approach is that they have not had the power to transform the physical urban design of a city in the truest sense—the impacts are neither at the urban scale nor have they impacted the design of the city beyond the normal accretive process of city development that would have otherwise happened.

Ultimately, what may be ultimately required is what Komninos calls a cooperative "collective strategic intelligence"[32] to understand and translate the data into actionable outcomes, and reshapes the city as a matter of process. Thirft argues that these new digital urban artifacts (data) should create new coalitions, new forces, new realities in order to process and translate into policy. With the difficult technical and policy questions that could potentially arise, Rycroft argues for

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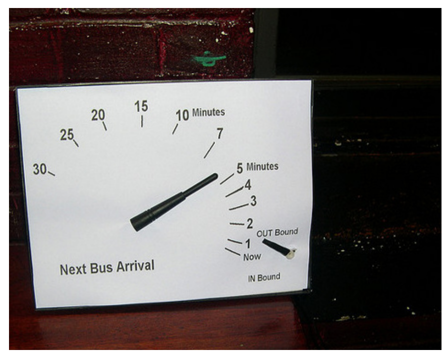

a

b

Figure 4a: MBTA Countdown Clock Prototype

Figure 4b: Eyestop Concept for Florence

the development and maintenance of institutional arrangements that enhance trust and reciprocity among the different knowledge communities is required to share and inform decisions.[33] Citing Anders Lundgren, he says that a normal pattern of local learning is required: retaining previous experience, combining it with prevailing circumstances, as it is of developing novel solutions. As part of this normal process, a valorization of experimentation is needed, particularly when no normal routines or heuristics may be present for new challenges.

Without evidence of this process for long-term collaboration, Greenfield finds only three inevitable conclusions of how the investment in digital technologies will end:

> "One, you install the screens and nobody uses them, ever -- people are set in their ways and the technology dies from disinterest. Two, there's some initial uptake, but because you designed the system so rigidly, they give up. Three, the best case is that people take it up in some way that it is enormously successful, but it has nothing at all to do with what the planners and strategists ever imagined."

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